Wize Training

Getting started with the old new LPWAN technology

Contents

Wize

AllWize

LPWAN Ecosystem

Context

What's the Internet of Things?

Everyday objects connected to the network (lights, home appliances, machines,...). Tightly coupled to other concepts like «smart city», «smart home», «machine learning», «artificial intelligence», «industry 4.0», «embedded systems», ...

IoT and Big Data are related concepts. Millions of devices producing hundreds of millions of data points.

But what for?

AllWize

Whose fault is this?

1980

David Nichols

Graduate students at the Carnegie Mellon University

His too

Wize

AllWize

Wize

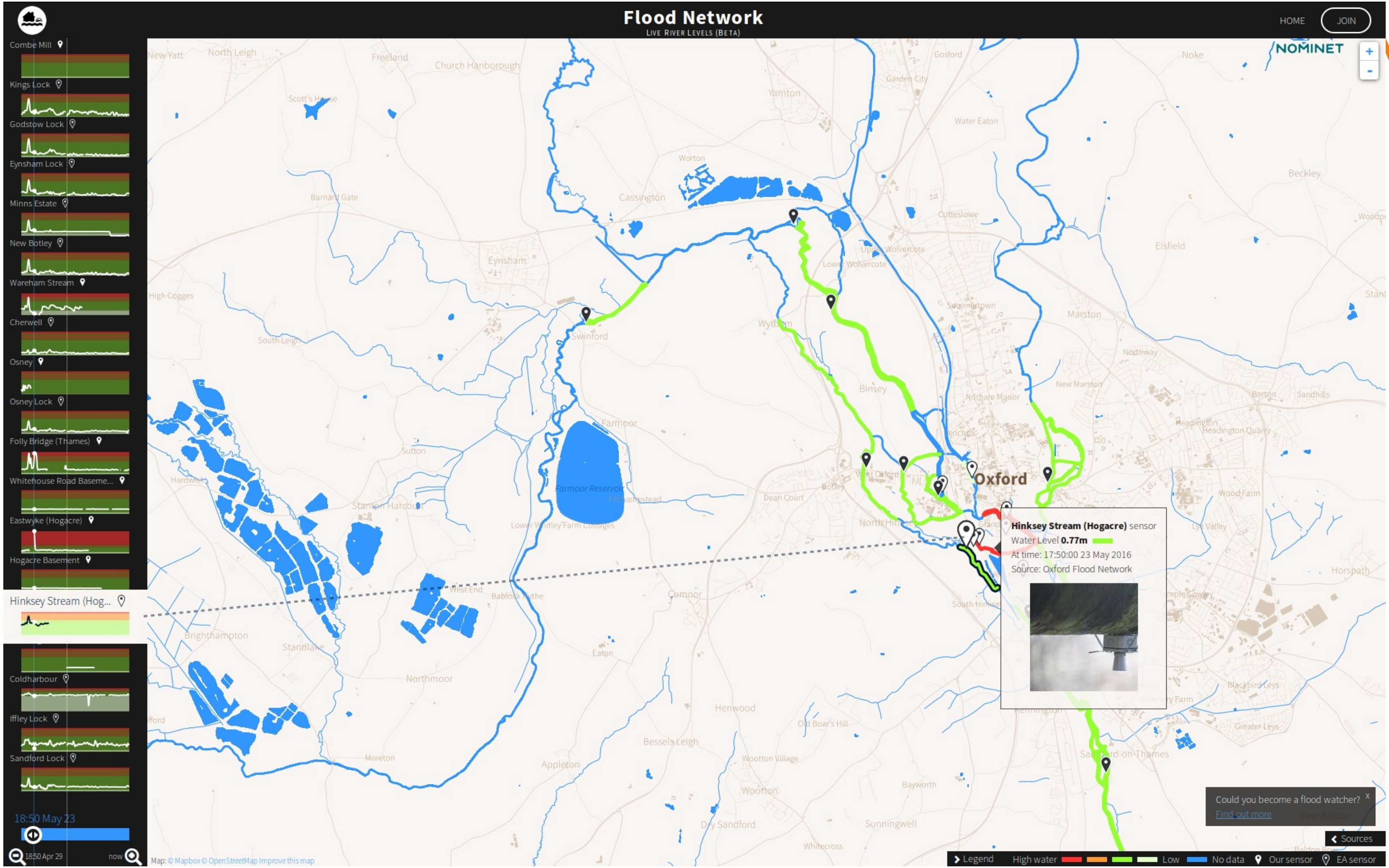
AllWize

The Vinduino sensor is a resistive solid-state sensor, that responds accurately over the whole soil moisture range (0 to -300 kPa). Read more

The Vinduino R3 sensor station is a solar powered remote sensor platform. It is designed for optimizing agricultural irrigation, aimed at saving irrigation water and optimizing crop health. Read more

A Globalsat LD-20 USB dongle together with a low cost Raspberry Pi computer makes a powerful gateway for your private Vinduino sensor network.

AllWize


Flood Network
Live River Levels (Beta)
HOME
JOIN
NOMINET
Combe Mill
Kings Lock
Godstow Lock
Eynsham Lock
Minns Estate
New Botley
Wareham Stream
Cherwell
Osney
Osney Lock
Folly Bridge (Thames)
Whitehouse Road Baseme...
Eastwyke (Hogacre)
Hogacre Basement
Hinksey Stream (Hog...
Coldharbour
Iffley Lock
Sandford Lock
18:50 May 23
18:50 Apr 29
now
Oxford
Hinksey Stream (Hogacre) sensor
Water Level 0.77m
At time: 17:50:00 23 May 2016
Source: Oxford Flood Network
Could you become a flood watcher?
Find out more
Sources
Legend
High water
Low
No data
Our sensor
EA sensor
Map: © Mapbox © OpenStreetMap Improve this map

