IoT & IPv6

IoT: IPv6 of Things

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2019

Outline

- Introduction to IoT
- IoT-IPv6 in the IETF
- Cases in Latinoamérica

"...So we had a 32-bit address was allowed 4.3 billion terminations which I thought in 1974 was enough to do the **EXPERIMENT** and I honestly thought that if it worked if the Internet idea actually worked that we would then build a **PRODUCTION** version of it and what happened is that it got loose into the use and then you know we have been using the **EXPERIMENTAL** Internet design since 1983 when we turned it on so in 2012 we turned on IPv6 and everywhere where it was capable of being run that's the **PRODUCTION** internet so you know **GET YOUR v6 IN PLACE SO YOU CAN RUN THE 21st CENTURY** version of the INTERNET..."

So,

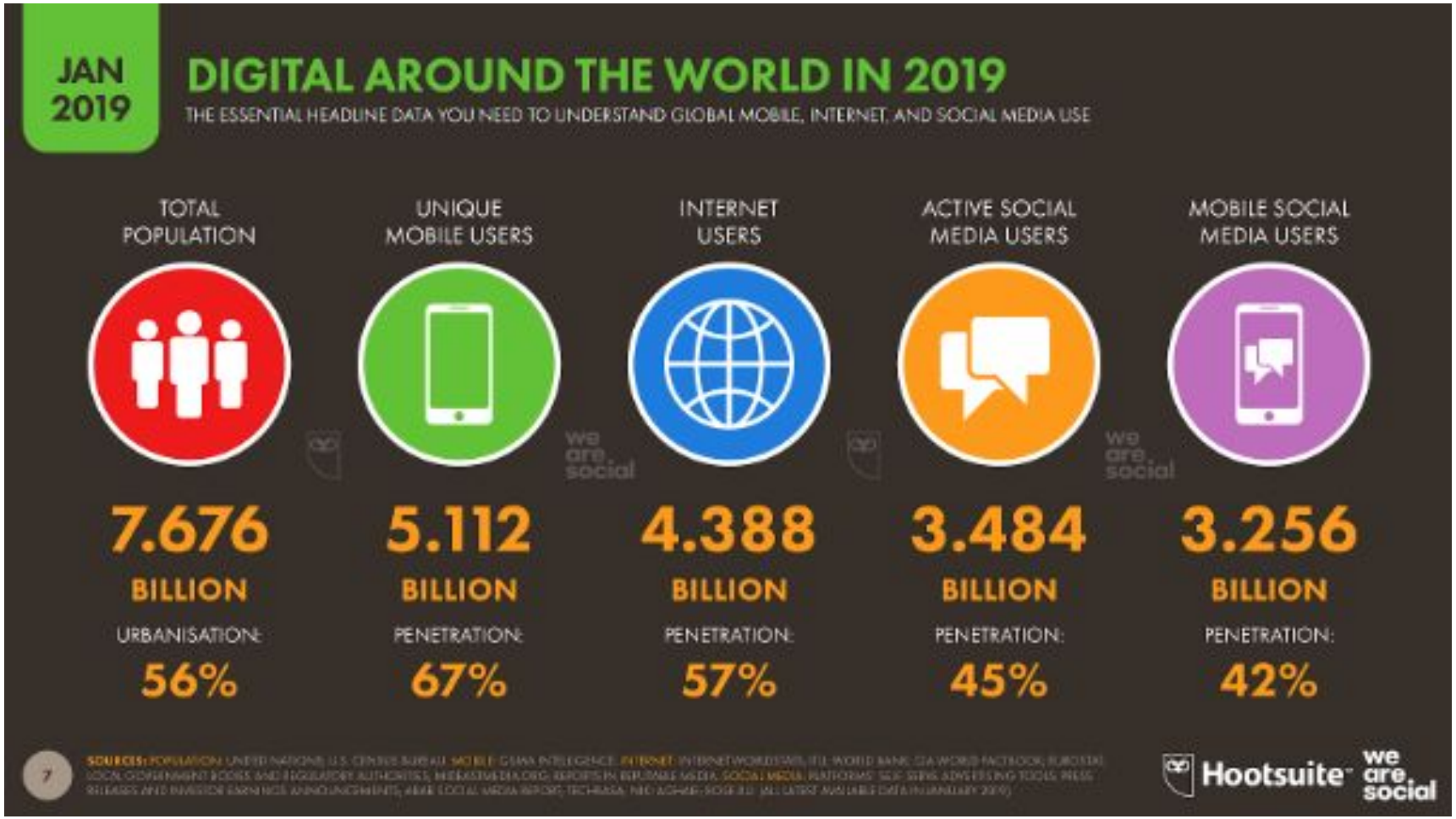
IPv4 → **BETA** version of Internet

IPv6 → **PRODUCTION** version of Internet

Hangout with Vint Cerf

https://youtu.be/17GtmwyvmWE

So, which is the current status?



https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates

Current work in standardization

Internet Engineering Task Force (IETF) — S. Deering, Retired
Request for Comments: 8200 — R. Hinden, Check Point Software
STD: 86
Obsoletes: 2460
Category: Standards Track — July 2017
ISSN: 2070-1721

Internet Protocol, Version 6 (IPv6) Specification

IETF released new version in 2017 as an **Internet Standard (STD)**

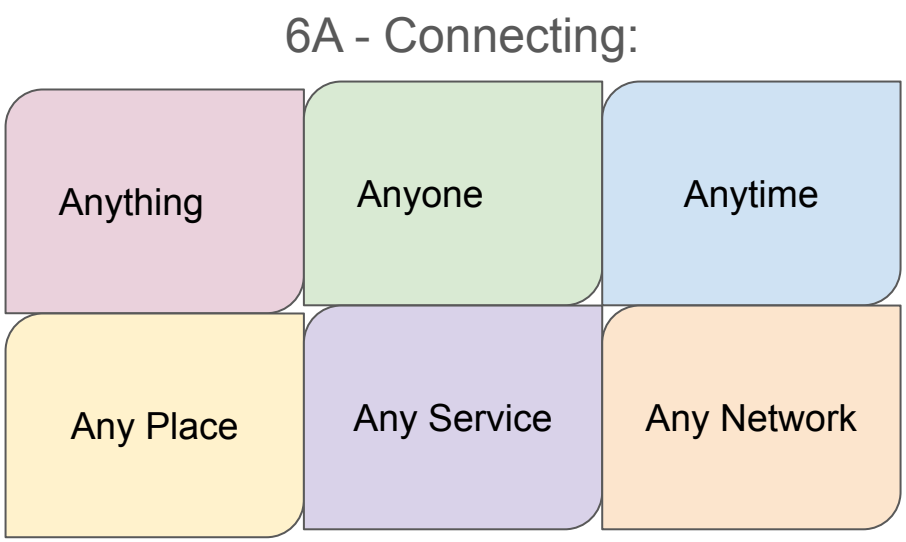
“The IETF is constantly working to clarify documents, and remove ambiguities that arise from real-life experiences. The transition from Draft Standard to Internet Standard represents such a clarification.”

Now, which is the role of IPv6 in the Internet of the Future?

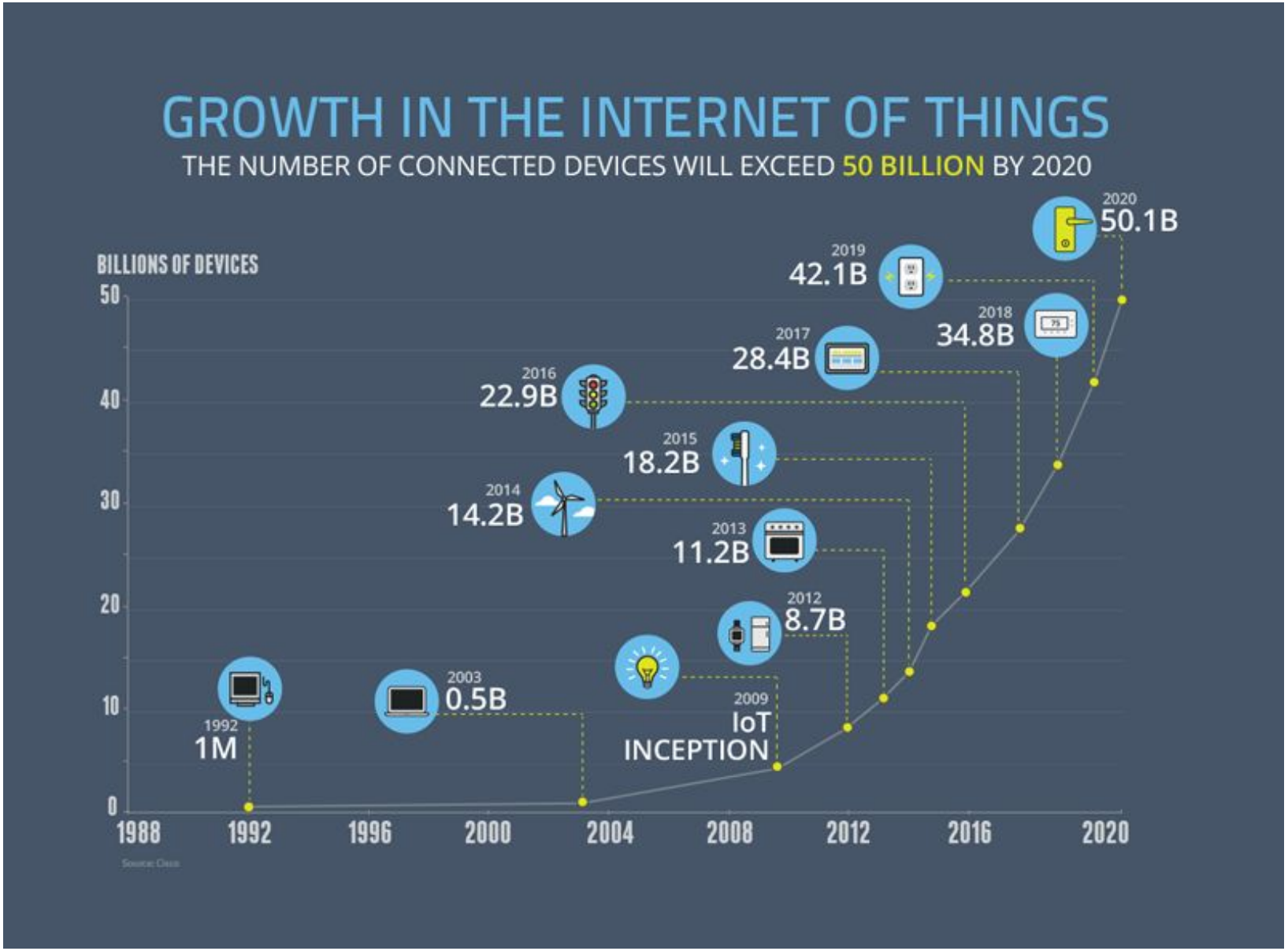
"Internet of Things" (IoT)

"Internet of Things" (IoT):

- “Everything that can be connected will be connected to Internet”.



http://4.bp.blogspot.com/-QK1xQB5VOs4/VDV9vlD7IjI/AAAAAAAAD6Y/7VOnwsUy7Go/s1600/IoT_Connecting_6.png



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http://theconnectivist-img.s3.amazonaws.com/wp-content/uploads/2014/05/Unknown.png

IPv6 over Constrained Node Networks (6lo) Applicability & Use cases -- draft-ietf-6lo-use-cases-05

- **Smart Home**
- **Smart Building**
- **Smart Health**
- **Smart City**
- **Smart Agriculture**

http://www.realtor.com/news/trends/where-to-look-for-smart-homes/

To be able to connect all type of devices to Internet.

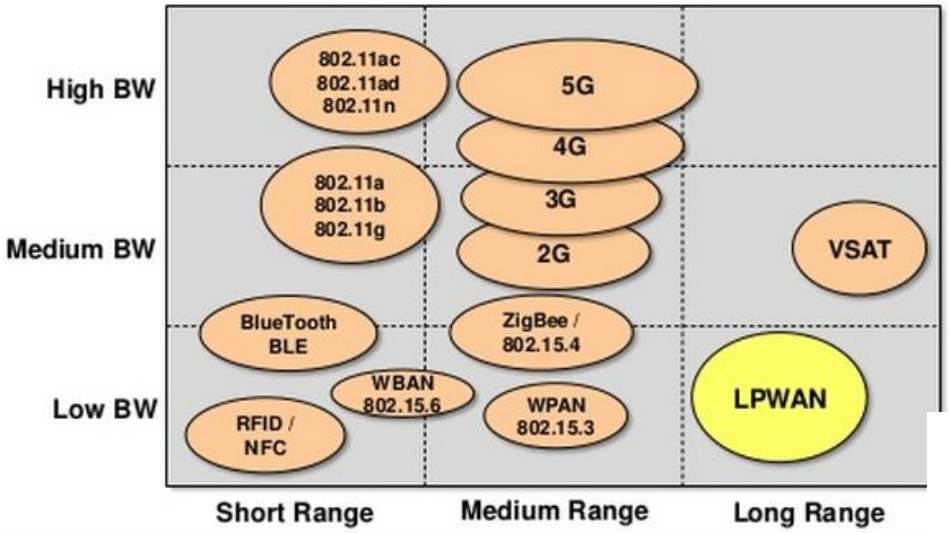
- Connected heterogeneous devices to Internet in heterogeneous networks => **Internet of Things (IoT)**
- Heterogeneous devices: devices with different type of constraints

Name	data size (e.g., RAM)	code size (e.g., Flash)
Class 0, C0	<< 10 KiB	<< 100 KiB
Class 1, C1	~ 10 KiB	~ 100 KiB
Class 2, C2	~ 50 KiB	~ 250 KiB

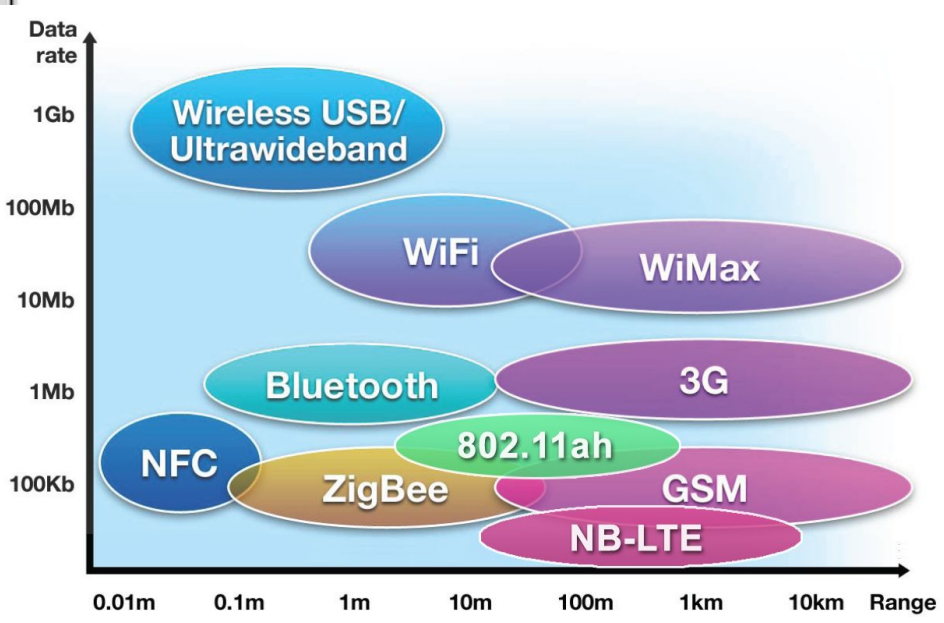
Classes of Constrained Devices (KiB = 1024 bytes) [RFC7228]

- Heterogeneous networks: networks with different type of constraints, e.g. high packet loss, low achievable bitrate/throughput, etc.

IoT connect objects to different BW and range



Source: google search



http://embedur.com/blogsandnews/Is-80211ah-a-contender-for-low-power-IoT.html

So, why IPv6 for IoT?

Since we are going to connect high amount of devices we need a protocol that has available high amount of IP addresses => IPv6

- IETF wanted to transmit IPv6 packets over 802.15.4 networks (WSN - Wireless Sensor Networks)
- 802.15.4 has a packet with MTU 127 bytes.
- IPv6 has MTU de 1280 bytes.