AllWize

Wize

AllWize

Challenges

Challenges

Security

Manufacturer to user
Node to application
Tampering

Autonomy

Battery life
Battery replacement

Connectivity

No silver bullets
Multi-protocol
Critical systems

Interoperatibility

Standards
Modularisation
Sovereignty

Challenges

Awareness

User-technology relation
Artificial Intelligence
Privacy

Big data

Volume
Variety
Speed

Business model

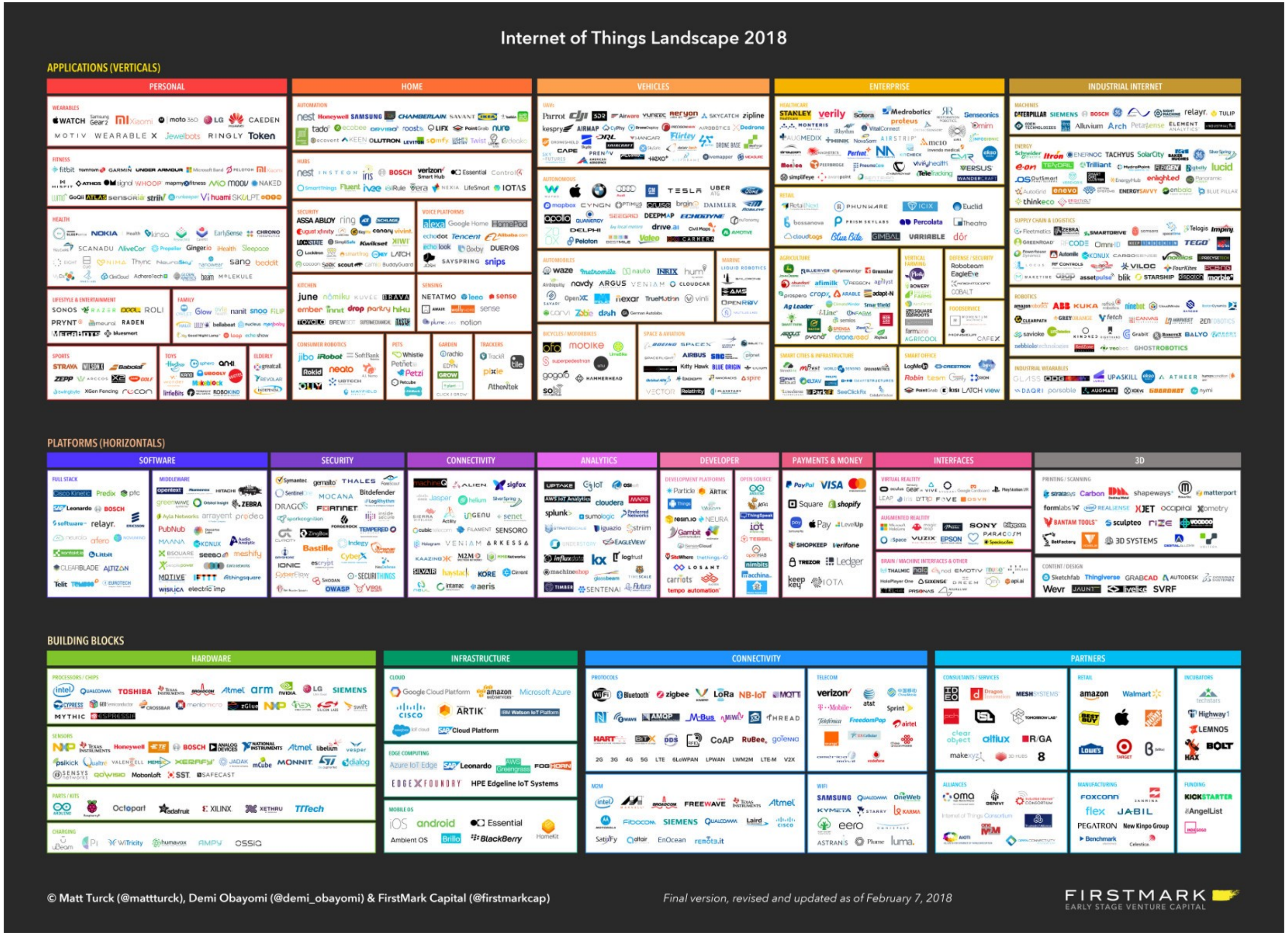
Data-centered
Commons

Scalability

Rapid growth
Unknown future requirements
Big data nightmare

Verticals

Wize



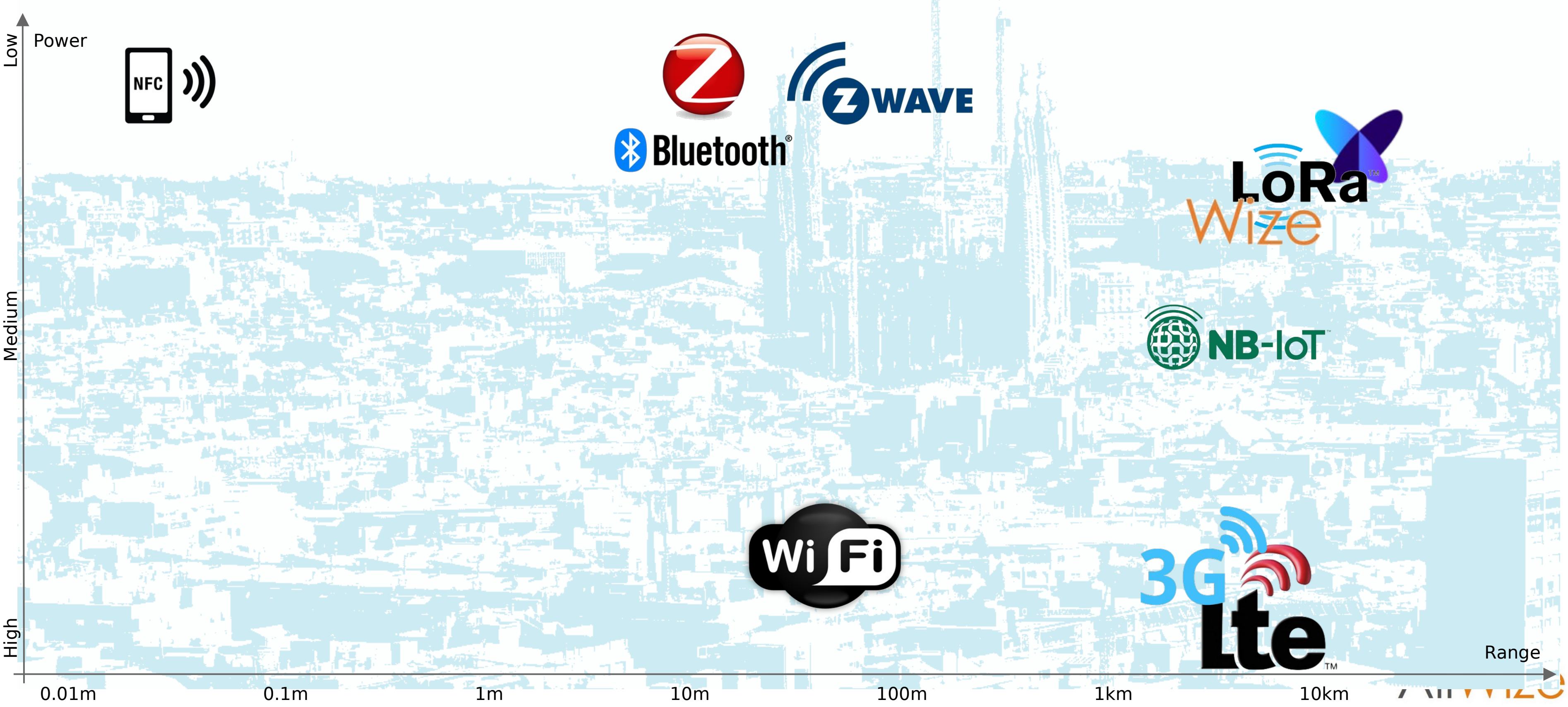
AllWize

Technologies

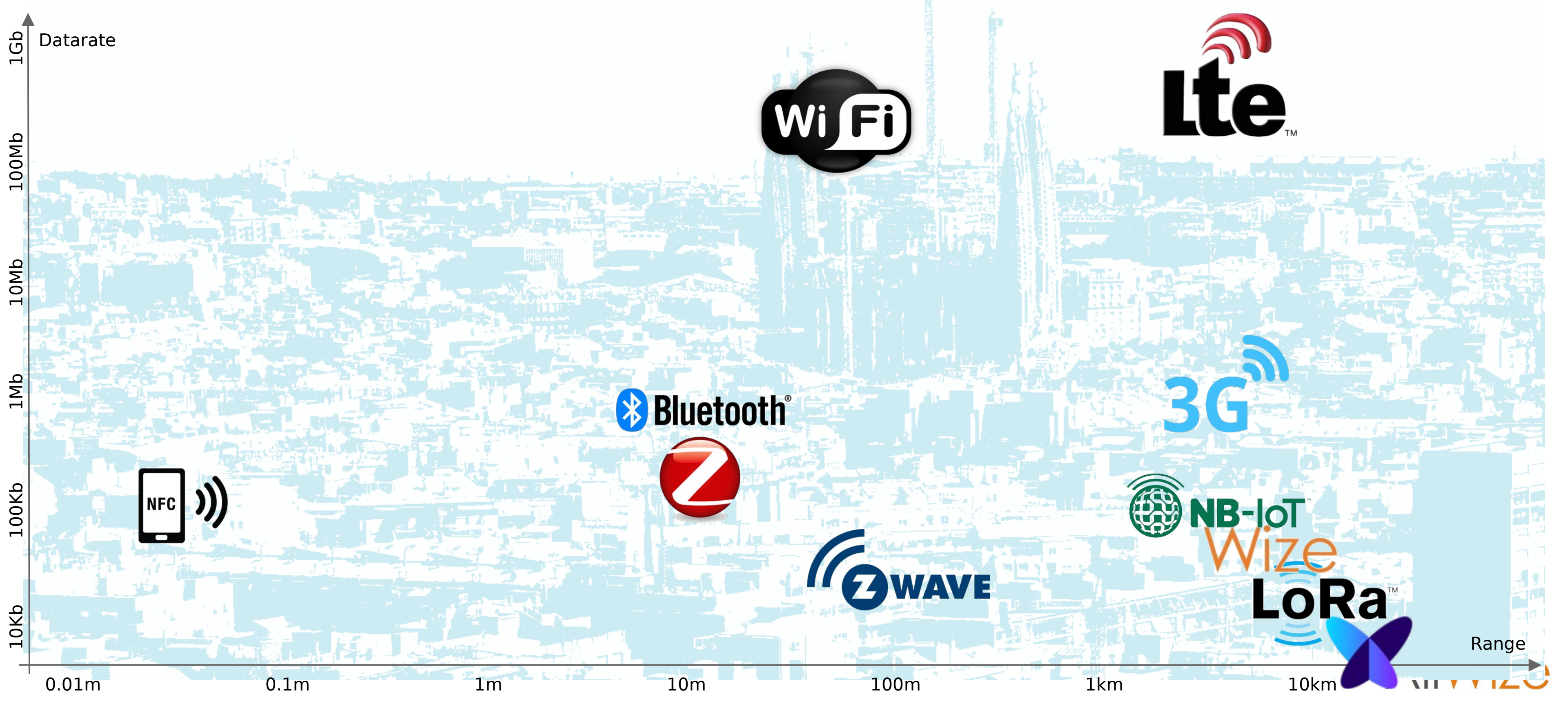
Different LPWAN Approaches

https://www.youtube.com/watch?v=grxnwoKDxAc

Wireless Technologies

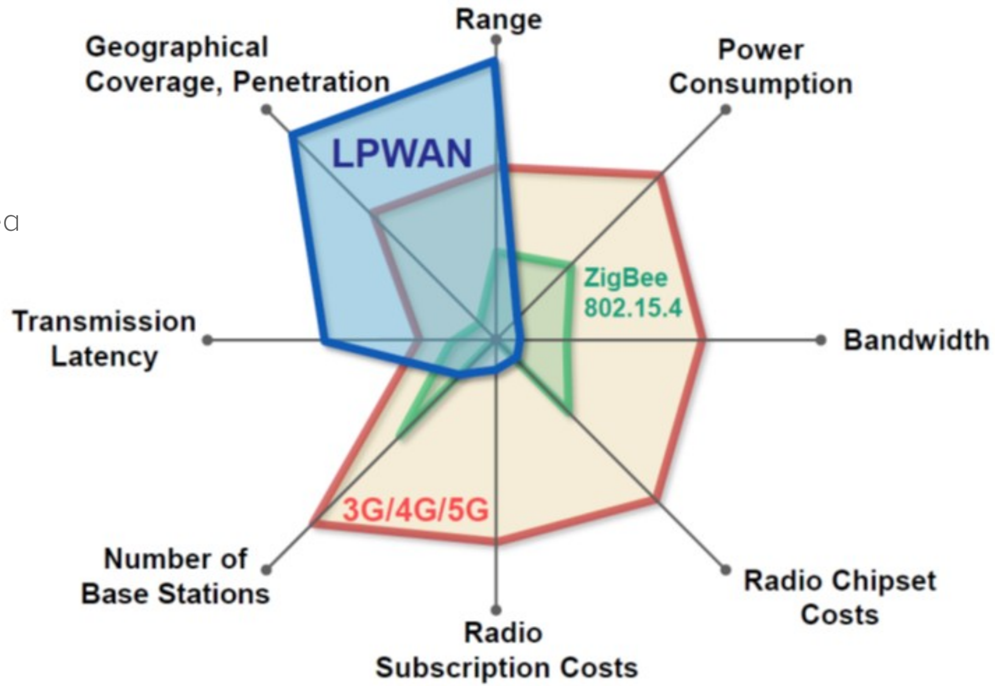


Wireless Technologies



LPWAN technologies

- Low Power Wide Area Networks
- Low Power
    - Autonomous devices
- Long range
    - A single receptor might service a wide area
    - 2km in urban environment
    - 10km in rural environment
- Band width
    - Few messages a day
    - Few information per message
    - Telemetry oriented



Capillarity / Last Mile

Coverage where you need it,
made easy!

Network scalability

INTERNET OF THINGS

Understanding the Limits of LoRaWAN

Ferran Adelantado, Xavier Vilajosana, Pere Tuset-Peiro, Borja Martinez, Joan Melià-Seguí, and Thomas Watteyne

Low-power wide area working technology o long-range communi tion, which enables n types of services. Seve solutions exist; LoRaW is arguably the most adopted. The authors provide an impartial a fair overview of the ca

2186 IEEE INTERNET OF THINGS JOURNAL, VOL. 4, NO. 6, DECEMBER 2017

Scalability Analysis of Large-Scale LoRaWAN Networks in ns-3

Floris Van den Abeele, Jetmir Haxhibeqiri, Ingrid Moerman, and Jeroen Hoebeke

Abstract—As LoRaWAN networks are actively being deployed in the field, it is important to comprehend the limitations of this low power wide area network technology. Previous work has raised questions in terms of the scalability and capacity

technologies such as cellular or WPAN [2]. Low power wide area networks (LPWANs) are a new set of technologies that are designed to fill this gap in traditional technologies. By combining low energy usage with long range communication, e, low ves up traffic M2M 20 [3].

On the Limits of LoRaWAN Channel Access

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Abstract—The rising tide of the Internet of Things has brought to the surface numerous low-power, long-range and low-bitrate wireless network technologies. One of them, LoRaWAN, is being intensely popularized as a solution for sensor networks, however, its potential and limitations are unclear, because there is still neither accurate study nor massive LoRaWAN deployment. This paper surveys and analyzes LoRaWAN operation, focusing on performance evaluation of its channel access as the most crucial component for massive machine type communication. We reveal and point out weaknesses of the LoRaWAN specification and propose solutions to improve LoRaWAN performance.

Keywords—LoRa, LoRaWAN, LPWAN, Channel Access,

The rest of the paper is organized as follows. Section II gives briefly introduces the LoRa and LoRaWAN technologies, focusing on their features, critical for multiple access, their weaknesses, and unclear spots of the specification. Section III describes the scenario in which we evaluate the performance of a dense LoRaWAN network. In Section IV, we present and analyze simulation results. Section V concludes the paper.

II. LoRaWAN

A. Network Architecture

Existing Technologies (some of them)

	WiFi	LoRa	sigfox	Wize	NB-IoT
Power efficiency	Low	**High**	**Highest**	**High**	Medium - low
Range	Short	**Long**	**Long**	**Long**	Medium - short
Encryption	AES256	AES128 (NW/APP)	AES128	AES128/Custom	Custom
Data rate	50-1000Mbps	250-11000bps	10-1000bps	2400-9600kbps	20-250kbps
Deployment	**Everywhere-ish**	Scattered	**Urban & comms**	**Some cities**	Pilots
Modulation	CCK / PSK / QAM	Wide band CSS (chip lock-in)	Narrow band BPSK	Narrow band FSK	DMA narrow band
Band	**2.4 – 5 GHz**	**868 MHz**	**868 MHz**	**169 MHz**	700 MHz – 2.2 GHz
Business Model	**Private network**	**Private network**	Proprietary network (network lock-in)	**Private network**	Proprietary network (network lock-in)
Gateway Cost	**< 100€**	**300€ and less**	?	~ 2000€	Expensive

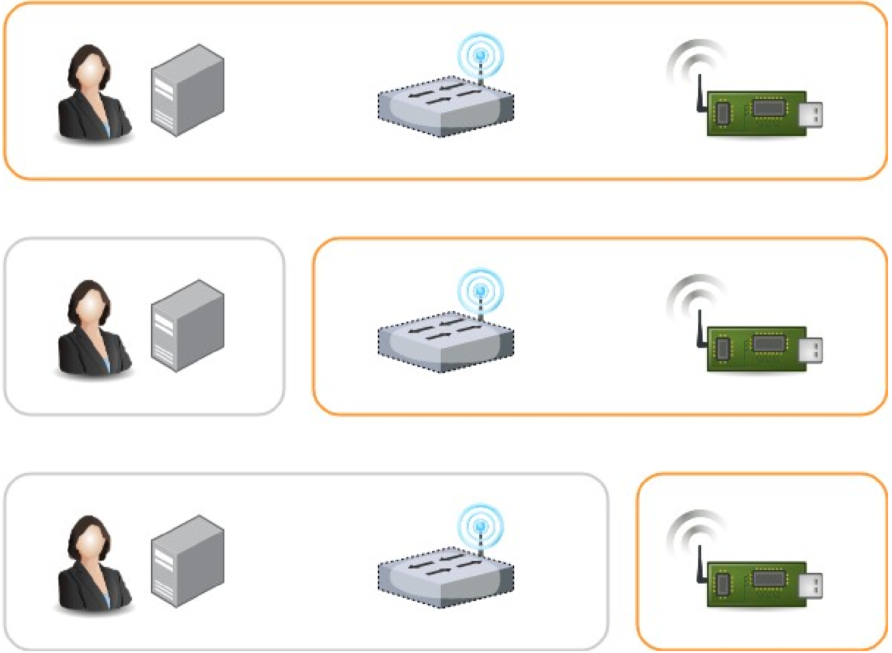
Network Ownership

Network Models

Private network
Devices and gateways are customer's property, self-operation

Hybrid network
Devices and gateways are customer's property but the operation is external

Operated network
Devices are customer's property, but infrastructure and operation is external



AllWize

Private Vs. Operated

Wize

sigfox

GRDF
GAZ RÉSEAU
DISTRIBUTION FRANCE

THE THINGS
INDUSTRIES

redexia
iot network

AllWize

Industry support

sigfox

NB-IoT™

suez

Wize

GRDF
GAZ RÉSEAU
DISTRIBUTION FRANCE

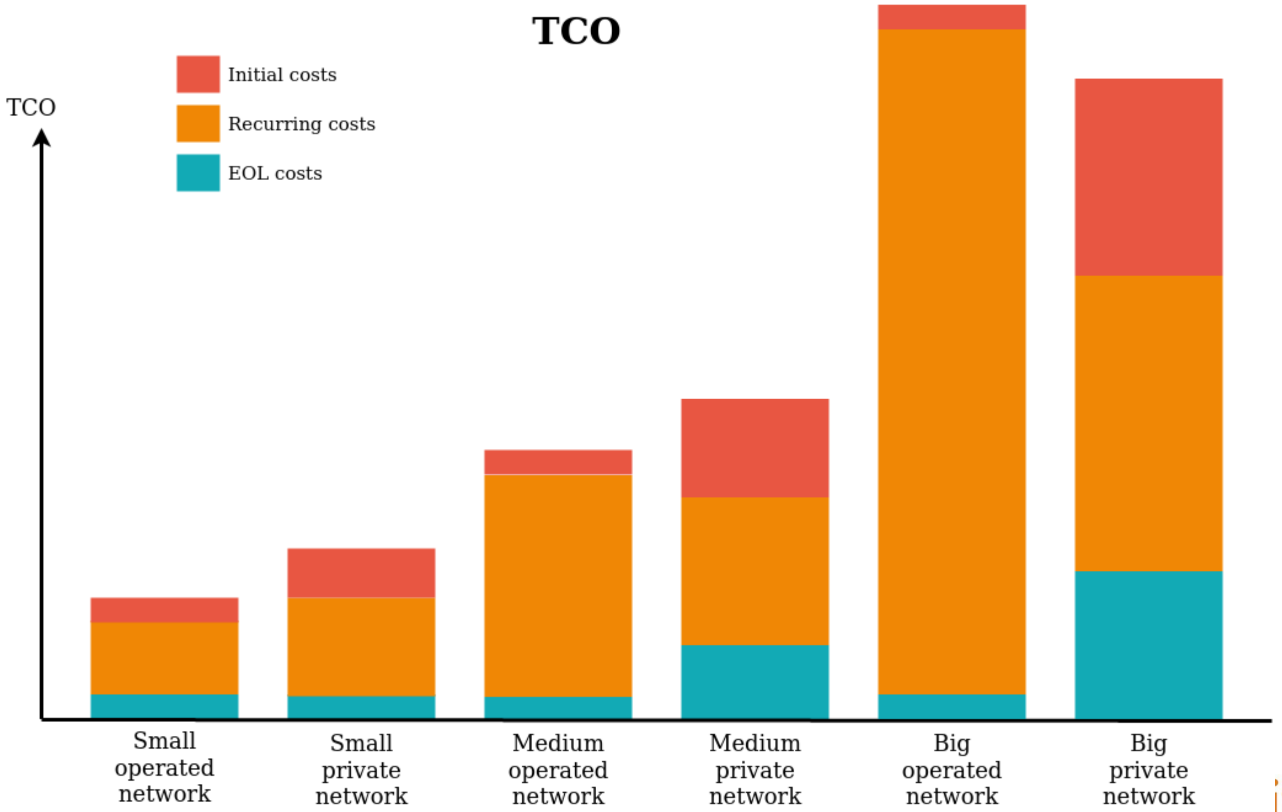
LoRa™

Total Cost of Ownership (TCO)

Initial costs:
- Purchase
- Delivery
- Installation
- Training

Recurring costs:
- Cost of ownership
- Maintenance
- Operation
- Non-quality costs

EOL costs:
- Disposal



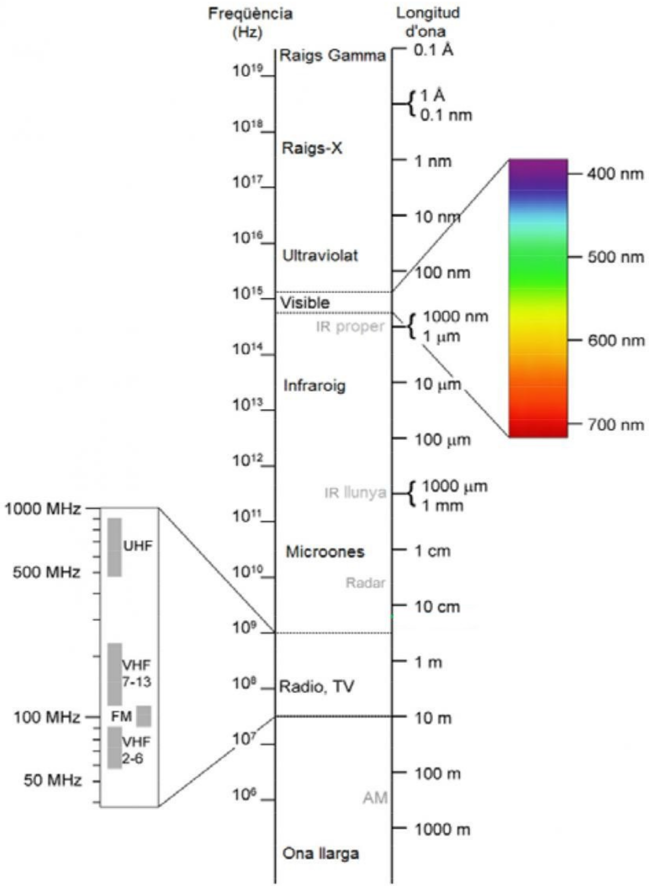
Radio frequency
Key concepts

Frequency and wave length

The frequency is the main characteristic of an electromagnetic signal: the number of times it vibrates per second, expressed in Hertz (1Hz=1/s). Wave length is the length the wave travels on a single period and it is expressed in meters (m).

$$f = c / \lambda$$

An easy way to translate from frequency to wave length and back is to know that **a 300MHz wave has a length of 1 meter**. A 600MHz one will have 50cm wave length and a 150Mhz one will have 2 meters wave length. A 868MHz signal (like the one used by TTN in Europe) has a wave length of 34,5cm and a WiFi 2.4GHz on is only 12,5cm.



Decibels

Decibel is a dimension-less (relative) logarithmic unit that represents the gain or loss of a magnitude. In telecommunications we calculate about the power gain (or loss) as:

$$g_P(dB) = 10 \cdot \log(p_o / p_i)$$

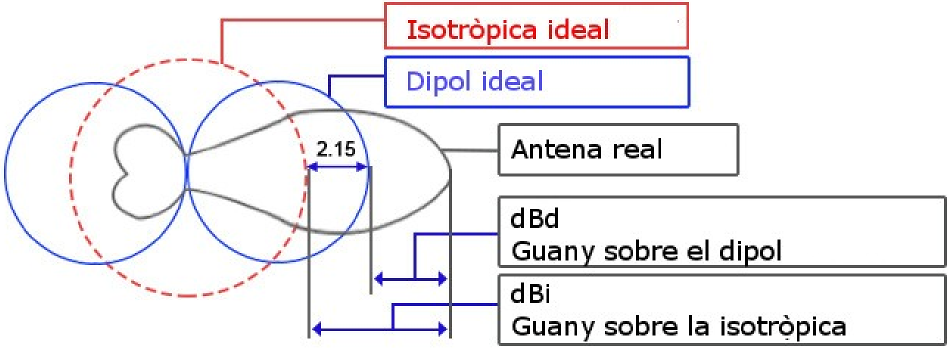
Therefore, +3dB is equivalent to a 2 times gain (output power is twice the input power). +6dB is 4 times, +9dB means 8 times, +10dB means 10x, +20dB is a 100 times more and +30dB is a 1000x factor.