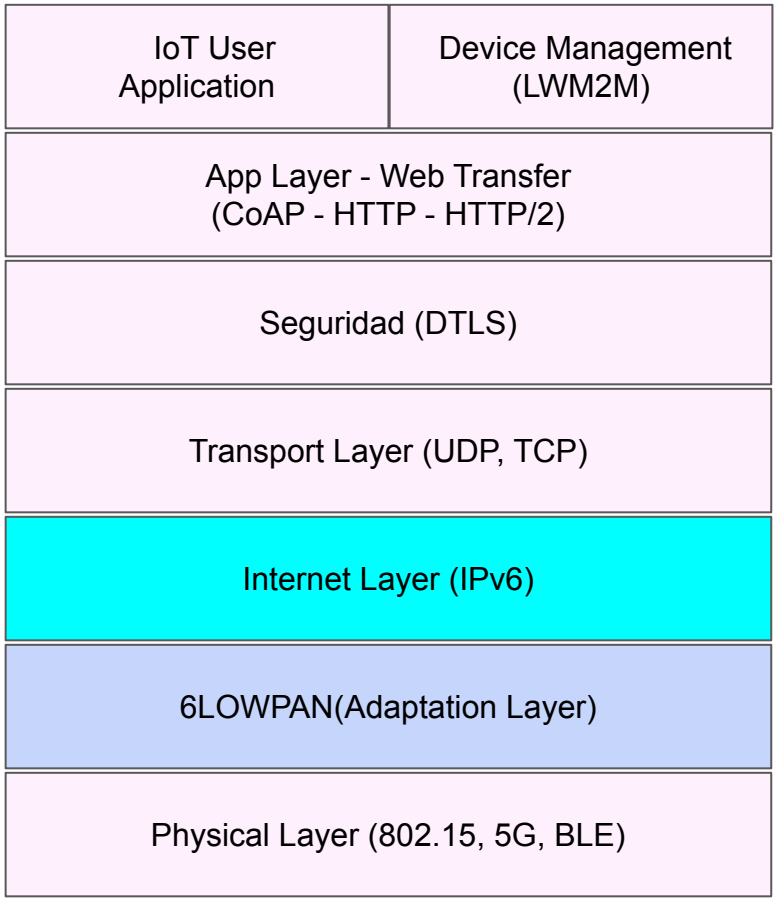
SOLUTION????

-

Source: google search

6LoWPAN: IPv6 over Low-Power Wireless Personal Area Networks.

- 6LoWPAN is an adaptation layer developed in the IETF.
- 6LoWPAN compress the IPv6 header (RFC4944, RFC6282), UDP header (RFC 6282)



Compression Method - **LoWPAN_IPHC** assumes:

Version is 6

Traffic Class and Flow Label are both zero

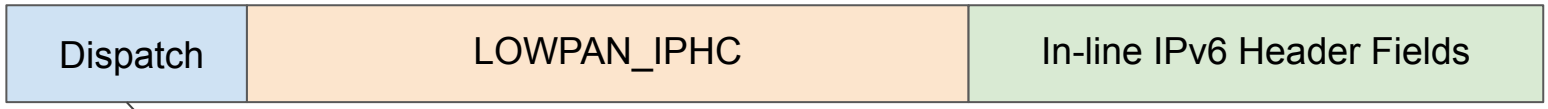
Payload Length can be inferred from lower layers from either the 6LoWPAN Fragmentation header or the IEEE 802.15.4 header;

Hop Limit will be set to a well-known value by the source

The addresses assigned to 6LoWPAN interfaces will be formed using the link-local prefix or a small set of routable prefixes assigned to the entire 6LoWPAN

Addresses assigned to 6LoWPAN interfaces are formed with an IID derived directly from either the 64-bit extended or the 16-bit short IEEE 802.15.4 addresses.

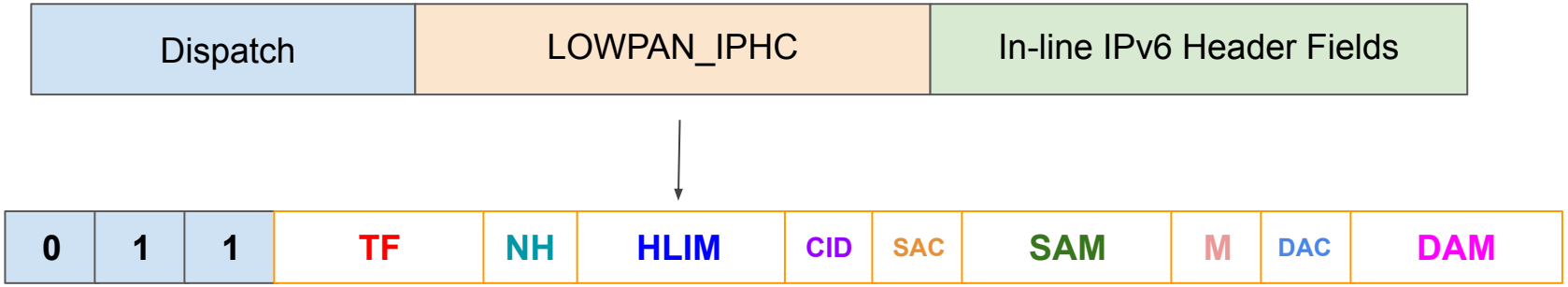
LOWPAN_IPHC Header



Bit Pattern	Page	Header Type	Reference
00 xxxxxx	0	NALP	[RFC4944][RFC8025]
00 xxxxxx	1-14	Unassigned	
00 xxxxxx	15	Reserved for Experimental Use	[RFC8025]
01 000000	0	ESC	[RFC6282]
01 000000	1-14	Unassigned	
01 000000	15	Reserved for Experimental Use	[RFC8025]
01 000001	0	IPv6 - uncompressed IPv6 Addresses	[RFC4944][RFC8025]
01 000001	1-14	Unassigned	
01 000001	15	Reserved for Experimental Use	[RFC8025]
01 000010	0	LOWPAN_HC1 - LOWPAN_HC1 compressed IPv6	[RFC4944][RFC8025]
01 000010	1-14	Unassigned	
01 000010	15	Reserved for Experimental Use	[RFC8025]
01 000011	0	LOWPAN_DFF	[RFC6971][RFC8025]
01 000011	1-14	Unassigned	
01 000011	15	Reserved for Experimental Use	[RFC8025]
01 000100 through 01 001111	0-14	Unassigned	
01 000100 through 01 001111	15	Reserved for Experimental Use	[RFC8025]
01 010000	0	LOWPAN_BC0 - LOWPAN_BC0 broadcast	[RFC4944][RFC8025]
01 010000	1-14	Unassigned	
01 010000	15	Reserved for Experimental Use	[RFC8025]
01 010001 through 01 011111	0-14	Unassigned	
01 010001 through 01 011111	15	Reserved for Experimental Use	[RFC8025]
01 1xxxxx	0-1	LOWPAN_IPHC	[RFC6282][RFC8025]
01 1xxxxx	2-14	Unassigned	
01 1xxxxx	15	Reserved for Experimental Use	[RFC8025]
10 xxxxxx	0	MESH - Mesh header	[RFC4944][RFC8025]
10 0xxxxx	1	for Critical 6LoWPAN Routing Headers	[RFC8138]
10 1xxxxx	1	for Elective 6LoWPAN Routing Headers	[RFC8138]
10 xxxxxx	2-14	Unassigned	
10 xxxxxx	15	Reserved for Experimental Use	[RFC8025]
11 000xxx	0	FRAG1 -- Fragmentation Header (first)	[RFC4944][RFC8025]
11 000xxx	1-14	Unassigned	
11 000xxx	15	Reserved for Experimental Use	[RFC8025]
11 001000 through 11 011111	0-14	Unassigned	
11 001000 through 11 011111	15	Reserved for Experimental Use	[RFC8025]
11 100xxx	0	FRAGN -- Fragmentation Header (subsequent)	[RFC4944][RFC8025]
11 100xxx	1-14	Unassigned	
11 100xxx	15	Reserved for Experimental Use	[RFC8025]
11 101000 through 11 101111	0-14	Unassigned	
11 101000 through 11 101111	15	Reserved for Experimental Use	[RFC8025]
11 11xxxx	0-15	Page switch	[RFC8025]

http://www.iana.org/assignments/_6lowpan-parameters/_6lowpan-parameters.xhtml#lowpan_nhc

LOWPAN_IPHC Header



TF: Traffic Class, Flow Label

NH: Next Header

HLIM: Hop Limit

CID: Context Identifier Extension

SAC: Source Address Compression

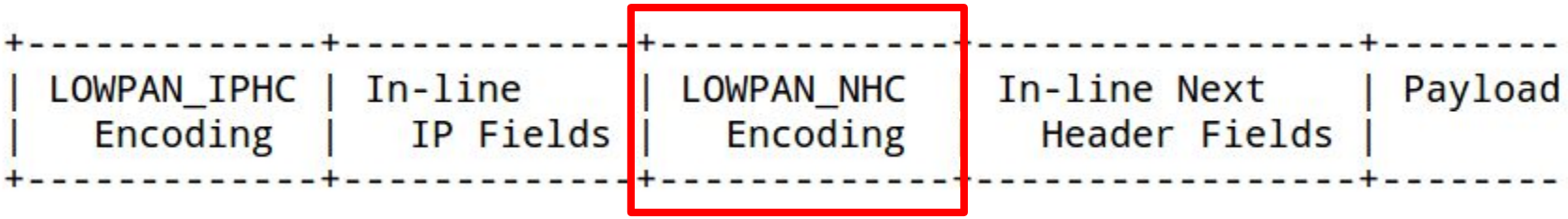
SAM: Source Address Mode

M: Multicast Compression

DAC: Destination Address Compression

DAM: Destination Address Mode

LOWPAN_NHC



Typical LOWPAN_IPHC/LOWPAN_NHC Header Configuration

IETF Working Groups supporting IPv6 for IoT

- IPv6 over Networks of Resource-constrained Nodes (6lo)
- Routing Over Low power and Lossy networks (roll)
- IPv6 over the TSCH mode of IEEE 802.15.4e (6tisch)
- IPv6 over Low Power Wide-Area Networks (lpwan)

So, what is next?

“Prepare to do business with things as they become customers”

[Leading the IoT - Gartner Insights on How to Lead in a Connected World - 2017]

And they will need an IPv6!!

JUNE 6th IPv6 Day

lacnic webinars

IoT/IPv6 Uses Cases: Real deployments and applications

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UTN FRM
Mendoza - Argentina

IoT/IPv6 Uses Cases:

Save the Peaches

IoT Uses Cases: Save the Peaches

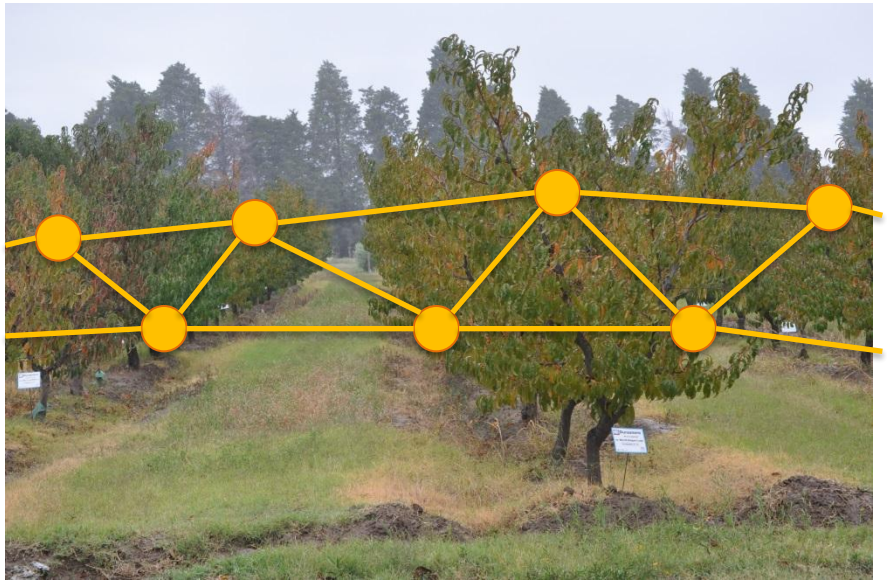
- Predicting Frost Event in Peaches Orchad
  - UTN (Argentina)
  - UDP (Chile)
  - INRIA (Francia)
  - INTA (Argentina)

- Objetivos
  - Predicción localizada de las heladas mediante la construcción de un modelo de aprendizaje automático a partir de datos microclimáticos de una red de sensores
  - Instalar un prototipo de red de sensores para medir las variables climáticas involucradas
  - Realizar campañas de medición e instalación

www.savethepeaches.com

Real Time Monitoring System

state-of-the-art



proposed solution

- •air temp
- •air RH
- •soil temp
- •soil moisture

1. A low-power wireless sensor system
2. Real-time data collection
3. Machine learning to predict frost events

(a) DC2274: Low-power wireless manager *(1 deployed)*

(b) Long-range prototype board *(3 deployed)*

(c) DC9018: External antenna mote *(2 deployed)*

(d) DC9003: chip antenna mote *(16 deployed)*

dust networks™

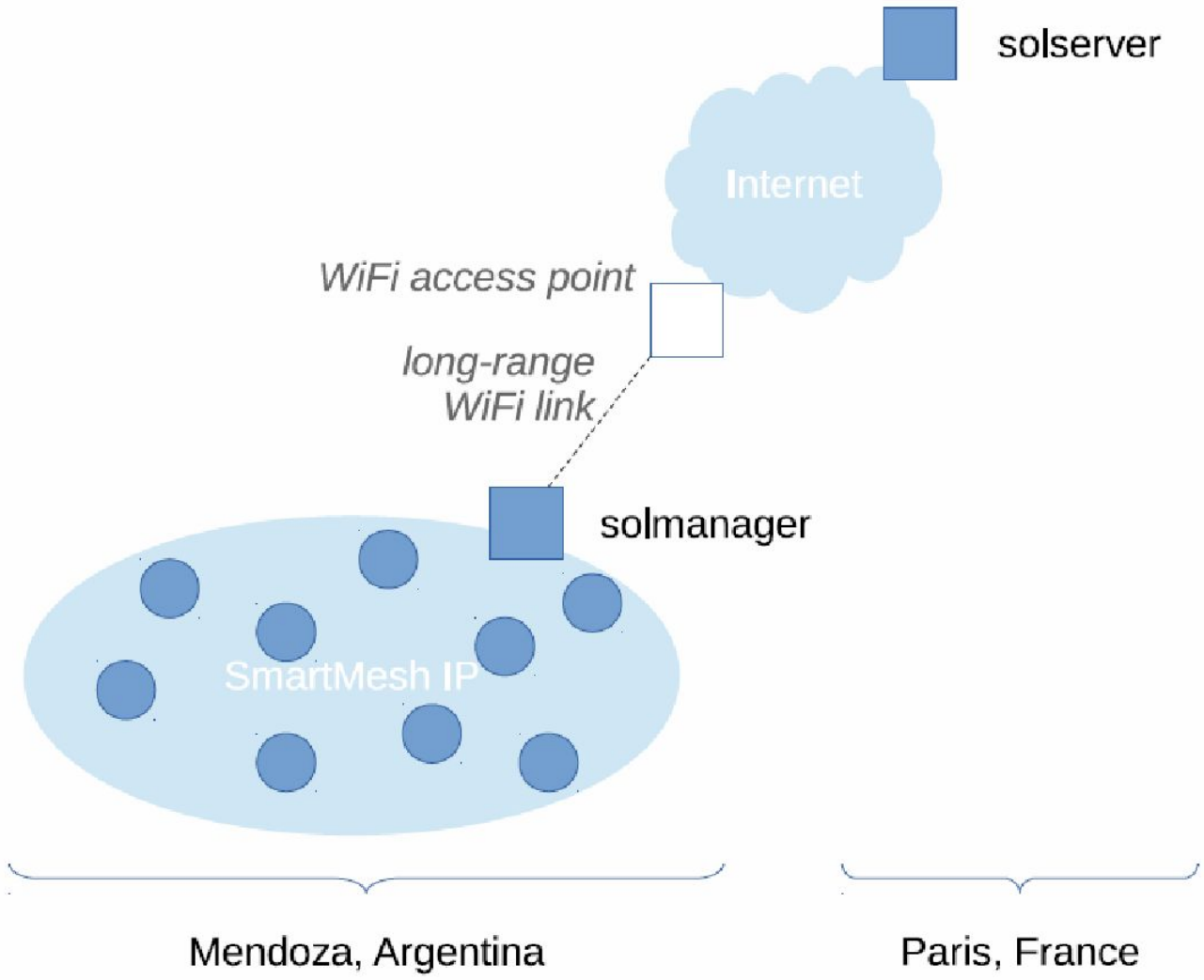
METRONOME SYSTEMS

- >50,000 SmartMesh networks deployed
- >99.999% end-to-end reliability
- >10 years of battery lifetime
- Developed as part of the REALMS associate team