From here on we can talk about different absolute and relative units:

- dBW: gain over 1W
- dBm: gain over 1mW (1dBW = 30dBm)
- dBi: gain relative to an isotropic antenna in the direction of maximum radiation
- dBd: gain relative to a dipole antenna in the direction of maximum radiation (dBd = 2.15 + dBi)

Antenna - Gain

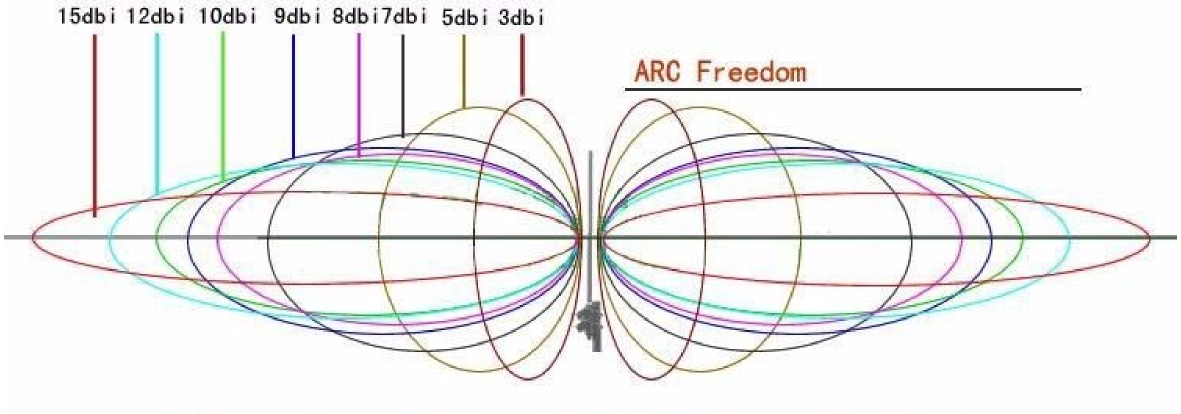
A perfect antenna will radiate power according to a characteristic pattern (radiation pattern), more or less directional, with certain beam width, etc. We say the gain of the antenna is the **power ratio (in dB) in the direction of maximum radiation compared to a reference (isotropic antenna or dipole antenna).** Therefore: it's not that the antenna is transmitting more power, it is only transmitting it in preference in a certain direction or directions.

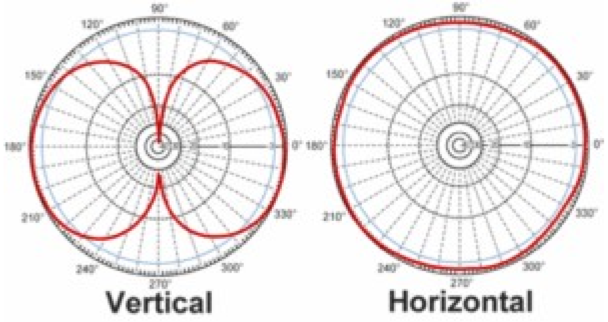


Antenna - Directionality

The antenna gain is usually related to the directionality. Greater directionality (less “omni”) means greater gain in that direction, but losses in all the other directions.

Directional antennas are great for radio-links, but not so great for broadcasting or service coverage.





Antenna - Impedance

The impedance is the complex resistance of an antenna and it must be the same for all the elements in the signal transmission path.

The impedance is a function of the resistance, the capacitance and the inductance of the circuit. The later two depend on the signal frequency. The resonance frequency for an antenna will be that where the inductance and capacitance cancel each other.

The **characteristic impedance** of a conductor (or an antenna) is the value of impedance for an infinite length trace (or reflection-less trace). Typical value for antenna impedance are **50**Ω.

There are solutions to “adapt” a circuit impedance to a certain antenna using T or π bridges.

Antenna - Impedance

AllWize

Antenna - Reflection coefficient

If the circuit impedance does not equal the antenna impedance, power transmission will not be efficient and might even bounce back and “fry” your circuit. This is the same reason why you should never power a radio device without an antenna attached to it since it will have an infinite impedance and all transmitting power will be reflected.

A good antenna should not have a reflection coefficient above 11% (VSWR<2, Voltage Standing Wave Ratio) at its resonance frequency.

$$|\Gamma|=(VSWR-1)/(VSWR+1) \qquad VSWR=(1+|\Gamma|)/(1-|\Gamma|)$$

Where Γ (also known as s11) is the reflection coefficient of the antenna, a measurement of the % of reflected power:

$$P_{REFLEXADA}/P_{TOTAL} = |\Gamma|^2 \qquad R(\%)=100\cdot|\Gamma|^2 \qquad R(dB)=20\cdot\log(|\Gamma|)$$

Transmitting power

Maximum transmitting power is regulated by the European Telecommunications Standards Institute (ETSI) in Europe and it depends on the frequency. In the 868MHz band the maximum allowed is 14dBm (25mW). In the USA the FCC allows up to 21dBm (126mW) in the 915MHz band. Radio Liberty transmission power was a 90dBm (1MW).

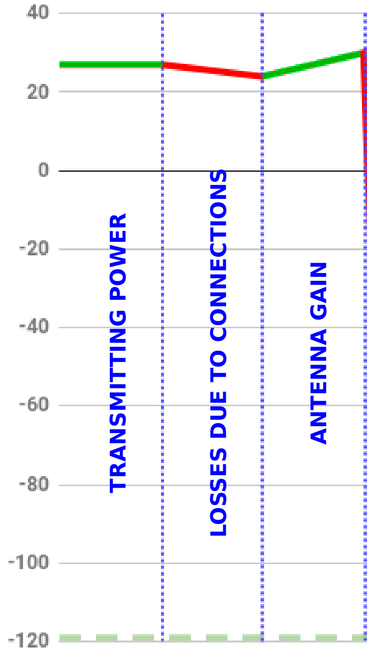
Band	dBm	mW
169MHz	27	500
433MHz	10	10
868MHz	14	25
2.4GHz	18-20	63-100
5GHz	20-23	100-200
“4G”	20-43	100-20.000
“5G”	24-50	250-100.000

Equivalent Radiated power (ERP)

This is the equivalent transmitter power to get the same radiation power of a dipole (or isotropic element if EIRP) at a certain point in the direction of maximum gain of the antenna.

It is the output of:

$$P_{ERP} = P_{TX} + L_C + G_{TX}$$

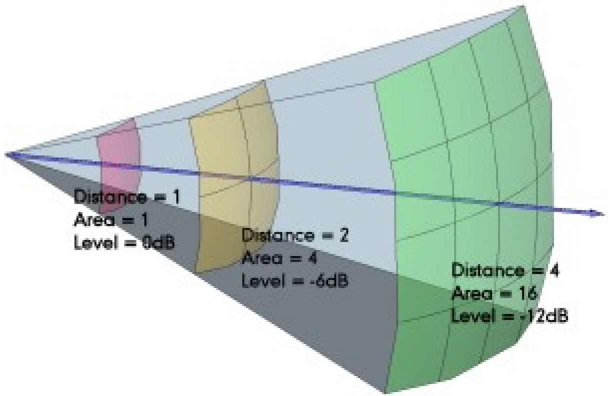


Transmitting power and Distance

Doubling the transmission power does not double the distance we can reach. Power is dissipated over a surface that is proportional to the square of the distance. A sphere surface is:

$$S(r) = 4 \cdot \pi \cdot r^2$$

Therefore, to double the range we must transmit 4 times more power or +6dB.



Attenuation - Path loss

Path loss is due to distance and obstacles in the path of a radio signal. There are different theoretical models to calculate the "path loss" in a given environment. The simplest says:

$$\mathbf{L_A(R) = L_0 - 10 \cdot n \cdot \log(R)}$$

Where R is the distance, L_0 is the loss at a distance of 1m from the source (it's -17dB for 169MHz, compared to -31.2dB for 868MHz) and n an experimental factor to account for the environment.

In practice, this means that under ideal conditions (no obstacles), the path loss due to free air (n=2) is **-6dB to double the distance**. This is expected since -6dB is the transmission power loss due to double the distance.

Description	n
Free air	2.0
Store	1.8-2.2
Office	2.6-3.0
Factory	3.3
Building, no LOS	2.1-4.5
Mixed interiors	1.2-6.5

Attenuation - Obstacles

Different materials have different impact on the electromagnetic waves depending on three parameters: material type (composition), density and thickness.

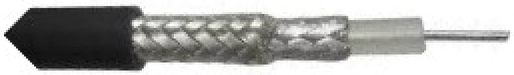
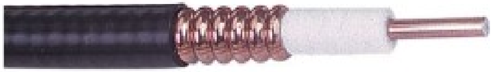
Composition affects differently depending on the wave frequency. Density and thickness both have a proportional linear impact on the attenuation.

	Attenuation (dB)		
Object / Material	**500 MHz**	**1 GHz**	**2.4 GHz**
Human body	2	3	4.2
17cm brick	3.5	5.5	7.5
20cm concrete	21	25	32
1cm pasterboard	0.1	0.3	0.6
1cm glass	1.2	2.2	3.4
10cm reinforced concrete	23	27	31
7cm wood	1.5	3	4.7

Attenuation - Cables

Also cables and connectors between elements imply a power transmission loss. It's particularly important not to use lengthy cables between the transceiver and the antenna.

https://www.qsl.net/co8tw/Coax_Calculator.htm

Cable	Description	Attenuation (dB/m)	
RG59	6.14mm, simple mesh	0.56	
RG223	5.33mm, double mesh	0.44	
RG214	10.8mm, double mesh	0.24	
LCF12	12.7mm, stiff	0.07	

Source: @gmag12

Attenuation - Connectors

A tipical loss is **-0.1dB** (about a 2% in signal). High fidelity connectors have lower values (-0.01dB).

TNC female

TNC male

N male

N female

BNC male

BNC female

SMA male

SMA female

RP-SMA male

RP-SMA female

uFL/IPX1 male

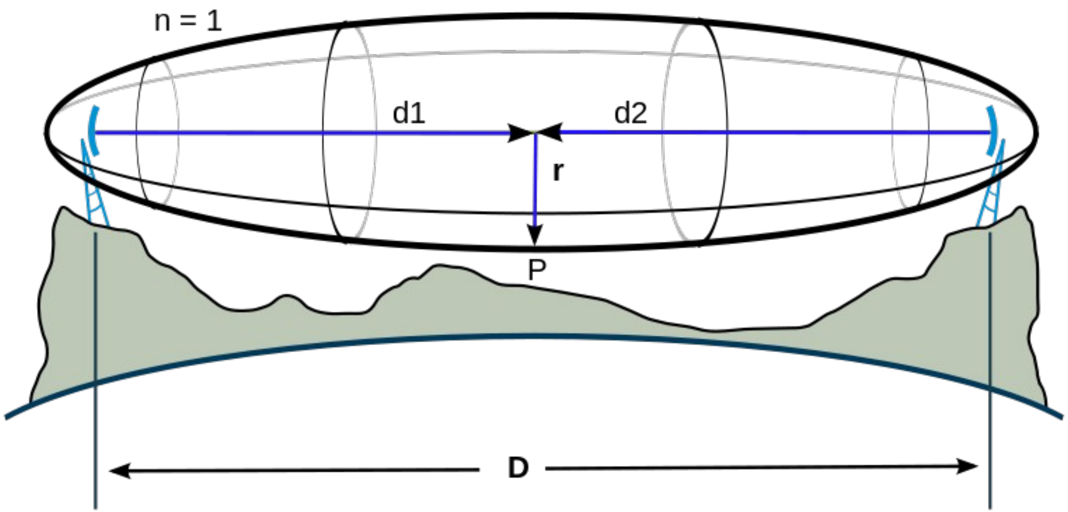
uFL/IPX1 female

Fresnel Zones

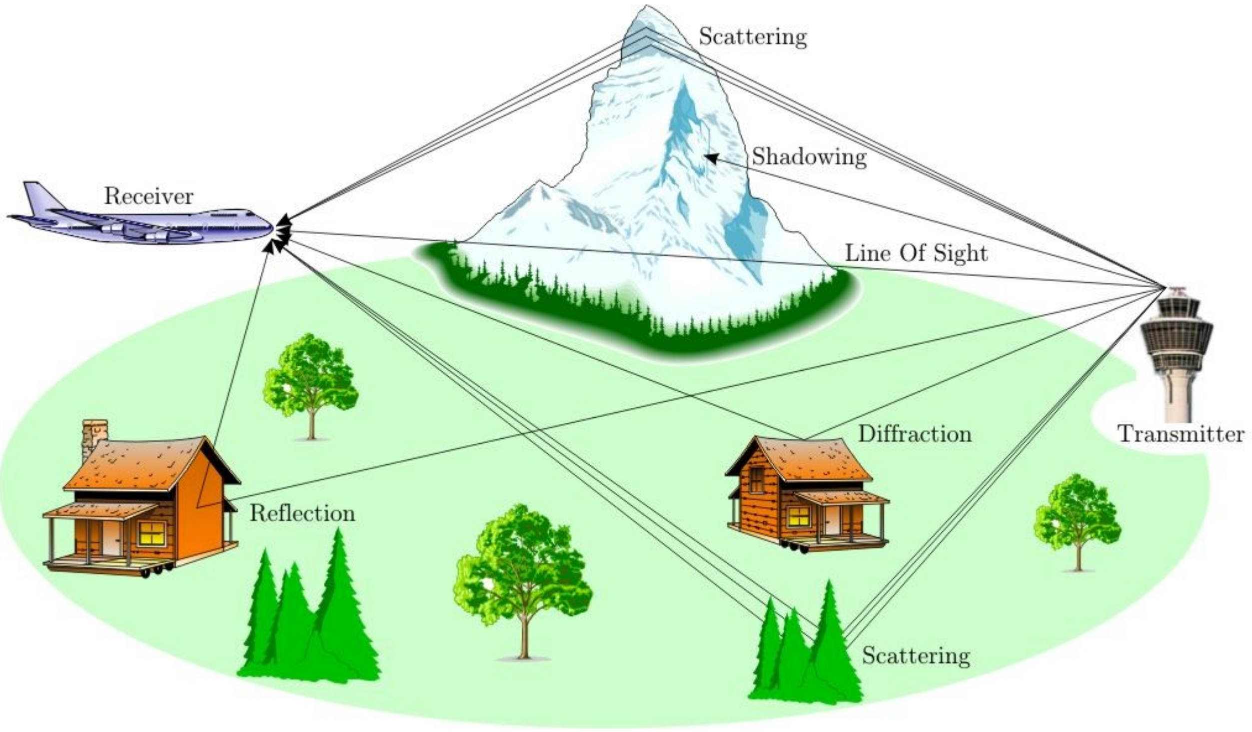
We often talk about the importance of having a "**line of sight**" (LOS) from transmitter to receiver. But obstacle "near" the LOS do impact on the signal.

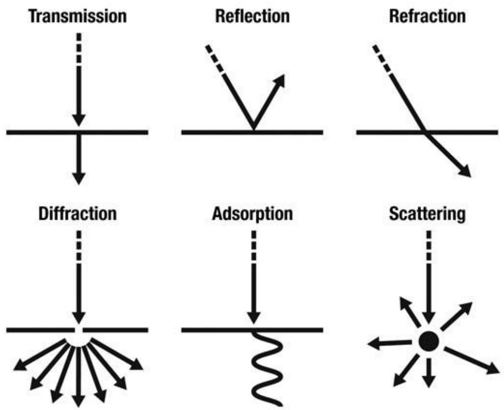
$$F_n=\sqrt{(n \cdot c \cdot d1 \cdot d2/(d1+d2)/f)}$$
$$r=F_1(d1=d2=D/2)=\sqrt{(c \cdot D/f/4)}$$
$$r(868MHz, D=1km)=9m$$

In general, if 80% of the first Fresnel Zone (n=1) is free of obstacles, the path is equivalent to free air.



Reflection, difraction, scattering,...





Signal to Noise Relation (SNR)

The range a radio signal can achieve also depends on the SNR factor. This, in turn, depends on the environment noise (of course) but also on the data rate of the signal.

Higher data rates (higher transmission speeds) require a bigger SNR. For instance: a 6Mbps WiFi signal will reach 7 times further under the same circumstances that a 54Mbps one.

Modulation	Data rate (Mbps)	Minimum SNR
BPSK 1/2	6	8
BPSK 3/4	9	9
QPSK 1/2	12	11
QPSK 3/4	18	13
16-QAM 1/2	24	16
16-QAM 3/4	36	20
64-QAM 1/2	48	24
64-QAM 3/4	54	25

Link Budget

The **link budget** is the sum of all **gains and losses** in a **transmission**.

$$LB = P_{TX} + G_{TX} + G_{RX} + L_{RX} + L_{TX} + L_C + L_A + L_O$$

Gains:

- Transmission power (**P_{TX}**)
- Transmission antenna gain (**G_{TX}**)
- Reception antenna gain (**G_{RX}**)

Losses:

- Antenna adaptation (**L_{RX}** and **L_{RX}**)
- Cables and Connectors (**L_C**)
- Air (**L_A**)
- Obstacles (**L_O**)

If the balance is greater than the **receiver sensitivity ($LB > S_{RX}$)**, the reception is possible. Both numbers are usually negative.

Link budget (example)

Let's do a link budget example between a Wize gateway and a node.