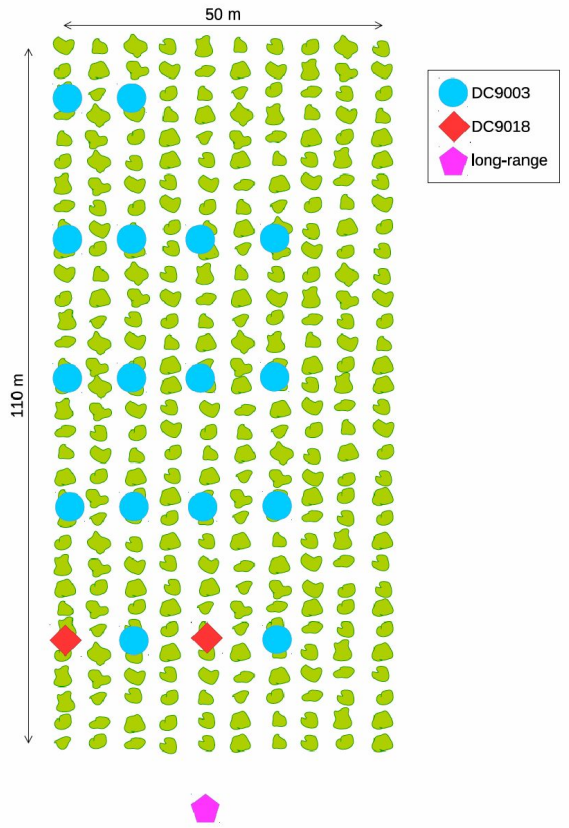
SmartMesh IP Node 2.4GHz 802.15.4e Wireless Mote Module

- Complete Radio Transceiver, Embedded Processor, and Networking Software for Forming a Self-Healing Mesh Network
- Compliant to 6LoWPAN Internet Protocol (IP) and IEEE 802.15.4e Standards
- Industry Low Power Radio Technology with 4.5mA-Receive 9.7mA-Transmit at 8dBm
- PCB Assembly with Chip Antenna or with MMCX Antenna Connector
- Micrium µCOS-II Real Time Operating System Based On-Chip Soft Dev Kit

Network Architecture



Deployment Site




Grafana - SaveThePeache
https://sol.paris.inria.fr/grafana/dashboard/db/savethepeaches
SaveThePeaches
Zoom Ou
Temperature
Celsius (°C)
30
25
20
15
10
5
0
-5
-10
5/25 00:00
5/26 00:00
5/27 00:00
5/28 00:00
5/29 00:00
5/30 00:00
5/31 00:00
6/1 00:00
6/2 00:00
6/3 00:00
6/4 00:00
6/5 00:00
6/6 00:00
00-17-0d-00-00-30-60-ef
00-17-0d-00-00-38-0f-66
00-17-0d-00-00-3f-f8-20
00-17-0d-00-00-3f-fe-87
00-17-0d-00-00-3f-fe-88
00-17-0d-00-00-58-32-36
00-17-0d-00-00-60-01-f8
00-17-0d-00-00-60-02-1b
00-17-0d-00-00-60-02-4b
00-17-0d-00-00-60-05-69
00-17-0d-00-00-60-05-78
00-17-0d-00-00-60-05-ab
00-17-0d-00-00-60-06-27
00-17-0d-00-00-60-08-d5
00-17-0d-00-00-b0-00-87
00-17-0d-00-00-b0-00-aa
00-17-0d-00-00-b0-00-cc
Average Temperature
5.95 °C
Min Discovered
-9
Max Discovered
9
Min Battery
-3.362 V
0.40
0.30
0.20
0.10
0
%
6/3
6/4
Battery Voltage
Voltage (mV)
3500
3000
2500
6/2 08:00
6/2 16:00
6/3 00:00
6/3 08:00
6/3 16:00
6/4 00:00
6/4 08:00
6/4 16:00
6/5 00:00
6/5 08:00
6/5 16:00
6/6 00:00
6/6 08:00
6/6 16:00
6/7 00:00
6/7 08:00
6/7 16:00
6/8 00
Charge
mC
250 K
200 K
150 K
100 K
50 K
0
29

IoT/IPv6 Uses Cases:

Gateway IoT con hard y soft libre

Versión CIAA
Versión Raspberry

IoT Gateway

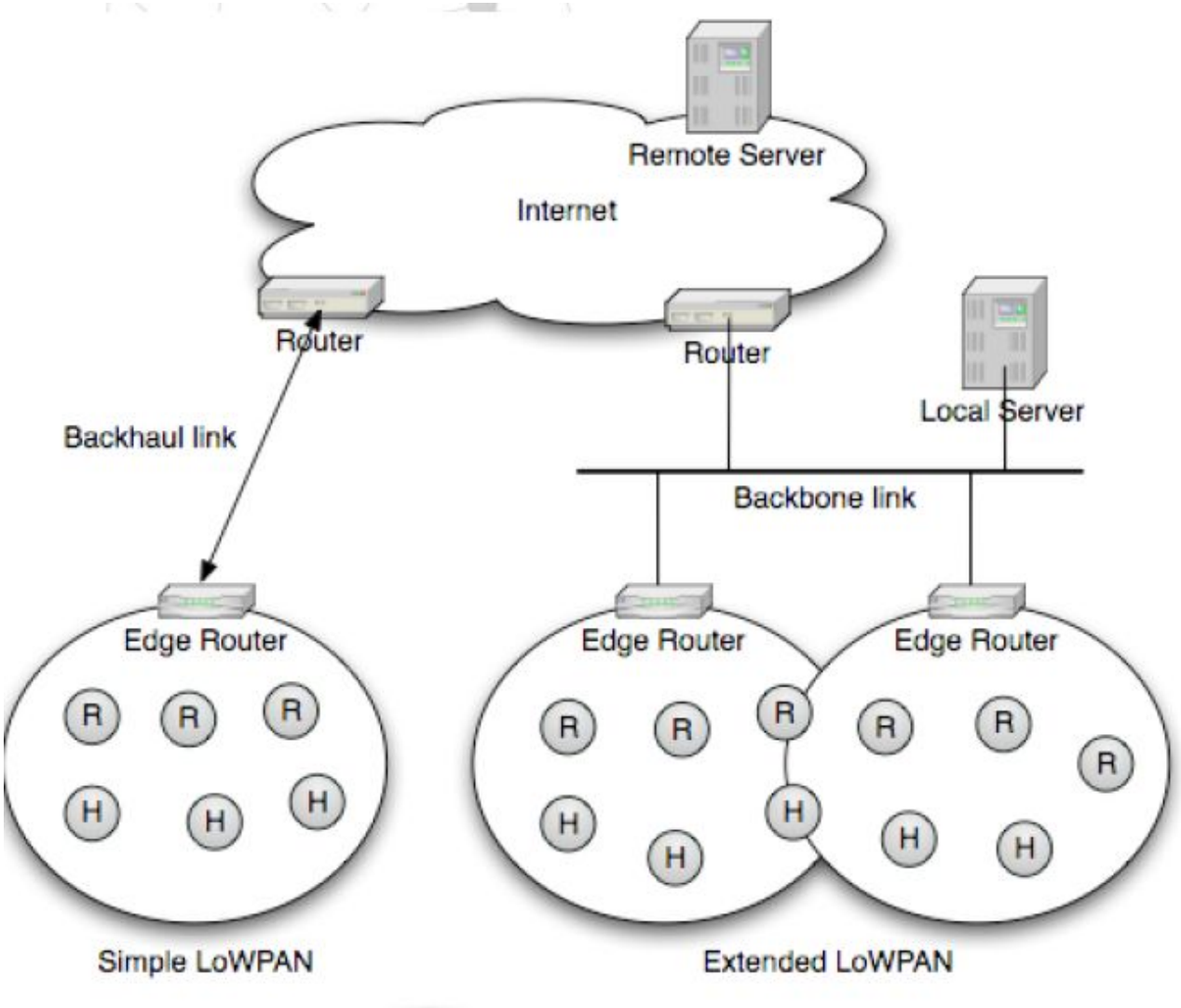
- Descripción:
  - Se describe la implementación de un sistema (hardware / software) de pasarela y red WSN para IoT con tecnologías libres.