Gains:

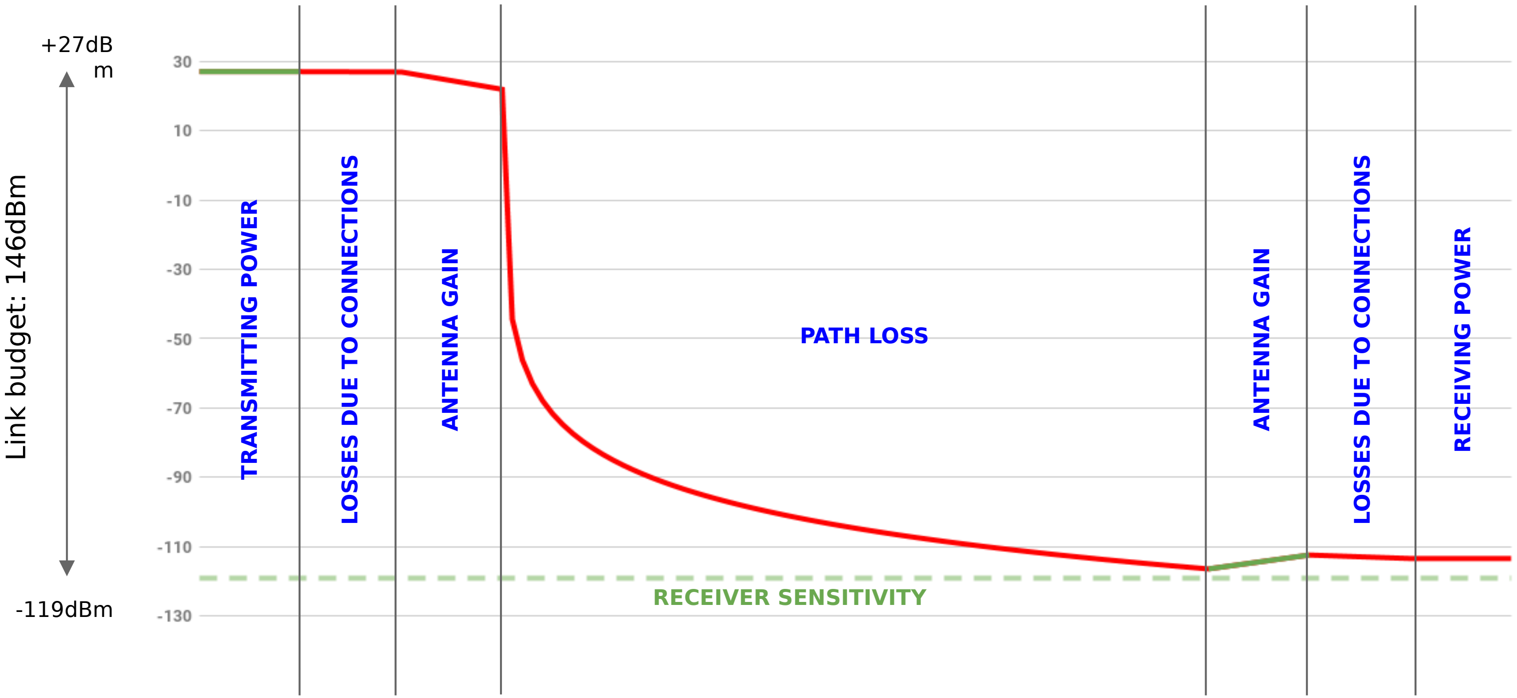
- Transmission power: +27dBm (max by ETSI)
- Equivalent sensitivity in the reception: -119dBm (RC1701HP @ 2.4kbps) to -126dBm (Grade equipment @ 2.4kbps)
- Transmitter antenna gain: -9dBi (H169-SMA)
- Receiver antenna gain: -9dBi (H169-SMA) or +4dBi (rooftop antenna)

Losses:

- Connector in node: -0.1dB
- Connector in gateway: -0.1dB
- Environment 'n' constant: 4 (urban)

Source: Radiocrafts AN021

Link budget (example using AllWize boards)



AllWize

Range calculation (Worse scenario hw-wise)

$$S_{RX} = P_{TX} + G_{TX} + G_{RX} + L_C + L_A$$
$$-119 = 27 - 9 - 9 - 0.2 + L_A$$
$$L_A = -127{,}8\text{dB}$$
$$L_A = L_0 - 10 \cdot n \cdot \log(R) = -17 - 10 \cdot n \cdot \log(R)$$
$$R = 10^{11{,}08/n}$$

n	R (km)
4 (urban)	~0.6
3 (rural)	~5.0
2 (free air LOS)	~350

Link budget (Best scenario HW-Wize)

$$S_{RX} = P_{TX} + G_{TX} + G_{RX} + L_C + L_A$$

$$-126 = 27 + 4 - 9 - 0.2 + L_A$$

$$L_A = -147{,}8\text{dB}$$

$$L_A = L_0 - 10 \cdot n \cdot \log(R) = -17 - 10 \cdot n \cdot \log(R)$$

$$R = 10^{13{,}08/n}$$

n	R (km)
4 (urban)	~1.8
3 (rural)	~23
2 (free air LOS)	~3500

Advices

Gateway

- Use an **omnidirectional antenna**.
- Good earth connection, lighting protection.
- Place it high above ground.
- Away from other **obstacles**, especially metallic ones.
- Shorter possible cable (**gateway in pole**).
- Quality **coaxial cable** between gateway and antenna

Node

- Think about **polarization** in the antenna (orientation).
- Check the antenna ground plane or, even better, use a full dipole.

Both

- Good quality, protected, connectors.
- Matching **impedance**!

Wize In-Depth

Context

From pagers to IoT

AllWize

Wize, Wize-Alliance, AllWize,...

The Wize Alliance

- Suez and GRDF have been using the 169MHz band for years now.
- Suez has over 3.5 million devices connected in Europe, 1 million in Spain.
- GRDF will have 12 million devices in France by 2023, 90% coverage over the continental territory.
- GRDF is getting ready to operate the network as a telco.

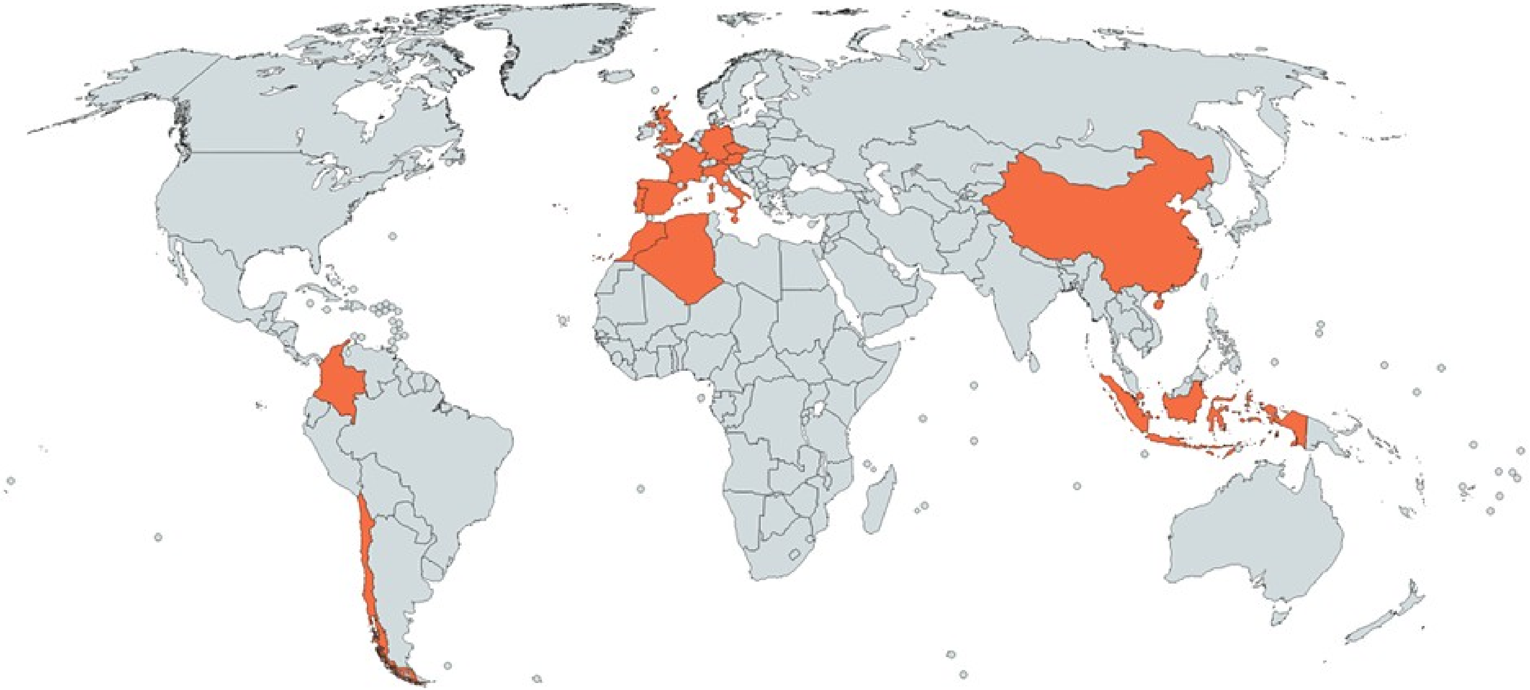
A little bit of History

- In 1999 the frequency dedicated to pagers is freed
- In 2013 the same frequency is assigned to Wireless M-Bus type N (EN-13575)
- In 2017 the Wize Alliance is born and defines the first version the Wize protocol, based on the Wireless M-Bus 4 but IoT oriented.
- In 2018 AllWize joins the Wize Alliance, the intention is to ease the access to the technology (affordable hardware, libraries,...)
- In 2018 Q4 AllWize succeeds in designing and building a prototyping board based on the MKR family by Arduino
- In 2019 Q2 the first AllWize K1 (Arduino shield) and AllWize K2 (*standalone*) are released

Wize overview

- LAN protocol
- Defines OSI layers 1 (channels & modulation), 2 (MAC, message flows, OTA), 6 (presentation) and 7 (custom and common app frames)
- Uses the 169MHz band, license-free in the EU (less busy than 868MHz)
- Higher transmission power limit defined by ETSI
- No chip lock-in, no network lock-in, open specs
- Narrow band (12.5 - 25kHz)
- Bidirectional transmission
- Defines (optional) encryption mechanisms
- OTA updates

Where?



Pros and Cons of Wize and 169MHz band

Air losses	Air losses are proportional to the frequency (about +14dB for 169MHz vs 868MHz)	
Obstacle losses	Less frequency more penetration	
Polarization losses	Frequency does not impact	≈
Antenna gains	Antennas are more complex and less efficient for lower frequencies (good 169MHz antennas have gains of ~0dBi!!)	
Transmission power	The ETSI limit for 169MHz is 27dBm (500mW) whereas only 14dBm (25mW) for 868MHz	
Reception sensibility	Base speed transmission with Wize is 2400bps, with Sigfox (as an example) it is 300bps. Faster transmission implies greater losses	
Processing gain	Sigfox and LoRa use advanced modulation techniques, Wize uses plain FSK for compatibility (modulation gain with LoRa means about 20dB)	

When? Range-wize

	LoRaWAN	SigFox	Wize	NB-IoT
TX Power	14	14	27	160
RX Sensitivity	-141	-142	-126	
Speed (bps)	300	100	2400	10000
TX antenna gain	2	2	-9	1
RX antenna gain	4	4	4	8
Frequency attenuation	-31	-31	-17	-31
Free space performance	130	131	131	138
Typical indoor penetration loss	-35	-35	-25	-35
Indoor performance	95	96	106	103

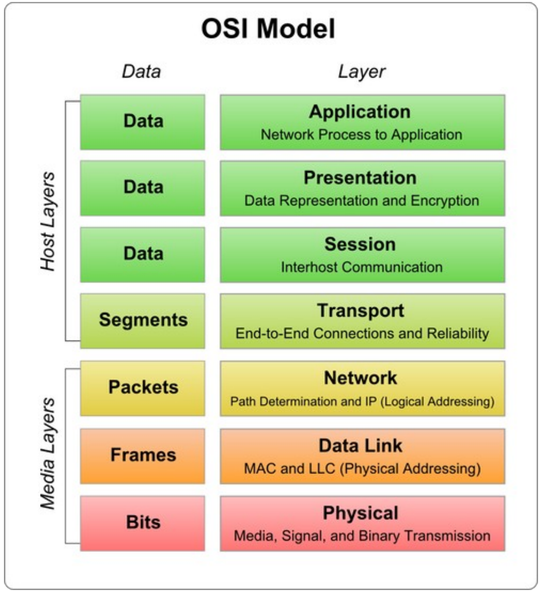
When? Power-wise

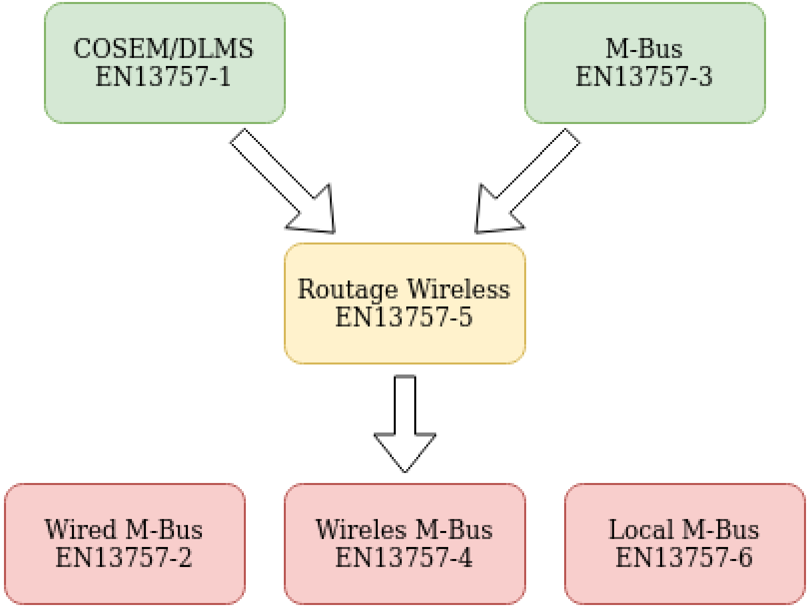
12 bytes/message	LoRaWAN	SigFox	Wize	NB-IoT
Message overhead	18	8	26	21
Max length (bytes)	51	12	102	
Speed (bps)	300	100	2400	10000
TX duration (s)	0,80	1,60	0,13	
Repetition factor	1	3	1	
TX duration (s)	0,80	4,80	0,13	
TX current (mA)	33	33	250	
TX energy (mA·s)	26,40	158,40	31,67	90-500
RX duration (s)	0,16		0,02	
RX current (mA)	15		28	
RX energy (mA·s)	2,40		0,56	10-100
Total energy (mA·s)	28,80		32,23	100-600

Protocol

EN13757-4 Standard

Wize





AllWize

Band and characteristics

Wize is defined in the EN13757-4 standard as mode N2.

It's bidirectional, with an uplink payload of up to 128bytes and a downlink of 128 or 256 bytes.

The 169MHz band has a duty cycle or 10% which means you can transmit 6 minutes every hour.

It supports bitrates from 2400 to 19200bps and defines a dual security layer based on AES128 (upgradable to AES256).

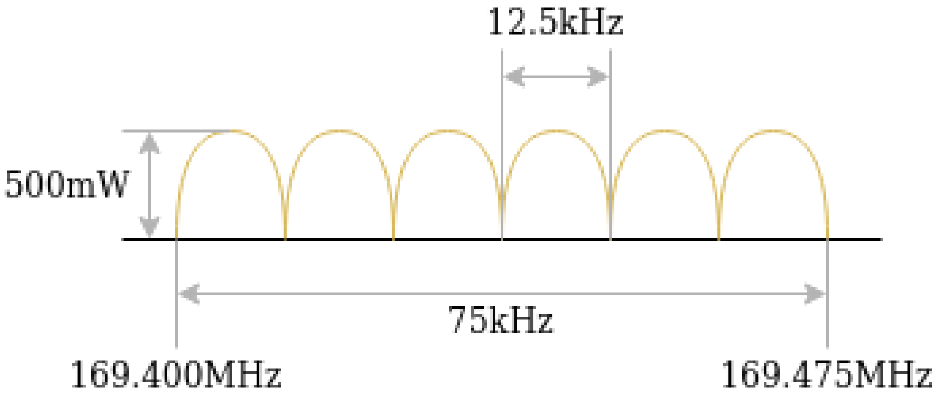
Mode	Band (MHz)	Bitrate (kbps)	Bidirectional
S1/S1-m	868,3	32,768	No
S2	868,3	32,768	Yes
T1	868,95	100	No
T2	868,95 / 868,3	100 / 32	Yes
R2	868,3	4,8	Yes
C1	868,95	100	No
C2	868,95 / 869,52	100 / 50	Yes
N1	169,4 – 169,475	2,4 to 19,2	No
N2	169,4 – 169,475	2,4 to 19,2	Yes
F2/F2-m	433,82	2,4	Yes

MODULATION

Radio spectrum divided into **6 channels**, each **12.5 kHz** wide. Typically 5 for uplinks and 1 for downlink messages

The ETSI (European Telecommunications Standards Institute) define a maximum transmitting power for the 169MHz band of **500mW** (or 27dBm). That's 20 times more transmitting power than LoRa or Sigfox on the 868Mhz band.