- Objetivo:
  - Diseñar y desarrollar un Sistema Gateway de IoT utilizando CIAA y Raspberry PI

IoT Gateway

- Objetivo Estrategico:
  - Utilizar tecnologías (hard/soft) de naturaleza libres/abiertas
  - El sistema final será de naturaleza libre/abierto
  - El sistema estará disponible para su uso/rediseño/modificación en forma libre

IoT Gateway: Topología



IoT Gateway

- CIAA GW
  - Hardware
    - CIAA - GW
    - Open Mote - WSN
  - Software
    - OSEK - OS
    - Contiki - OS
    - Grafana -
  - Protocolos:
    - Stack de protocolos TCP/IP del IETF
- Rasp GW
  - Hardware
    - R Pi 3 - GW
    - Open Mote - WSN
  - Software
    - Raspbian - OS
    - Contiki - OS
    - Grafana -
  - Protocolos:
    - Stack de protocolos TCP/IP del IETF

IoT Gateway

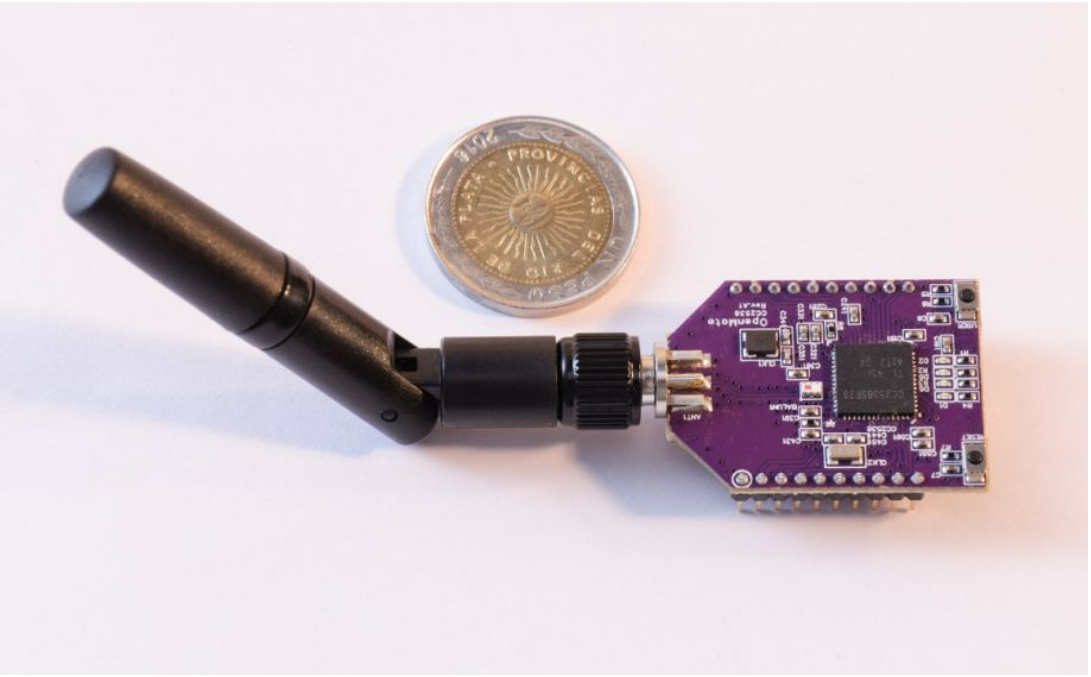
- Elección de Hardware para GW

CIAA – Computadora Industrial Abierta Argentina

Raspberry Pi 3

Open Mote

Open Mote CC 2538



Open Mote CC 2538

- Open Source.
- Open Hardware
- 32-bit Cortex-M3
  - 32 Kbytes of RAM
  - 512 Kbytes of Flash
- CC2520-like radio transceiver
  - IEEE 802.15.4-2006

IoT Gateway

GW OS

CIAA GW - OS

Free OSEK CIAA-Firmware

- Oficial del proyecto CIAA..
- Tiempo real
- Licencia libre y de acceso gratuito.
- Basado en el estándar de industria automotriz OSEK-VDX.

El principal motivo de usar CIAA-Firmware fue poder aportar al proyecto CIAA y también poder valernos de los aportes de otros usuarios

Raspberry Pi 3 GW - OS

Free Raspbian

- Oficial del proyecto Raspberry
- Licencia libre y de acceso gratuito.
- Basado en LINUX (Debian)

IoT Gateway

Software Open Mote

OpenMote admite

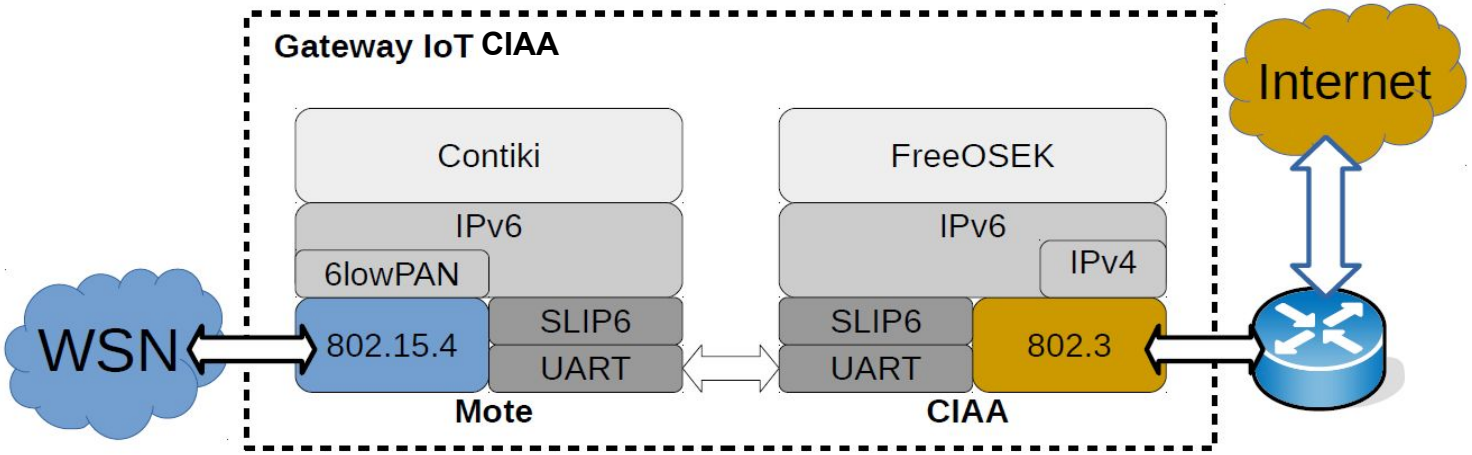
- OpenWSN
- Contiki
- freeRTOS
- Riot OS

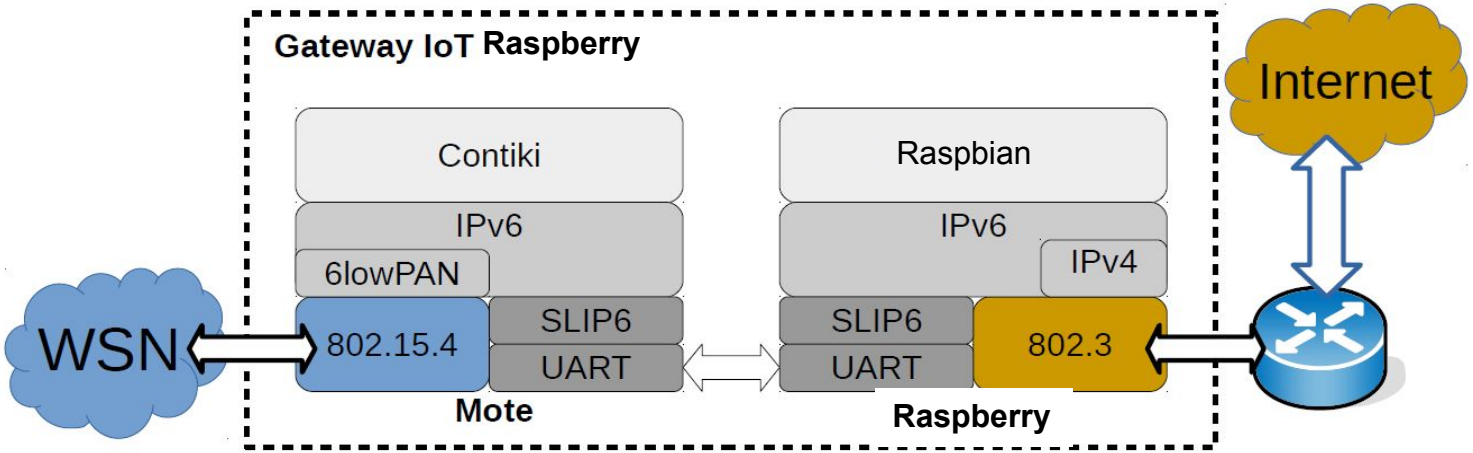
Se elige Contiki

- Buen comportamiento con Open Mote
- Se han hecho ensayos
- Implementado 6LoWPAN, RPL, etc