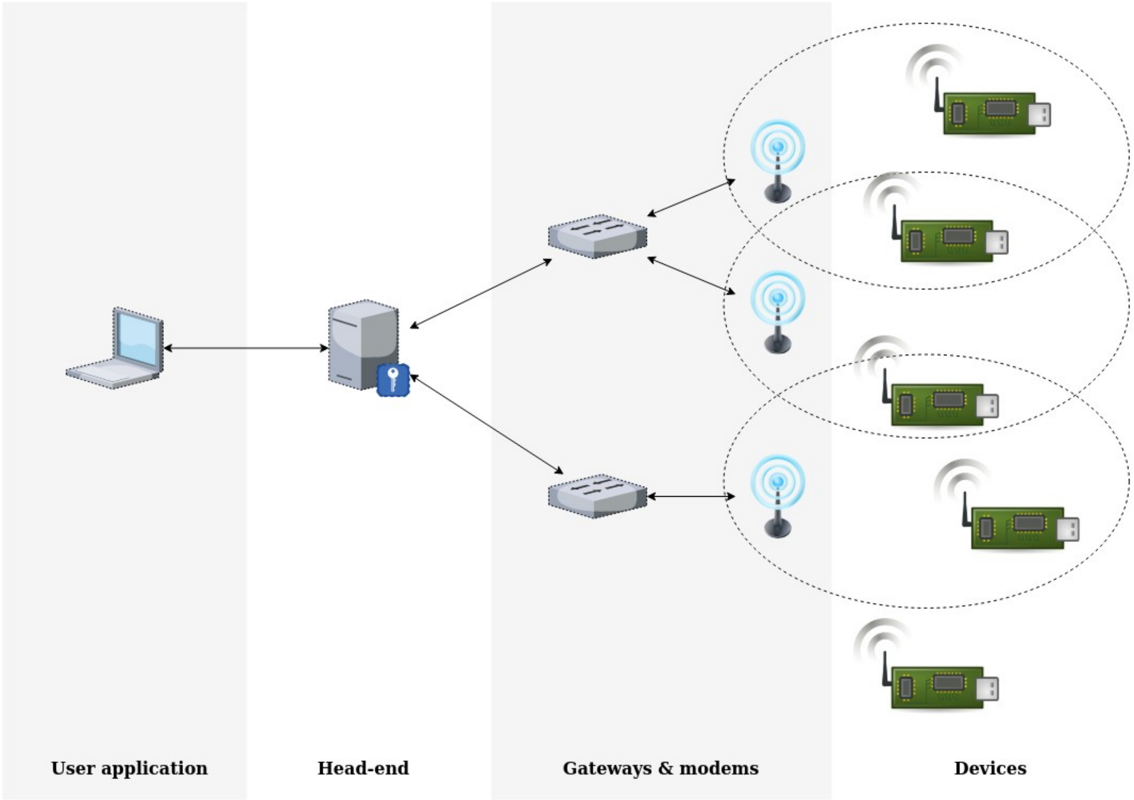
Modulation is based on **GFSK** and **4GFSK**.



LAN Architecture

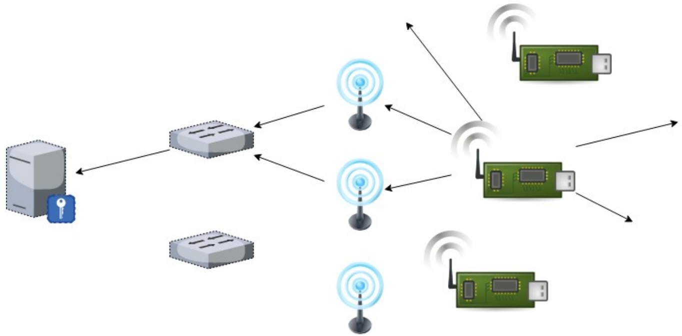
Each **Wize gateway** can be equipped with one or more **LAN modems**. A multi-modem gateways allows spatial diversity for better reception, improving device autonomy and reducing EM pollution.

The **Head-end system** is responsible for data collection, message deduplication, MAC layer management,... Gateways and the Head-end are connected via WAN networks.

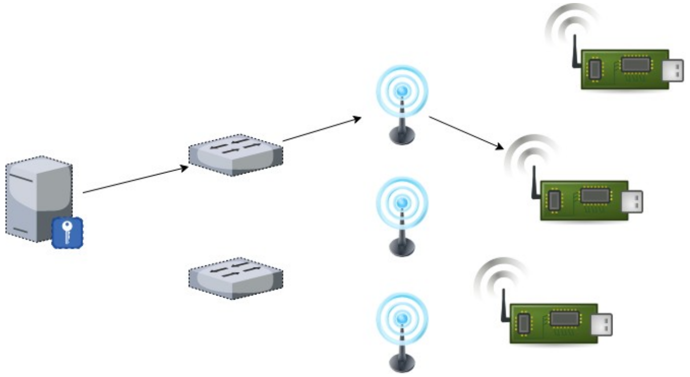


Message types

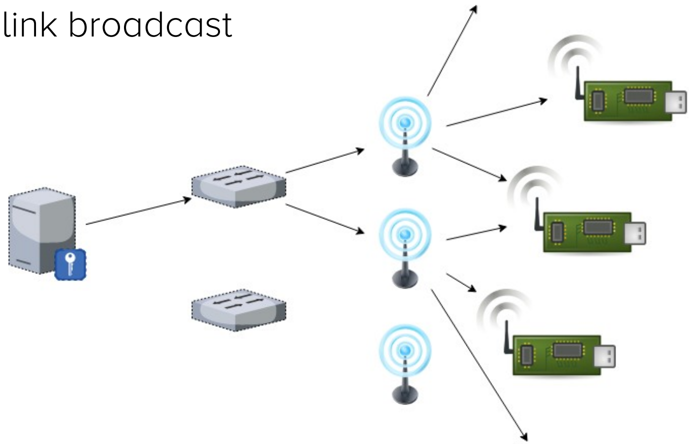
Uplink broadcast



Downlink unicast



Downlink broadcast



Message types

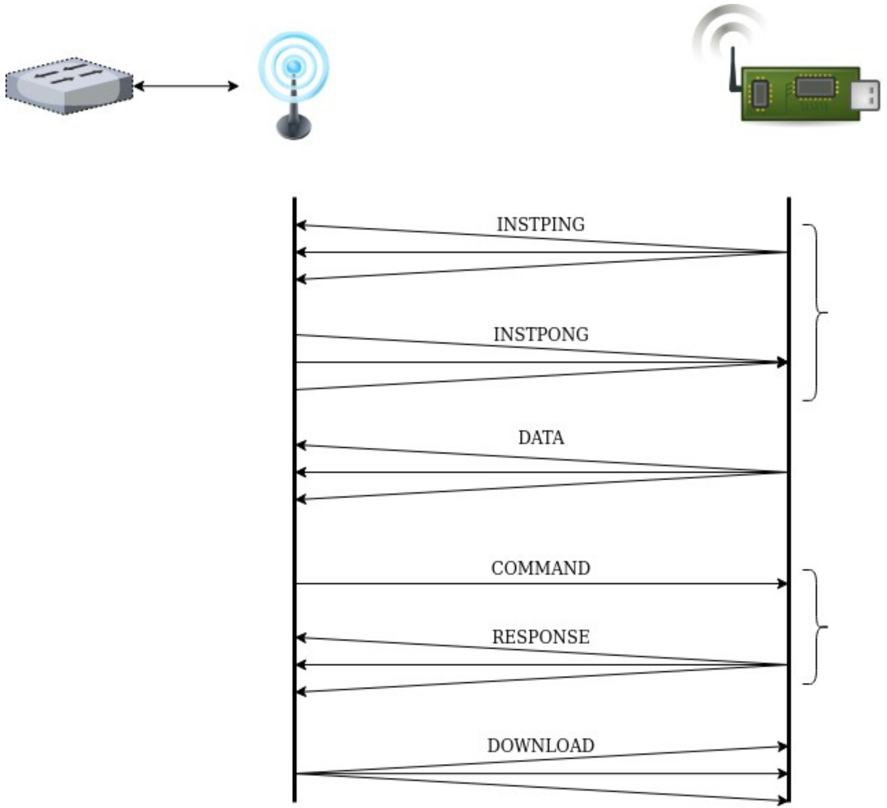
The standard defines 6 types of messages.

INSTPING and **INSTPONG** are connectivity test messages between the device and the gateway, the head-end is not involved here.

DATA messages are devices driven data uplinks with sensor data.

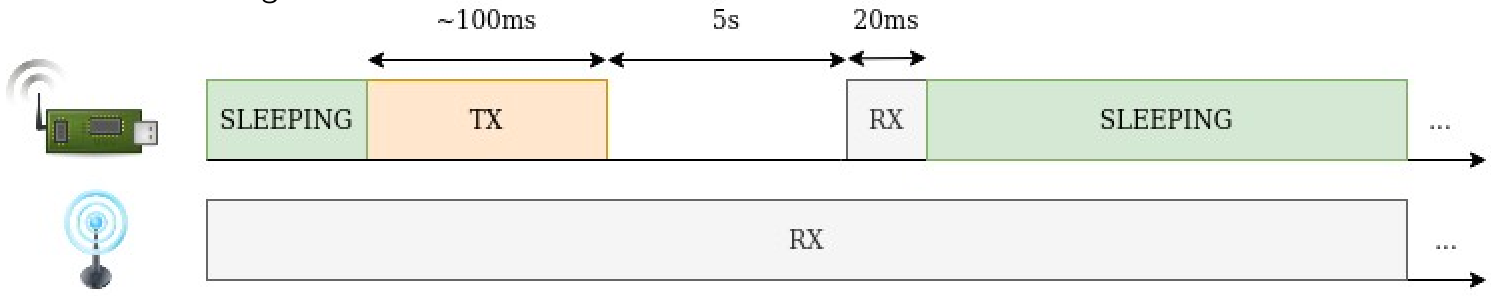
COMMAND and **RESPONSE** are MAC layer messages initiated by the head-end system to configure the devices.

DOWNLOAD messages are FOTA messages to update device firmware.

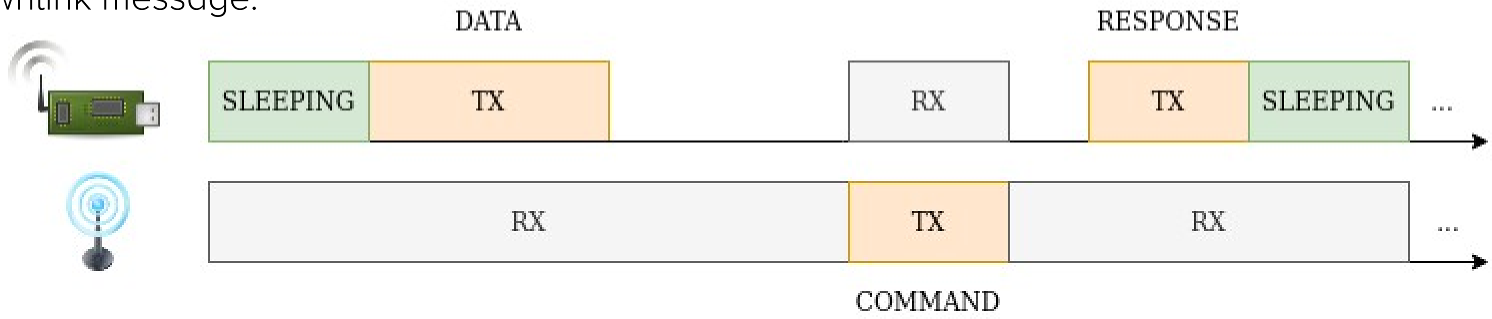


Bi-directionality

Without downlink message:

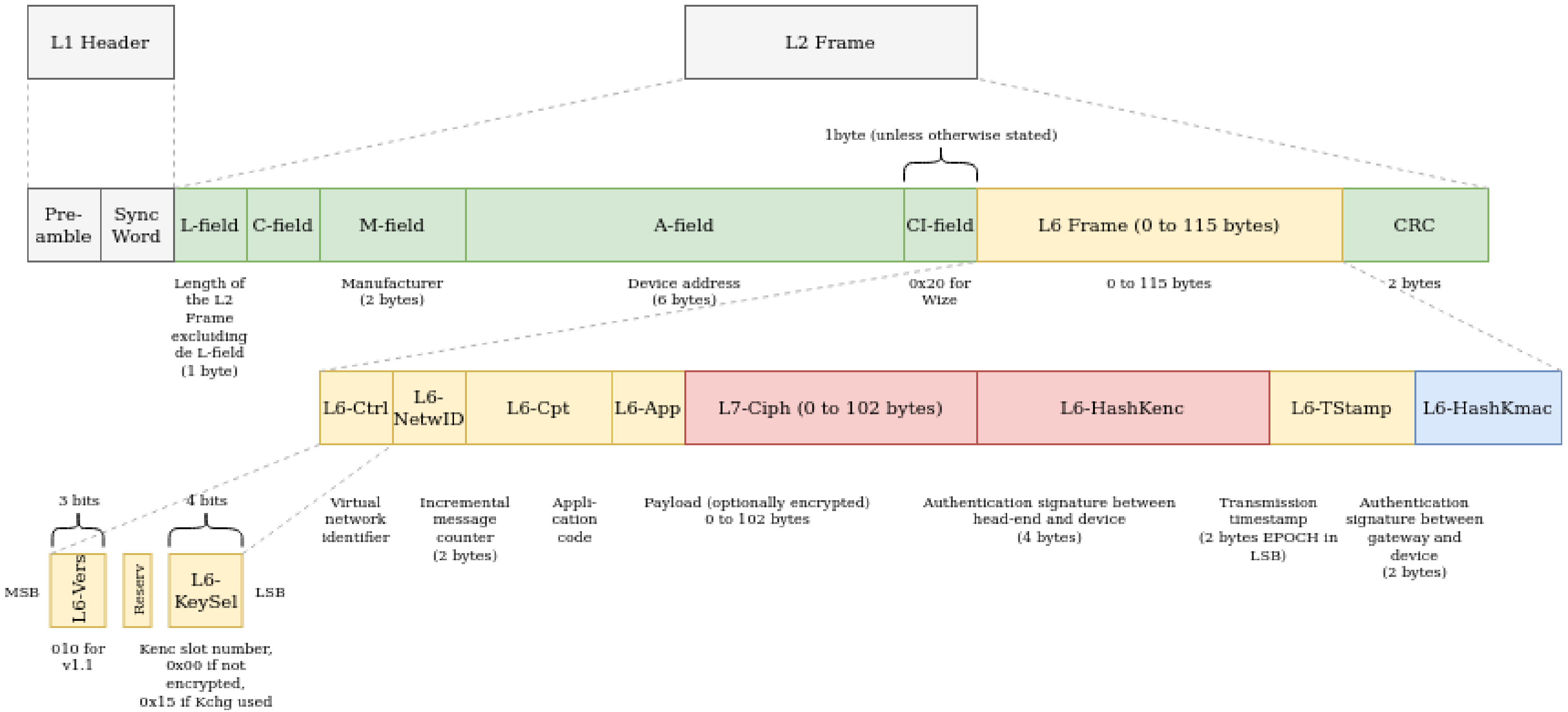


With downlink message:



AllWize

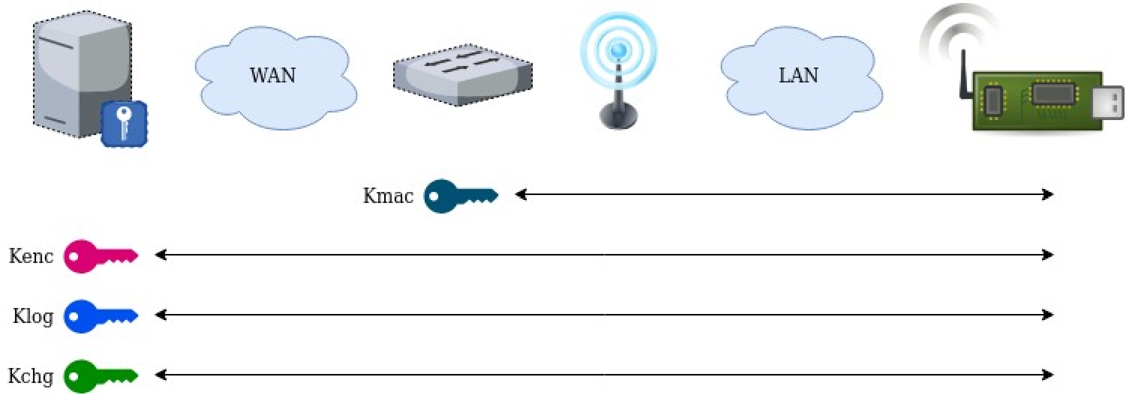
Wize Frame Format



Security

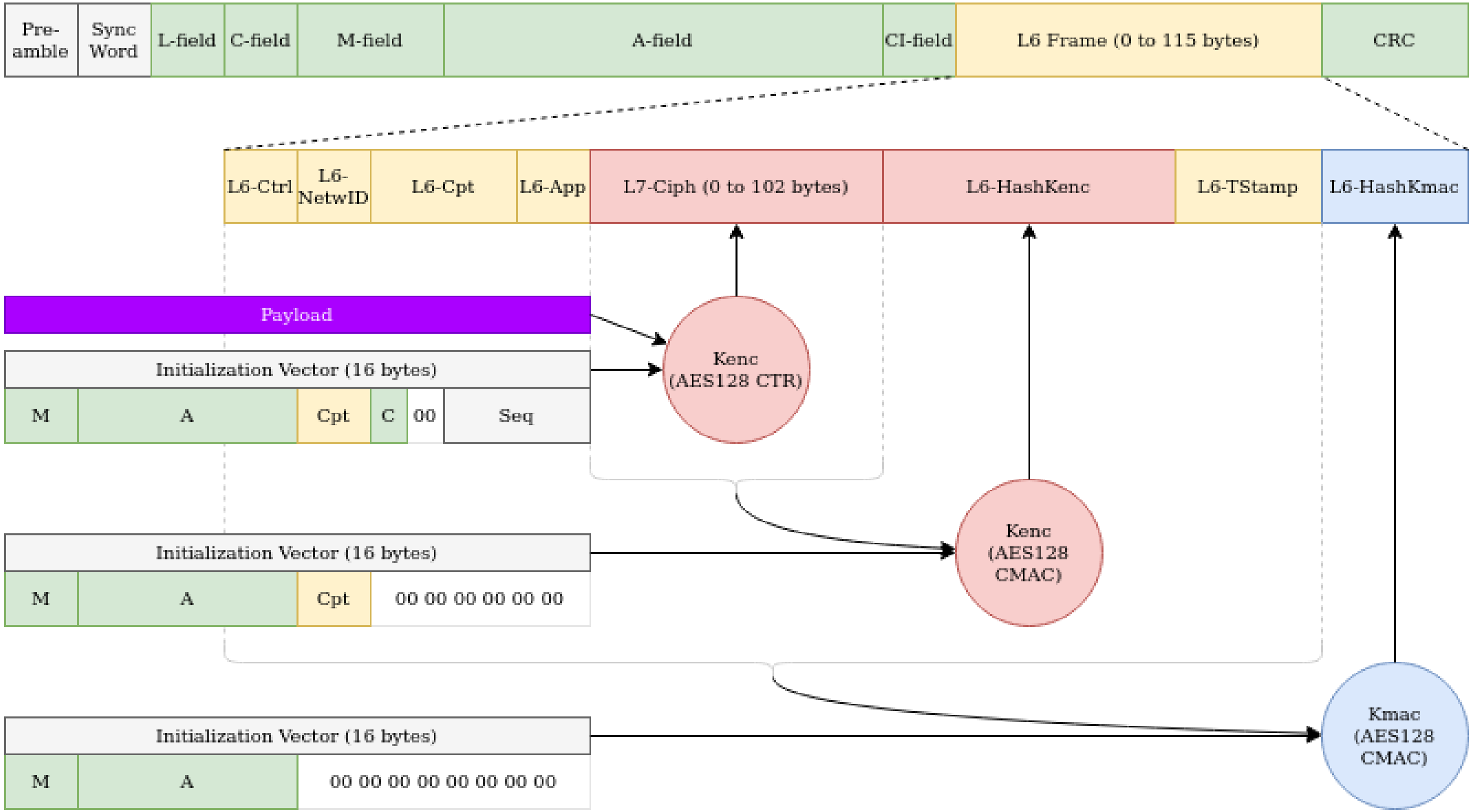
There are 4 different keys involved in a Wize Network security.

The network access authentication key (**Kmac**) between gateways and devices is associated with the network (**L6NetwId**), so there is one shared key for all elements in the same network.



The end-to-end authentication and ciphering is managed between the head-end system and the devices. For standard messages (DATA, COMMAND and RESPONSE) the involved key is the **Kenc**. Each device may have up to 14 different Kenc keys preconfigured and the key used is negotiated between the device and the head-end system using the **Kchg** key (this way the gateway can also update the Kenc keys in the device). For DOWNLOAD messages the key is replaced by a one-time use key (**Klog**).

Security


Pre-amble
Sync Word
L-field
C-field
M-field
A-field
CI-field
L6 Frame (0 to 115 bytes)
CRC
L6-Ctrl
L6-NetwID
L6-Cpt
L6-App
L7-Ciph (0 to 102 bytes)
L6-HashKenc
L6-TStamp
L6-HashKmac
Payload
Initialization Vector (16 bytes)
M
A
Cpt
C
00
Seq
Kenc (AES128 CTR)
Initialization Vector (16 bytes)
M
A
Cpt
00 00 00 00 00 00
Kenc (AES128 CMAC)
Initialization Vector (16 bytes)
M
A
00 00 00 00 00 00 00 00
Kmac (AES128 CMAC)

Application Layers

The standard defines 3 mandatory and 2 specific application layers (non-mandatory). Application codes are allocated by the Wize Alliance.

On top of that you can create your own application layers for your own use case. The 0xFE application code is available for testing devices.

The application is defined in the L6-App field in the Wize frame.

Application layer	Description	Code
APP-INSTALL	Connectivity test messages (INSTPING / INSTPONG)	0x01
APP-ADMIN	Device configuration and monitoring	0x02
APP-DOWNLOAD	Firmware Over the Air messages	N/A
	Reserved for future use	0x03 to 0x0F

Application layer	Description	
APP-METER-GAS	Gaz smart meters	Allocated by the Alliance
APP-METER-WTR	Water smart meters	
Custom	Your own application layer for your use case	0xFE

AllWize

COMMON APPLICATION LAYERS: APP_INSTALL

Handles **installation** and **commissioning**.

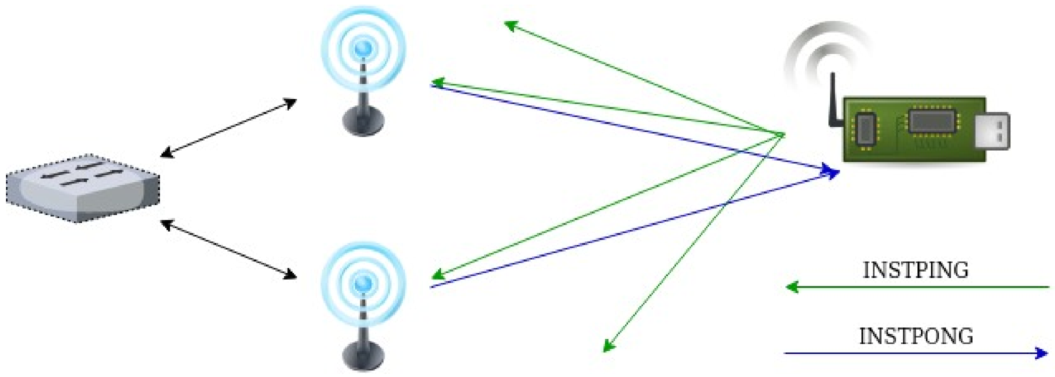
Negotiated between the devices and the gateway, the head-end system is not involved. Therefore, there is **authentication** via the Kmac key but **no encryption**.

PING request:

- L7DownChannel
- L7DownMod
- L7PingRxDelay
- L7PingRxLength

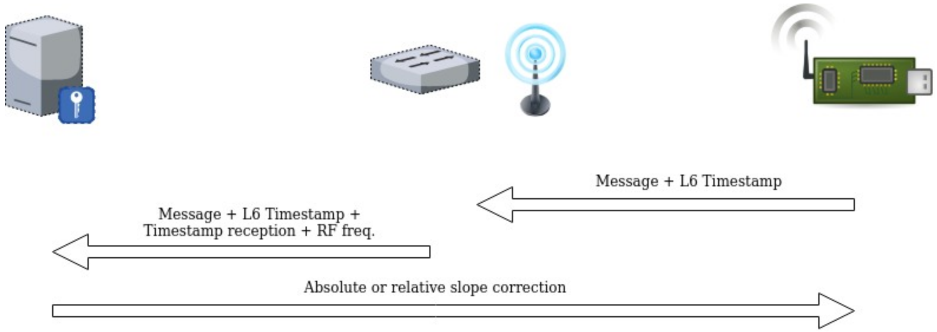
PONG response:

- L7ConcentId
- L7ModemId
- L7RSSI

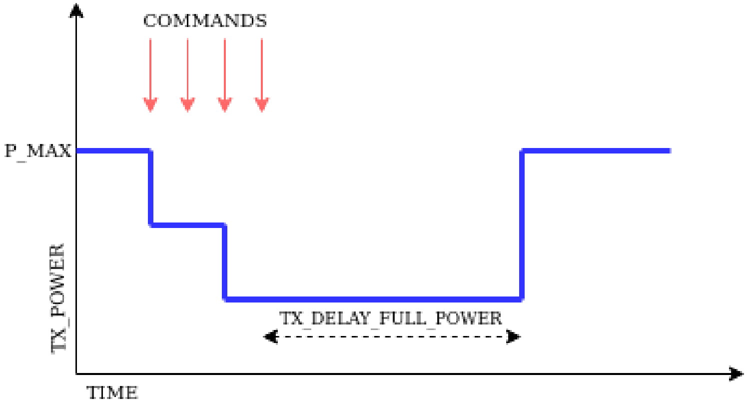


Common application layers: APP_ADMIN

Time and carrier frequency adjustment (corrects time drifts and lowers devices cost).



Dynamic (optional) device **transmission power** and **modulation datarate** adjustment with fallback.



Existing solutions

Hardware – Wize Compatible Transceivers

These are sub-GHz, Wize-compatible, integrated transceivers. You still have to **code the Wize stack** on top of it, but suppliers already have low level EN13757-4/N layers available. This is the most used approach at the moment.

Texas Instruments
CC1120

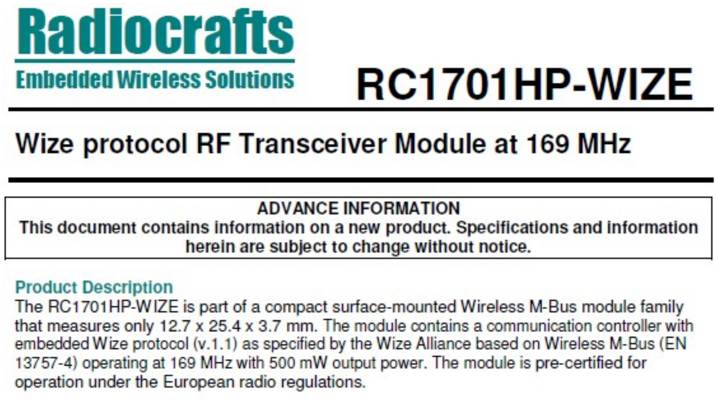
Analog Devices
ADF7030

Silicon Labs
SI4460

Silicon Labs
EFR32FG14

Hardware – Wize-Ready Chips & Modules

Wize-ready chips and modules, implementing the full Wize stack. Pushed by Suez (EFR32-based, already available), GRDF (STM32L4+ADF7030, 2020Q3, in collaboration with Alciom that's developing an OHL module called Wize'Up) and Radiocrafts (available since 2019).



Radiocrafts
Embedded Wireless Solutions

RC1701HP-WIZE

Wize protocol RF Transceiver Module at 169 MHz

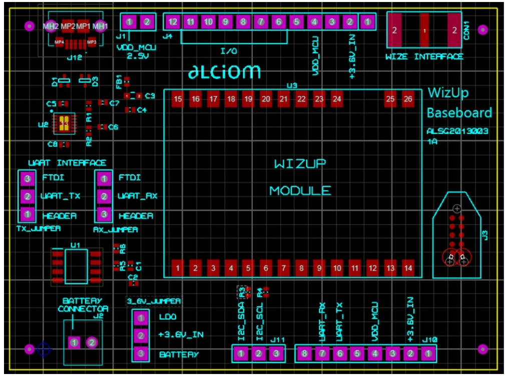
ADVANCE INFORMATION
This document contains information on a new product. Specifications and information herein are subject to change without notice.

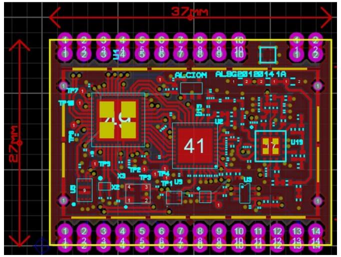
Product Description

The RC1701HP-WIZE is part of a compact surface-mounted Wireless M-Bus module family that measures only 12.7 x 25.4 x 3.7 mm. The module contains a communication controller with embedded Wize protocol (v.1.1) as specified by the Wize Alliance based on Wireless M-Bus (EN 13757-4) operating at 169 MHz with 500 mW output power. The module is pre-certified for operation under the European radio regulations.

Applications

- LPWAN
- Smart City
- Industrial IoT
- Utility meters (water, gas, electricity)
- Smart sensors





AllWize

Wize

Hardware - Products

sigrenEa
CONNECTIVITY FOR SMART RECYCLING

Enless Wireless
M2M & IoT Wireless Expert

SAGEMCOM

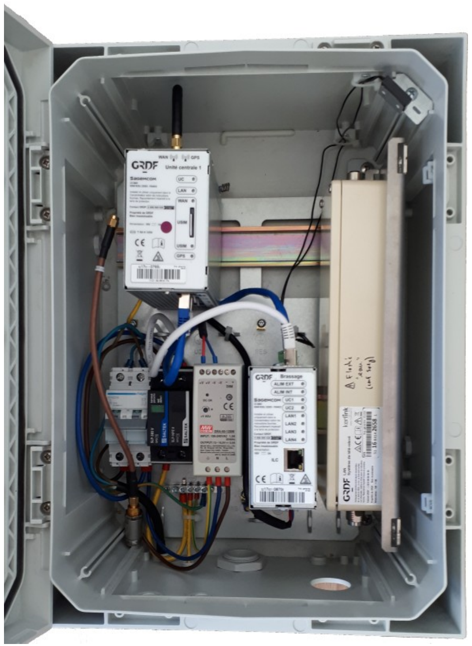
Itron

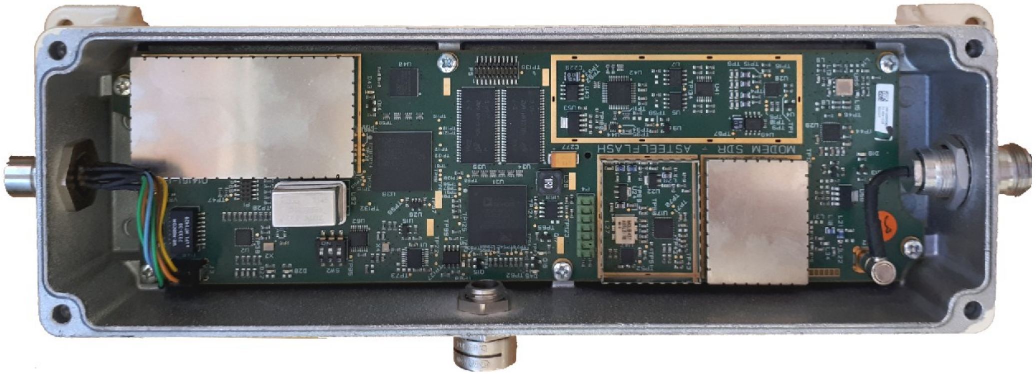
DIEHL
Metering

AllWize

Wize

Hardware - Gateways





suez

GRDF
GAZ RÉSEAU
DISTRIBUTION FRANCE

alciom

Sagemcom

kerlink
communication is everything

AllWize

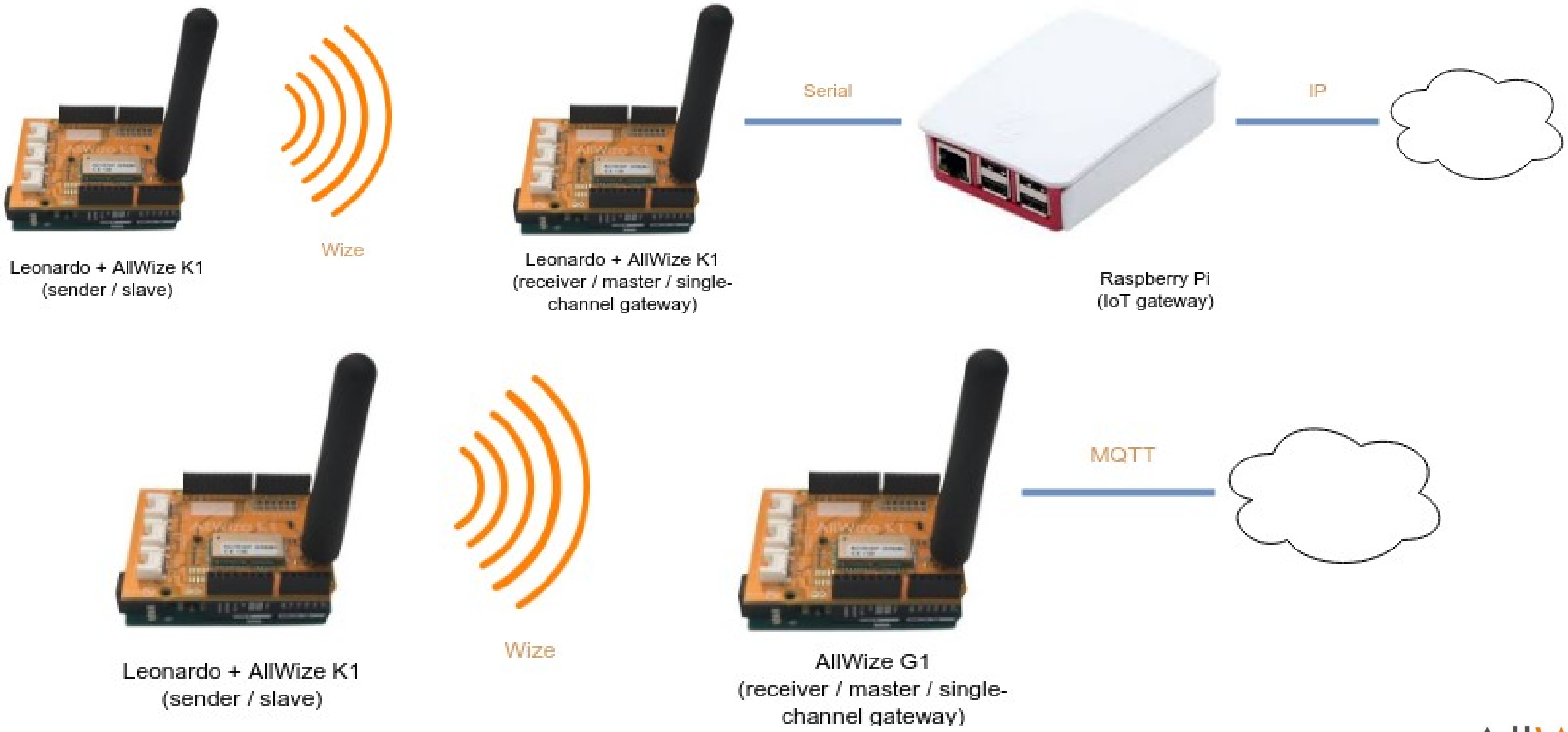
AllWize Hands-on Example

Hardware & Arch

AllWize K1 (revPB)

- Open Hardware
- Arduino Uno Shield
- MCP9701 temperature sensor
- RC1701HP-WIZE 169MHz radio module
- Grove™ connectors (digital, analog and I2C)
- SMA and iPEX antenna connectors

AllWize G1

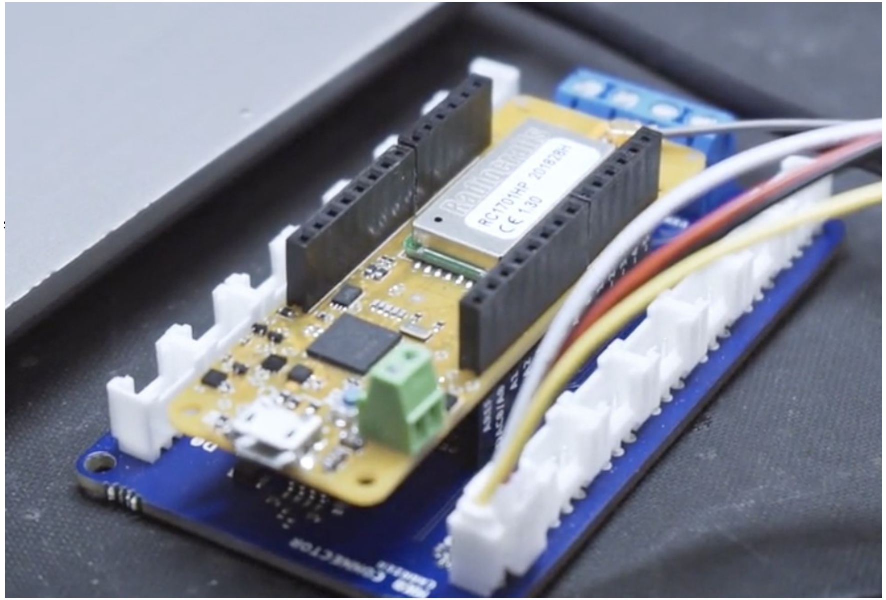


Wize

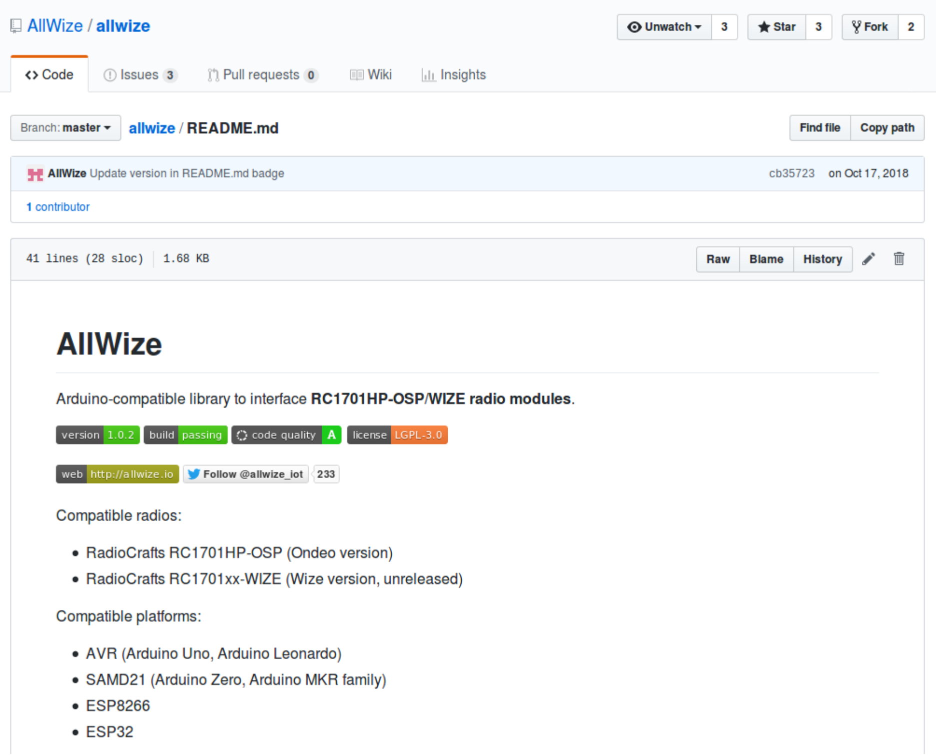
AllWize

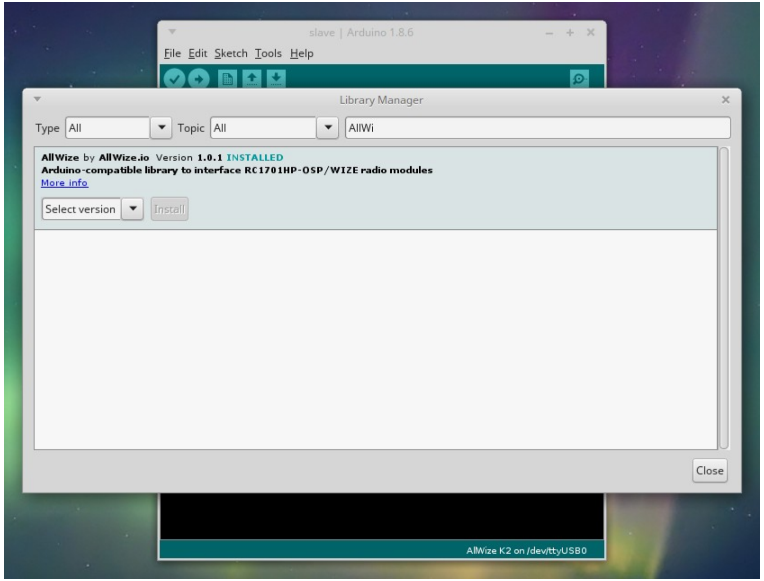
AllWize K2 (revPA)

- Open Hardware
- Inspired on MKR series by Arduino
- SAMD21 Cortex M0 32 bits ARM at 48MHz
- 256KB flash and 32KB SRAM
- 8xGPIO, 12xPWM, 1xUART, 1xSPI, 1xI2C, 7xADC, 1xDAC
- RTC
- RC1701HP-WIZE 169MHz radio module
- iPEX antenna connector

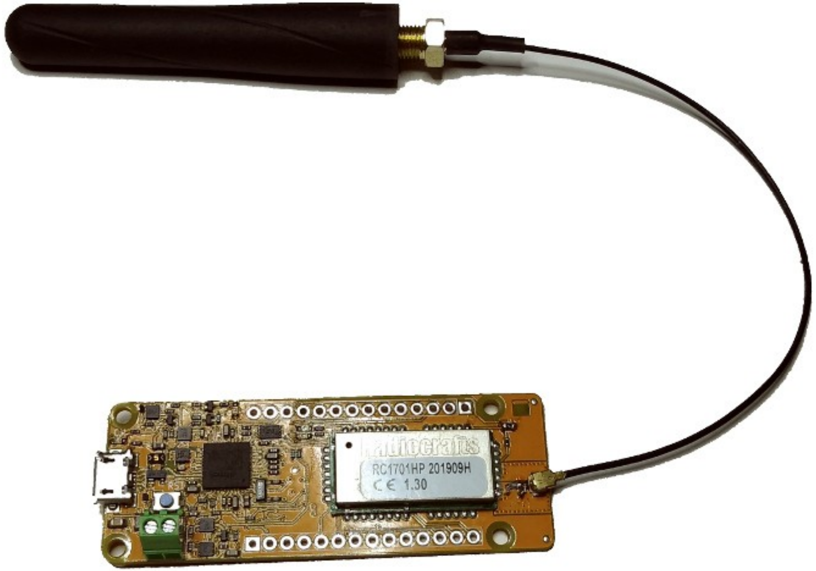


AllWize Library





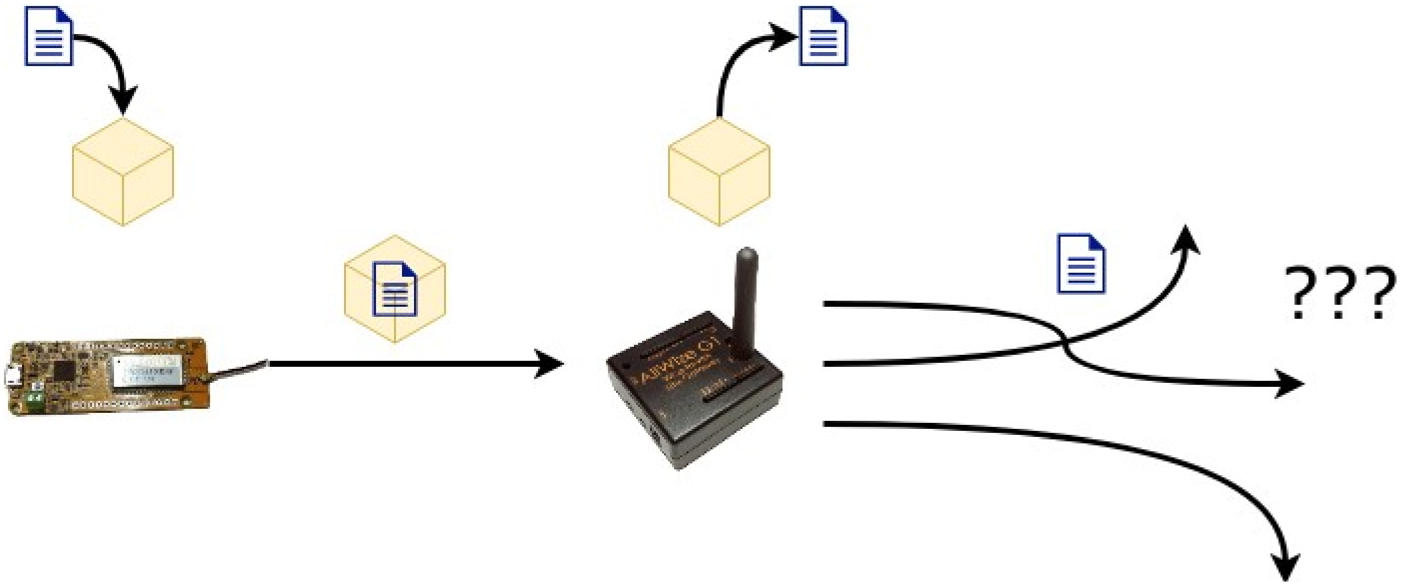
The Node



The Gateway

AllWize

Message Flow



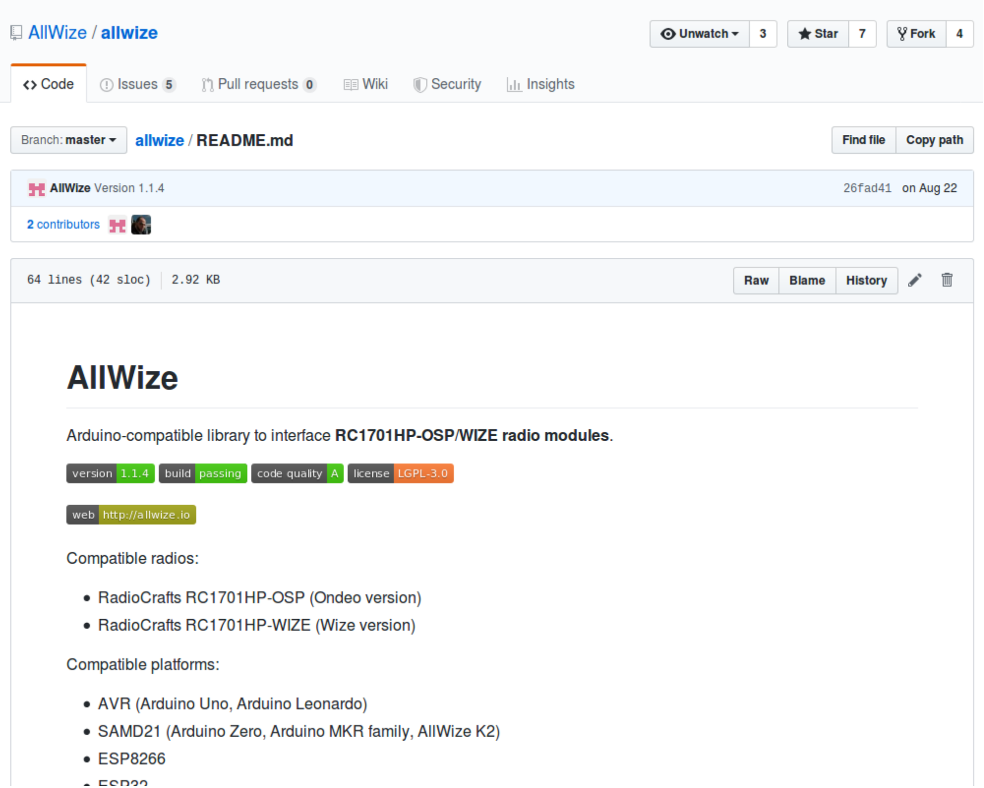
FIRMWARE & LIBS

REPOSITORY

We will be using examples from the AllWize library, so go ahead to

https://github.com/AllWize/allwize

Under “examples > lorawan” you can see the code we will be using for the gateway and node parts.

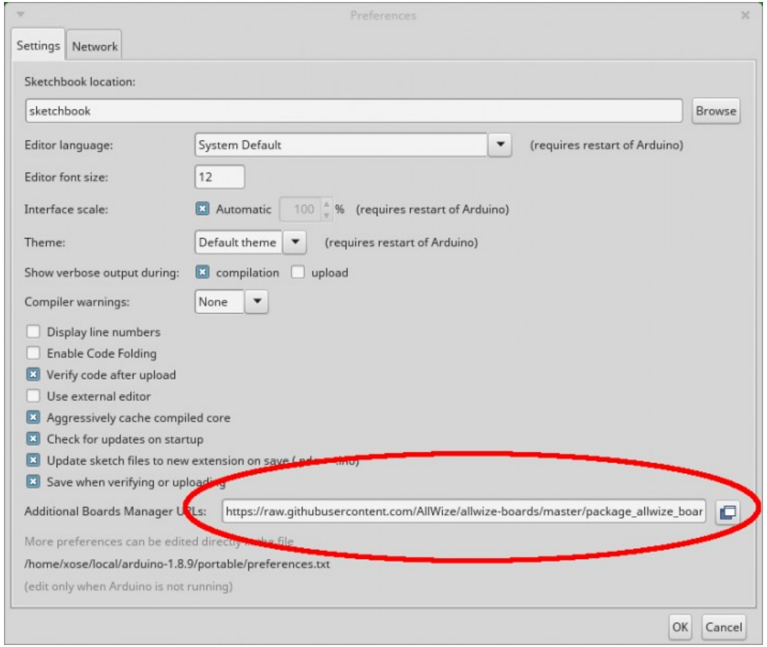


Support for the AllWize K2 in the Arduino IDE (1)

The Arduino IDE allows the user to define 3rd party board support via de “**Additional Boards Manager URLs**” field in the **Preferences** dialog.

It’s a comma-separated list of URLs pointing to board definitions in JSON format.