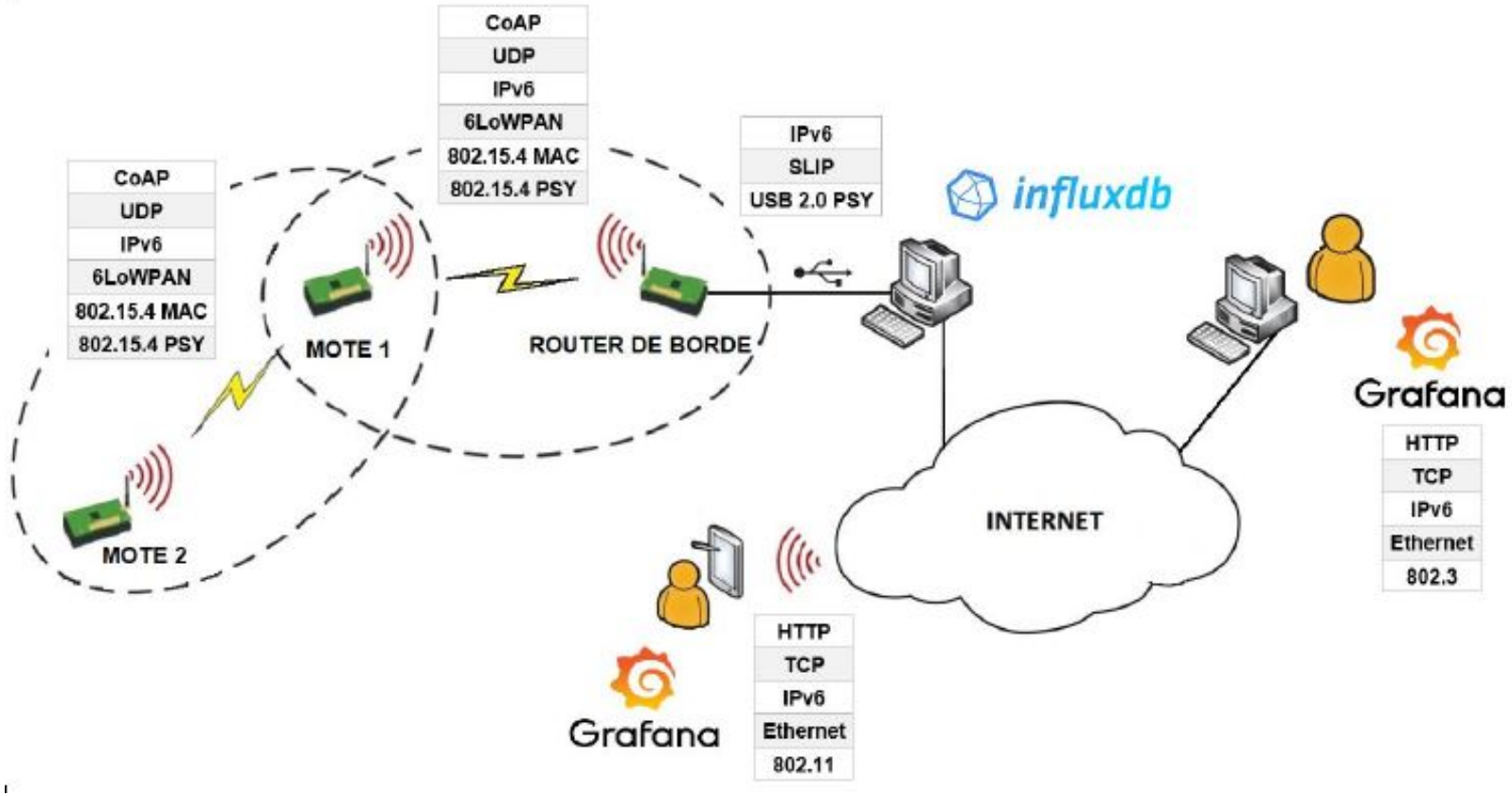
name	category	MCU w/o MMU	< 32 kB RAM	6LoWPAN	RTOS scheduler	HAL	energy-efficient MAC layers
Contiki	event-driven	✓	✓	✓	✘	✓	✓
RIOT	multi-threading	✓	✓	✓	✓	✓	✘
FreeRTOS	RTOS	✓	✓	✘	✓	✘	✘
uClinux	multi-threading	✓	✘	✓	✘	✓	✘
Android	multi-threading	✘	✘	✘	✘	✓	✘
Arduino	other	✓	✓	✘	✘	✓	✘

IoT Gateway

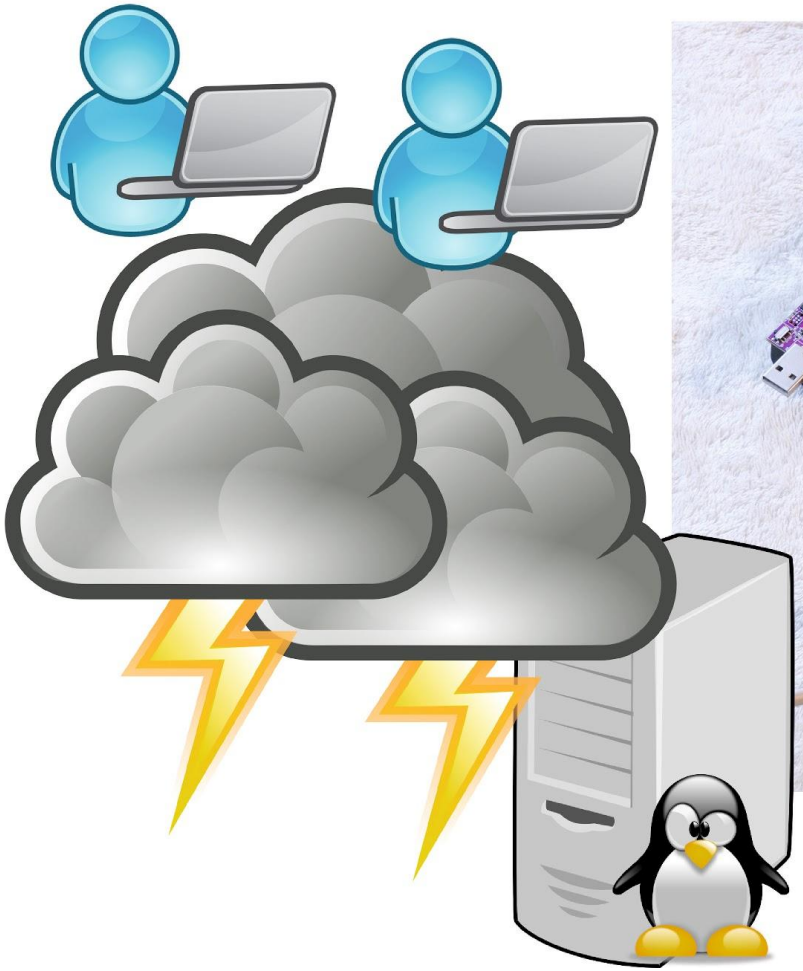

Gateway IoT CIAA
Internet
Contiki
FreeOSEK
IPv6
IPv6
6lowPAN
IPv4
WSN
802.15.4
SLIP6
UART
SLIP6
UART
802.3
Mote
CIAA