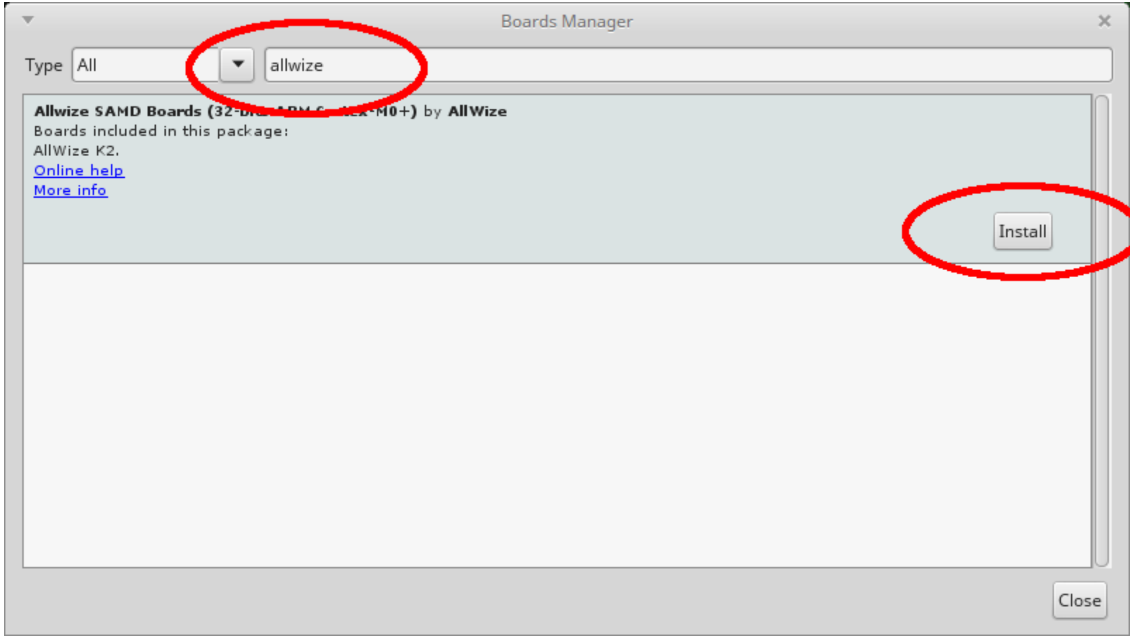
You will need to first add this URL to the Additional Boards Manager URLs field:



https://raw.githubusercontent.com/AllWize/allwize-boards/master/package_allwize_boards_index.json

Support for the AllWize K2 in the Arduino IDE (2)

Now open the Boards Manager dialog and search for **official SAMD boards support** and for the **AllWize Boards support** and install both.



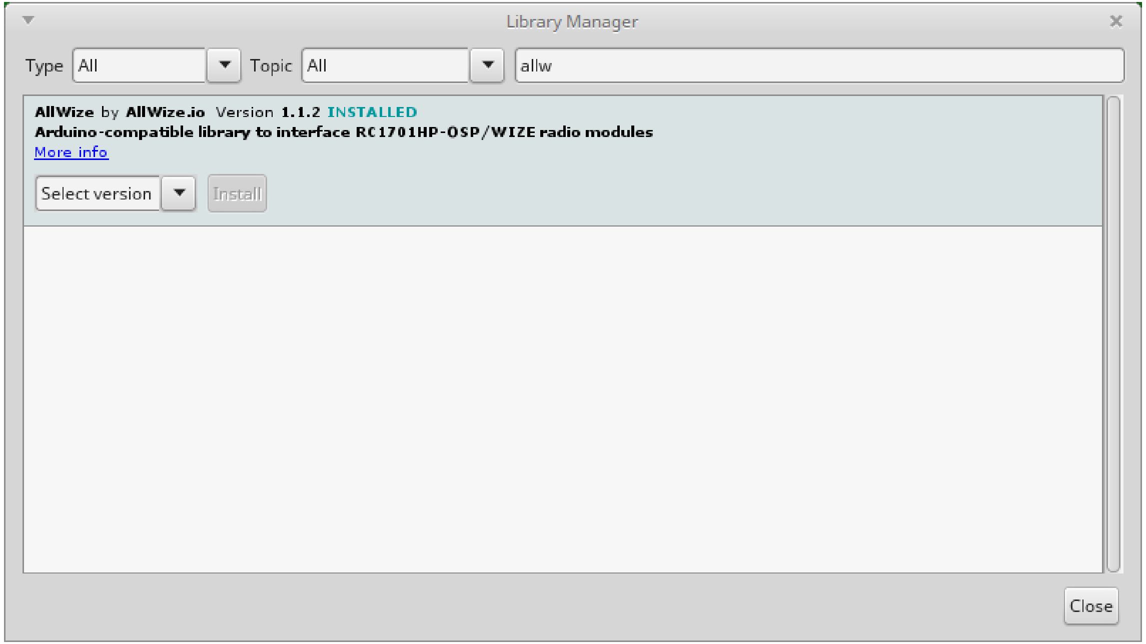
AllWize

AllWize Library et al.

Finally, install the libraries we will need. Do it from the Library Manager in the same IDE. You will need to install the following libraries:

- AllWize
- CayenneLPP
- MBUSPayload
- ArduinoJSON
- Sensor libraries

We will also need the AsyncMqttClient and its dependencies for the gateway (from ZIPs).



CODE

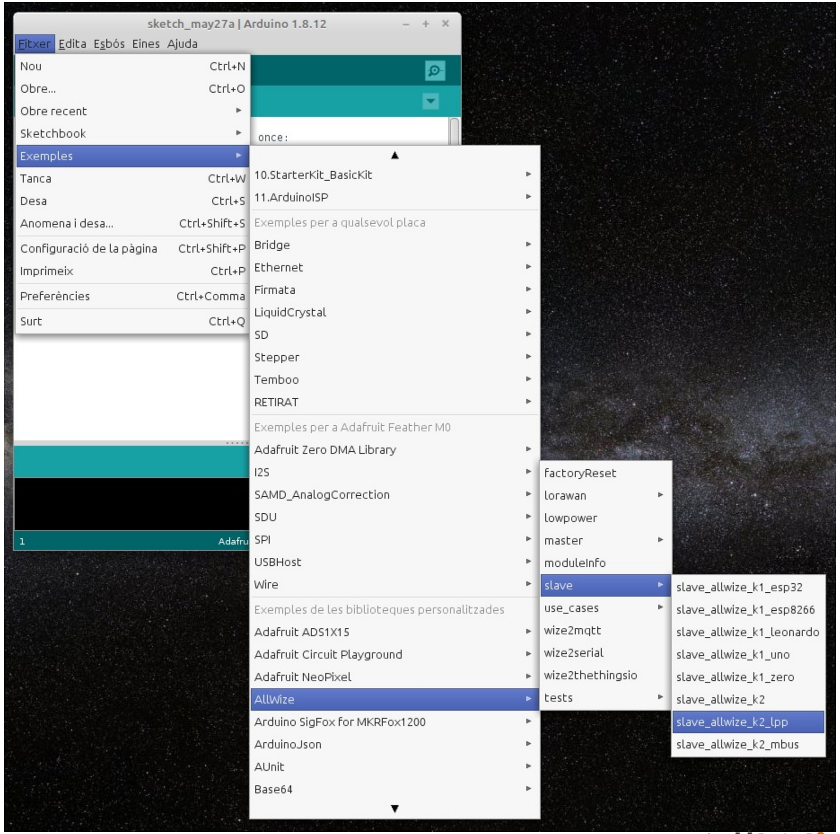
Wize Workshop code

https://github.com/AllWize/allwize-training

Wize Node Code Example

Just checkout the repository (or download it as a ZIP and uncompress it), and open the 'code/sensor/sensor.ino' file with the Arduino IDE.

You can also check other examples for the AllWize library from the IDE Examples menu.



Wize Node Code Example

Project dependencies

```
#include "AllWize.h"
#include "CayenneLPP.h"
```

Board configuration

```
#if defined(ARDUINO_AVR_LEONARDO)
	#define RESET_PIN		7
	#define MODULE_SERIAL	Serial1
	#define DEBUG_SERIAL	Serial
#endif // ARDUINO_AVR_LEONARDO

#if defined(ARDUINO_ALLWIZE_K2)
	#define RESET_PIN		7
	#define MODULE_SERIAL	SerialWize
	#define DEBUG_SERIAL	SerialUSB
#endif // ARDUINO_ALLWIZE_K2
```

Wize-LoRaWAN Node Code Example

Wize radio configuration

```
#define WIZE_CHANNEL        CHANNEL_04
#define WIZE_POWER          POWER_20dBm
#define WIZE_DATARATE       DATARATE_2400bps
#define WIZE_UID            0x20212223
```

Instances

```
AllWize allwize(&MODULE_SERIAL, RESET_PIN);
CayenneLPP lpp(16);
```

Wize Node Code Example

Wize radio setup

```
// Init AllWize object
allwize.begin();
if (!allwize.waitForReady()) {
	DEBUG_SERIAL.println("[WIZE] Error connecting to the module, check your wiring!");
	while (true);
}

// WIZE radio settings
allwize.slave();
allwize.setChannel(WIZE_CHANNEL, true);
allwize.setPower(WIZE_POWER);
allwize.setDataRate(WIZE_DATARATE);
allwize.setUID(WIZE_UID);
```

Wize Node Code Example

Sending

```
// Payload
lpp.reset();
lpp.addTemperature(1, getTemperature());
lpp.addRelativeHumidity(2, getHumidity());
lpp.addBarometricPressure(3, getPressure());

// Send the payload
if (!allwize.send(lpp.getBuffer(), lpp.getSize(), LORAWAN_PORT)) {
    DEBUG_SERIAL.println("[WIZE] Error sending message");
}
```

Wize to MQTT Gateway Code

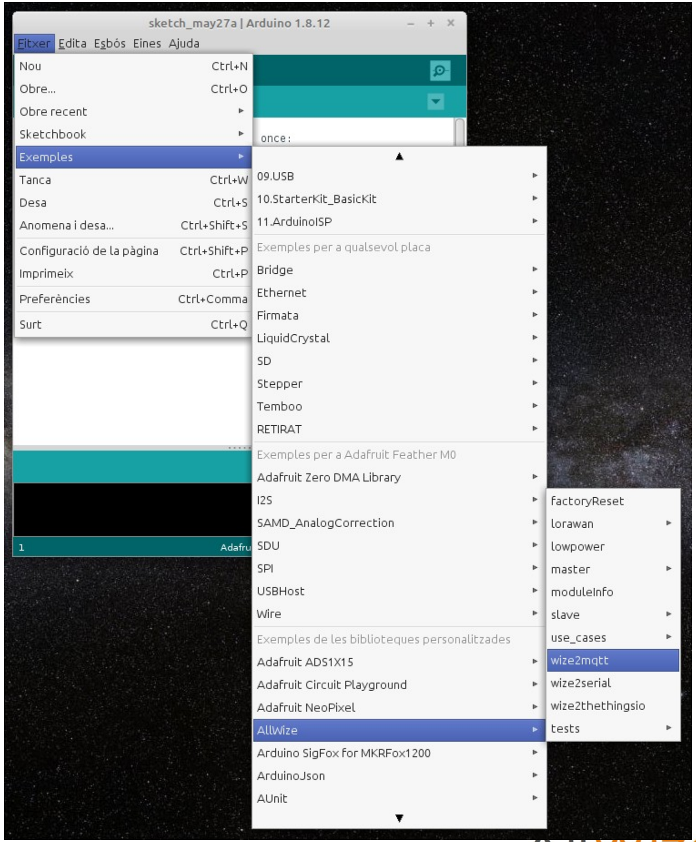
Now we will need the code for the gateway. The code implements a Wize to MQTT gateway over an ESP8266 board.

We will first have to install support for ESP8266 boards in the Board Manager.

The select the “AllWize > wize2mqtt” example from the IDE.

We will need to rename the “configuration.h.sample” file to “configuration.h” and edit its contents to match our setup.

The same code is under “code/gateway” folder in the training repository.



Wize to MQTT Gateway Code

The gateways code manages:

- WiFi connection
- Wize radio in master (receiver) mode
- MQTT forwarder
  - PING

```
[MQTT] Sending: gateway/482412345678/ping => {"gateway":
"mid":"4824","uid":"12345678","sn":"0000000000000000"}}
```

  - DATA

```
[WIZE] ADDR: 0x20212223, RSSI: -42, DATA: 026700A00368A6047326A205880651F70053340003E8
[MQTT] Sending: gateway/482412345678/uplink => {"app":254,"net":16,"uid":"20212223","cpt":13,"metadata":
{"ch":4,"freq":169.4438,"dr":2400,"toa":73.33334},"gateway":
{"mid":"4824","uid":"12345678","sn":"0000000000000000","rssi":-
42},"payload":"026700A00368A6047326A205880651F70053340003E8","fields":
{"temperature":16,"humidity":83,"pressure":989,"latitude":41.4199,"longitude":2.13,"altitude":10}}
```

MQTT Messages


```
gateway/482412345678/ping
{
  "gateway": {
    "mid": "4824",
    "uid": "12345678",
    "sn": "0000000000000000"
  }
}
```

```
gateway/482412345678/uplink
{
  "app": 254,
  "net": 16,
  "uid": "20212223",
  "cpt": 15,
  "metadata": {
    "ch": 4,
    "freq": 169.4438,
    "dr": 2400,
    "toa": 73.33334
  },
  "gateway": {
    "mid": "4824",
    "uid": "12345678",
    "sn": "0000000000000000",
    "rssi": -42
  },
  "payload": "026700B90368620473266405880651F70053340003E8",
  "fields": {
    "temperature": 18.5,
    "humidity": 49,
    "pressure": 982.8,
    "latitude": 41.4199,
    "longitude": 2.13,
    "altitude": 10
  }
}
```

Current Limitations

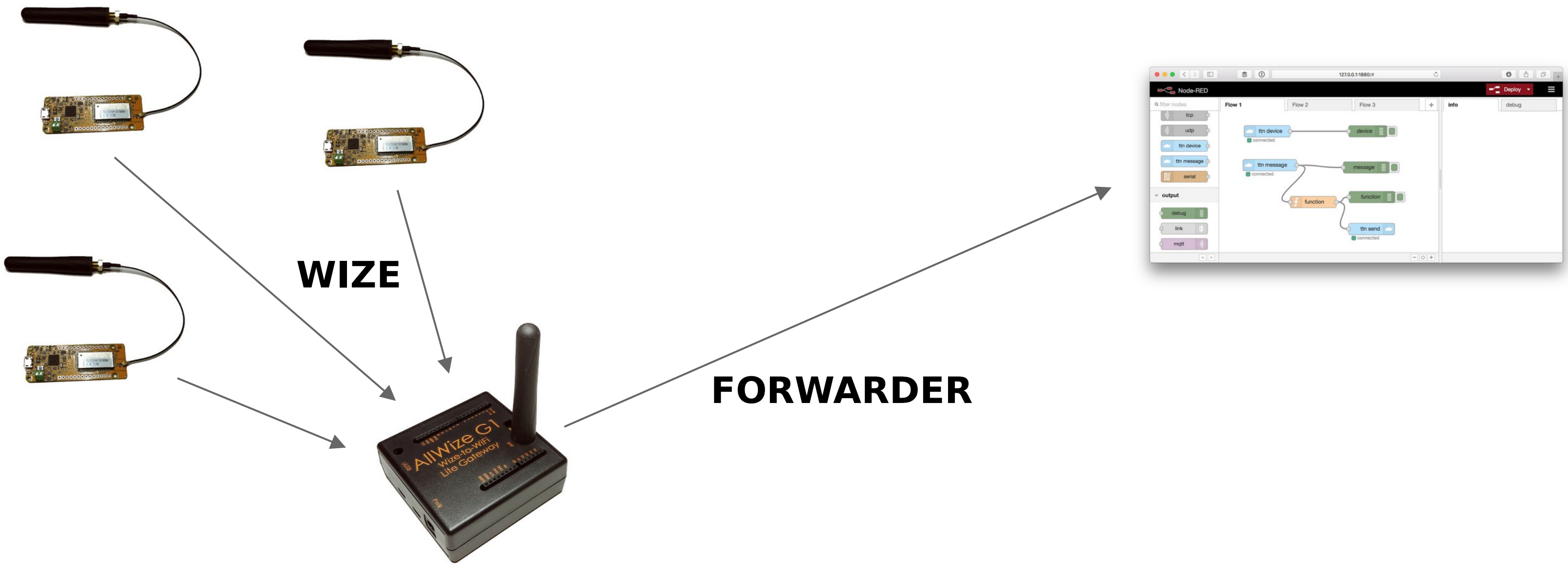
The Proof of Concept has some limitations as of today:

- We are using a **single channel gateway**
- It **only supports uplinks** at the moment

This means:

- There could be packet collisions since there is no orthogonality
- No downlink means we can't implement ACKs
- No downlink means we can't use actuators

And now what?



Wize

AllWize