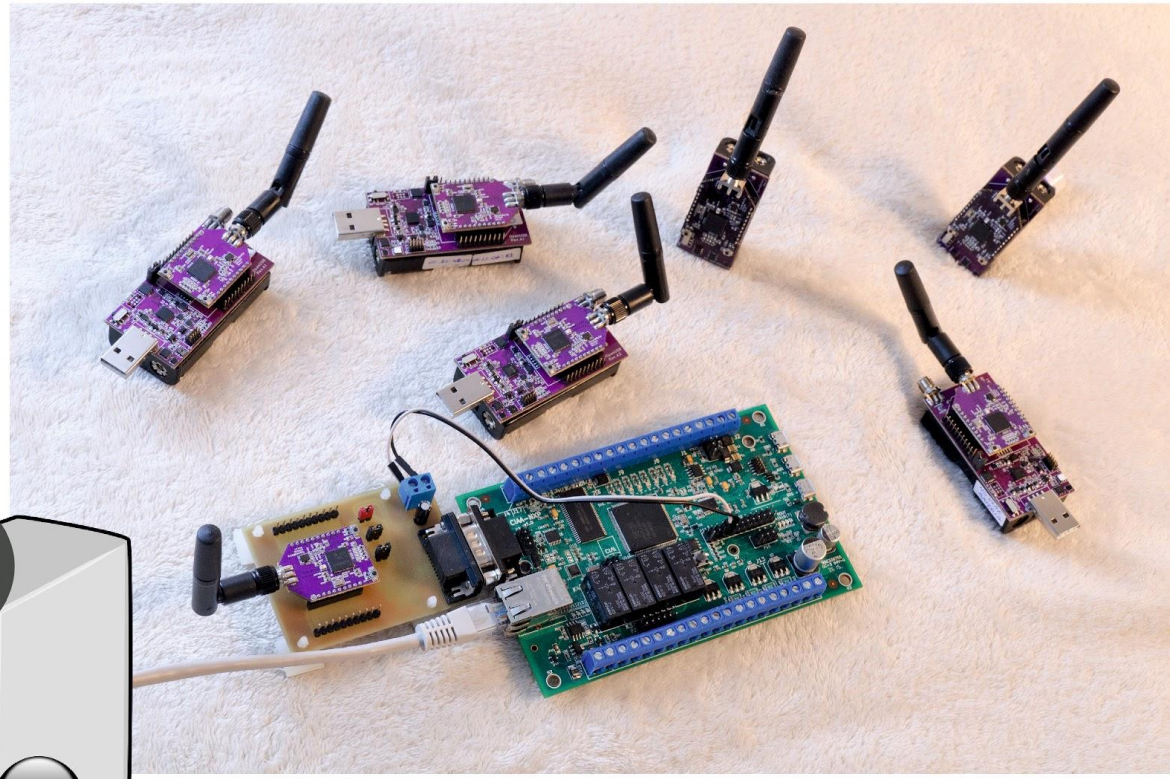

Gateway IoT Raspberry
Internet
Contiki
Raspbian
IPv6
IPv6
6lowPAN
IPv4
WSN
802.15.4
SLIP6
UART
SLIP6
UART
802.3
Mote
Raspberry

IoT Gateway

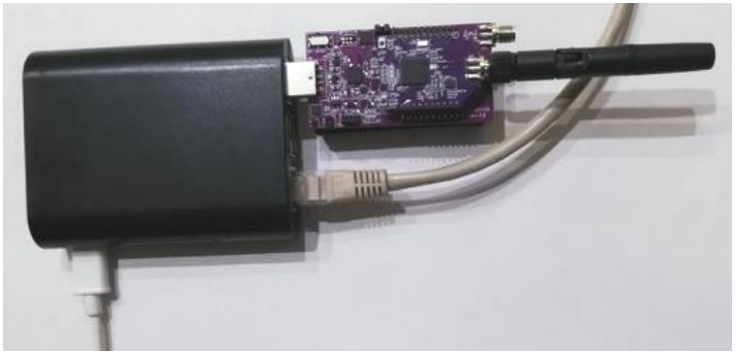

CoAP
UDP
IPv6
6LoWPAN
802.15.4 MAC
802.15.4 PSY
IPv6
SLIP
USB 2.0 PSY
influxdb
CoAP
UDP
IPv6
6LoWPAN
802.15.4 MAC
802.15.4 PSY
MOTE 1
ROUTER DE BORDE
MOTE 2
INTERNET
Grafana
HTTP
TCP
IPv6
Ethernet
802.3
Grafana
HTTP
TCP
IPv6
Ethernet
802.11

CIAA IoT Gateway





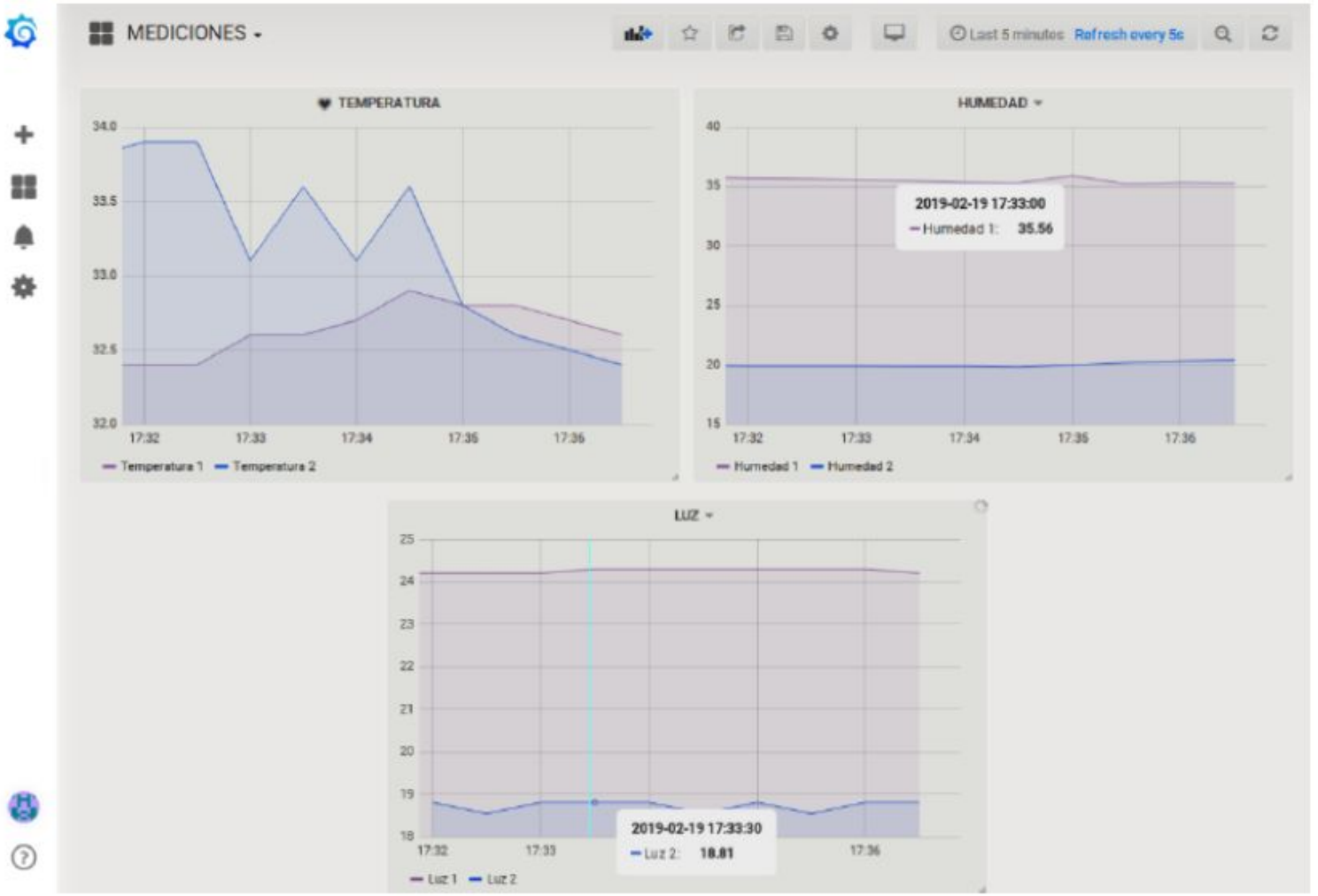
Raspberry IoT Gateway



Grafana

The open platform for analytics and monitoring

Raspberry IoT GW- Grafana



Takeaways... :-)

- IPv6 tiene una gran cantidad enorme de direcciones de Internet, haciéndolo apto para conectar objetos a Internet
- Internet de las cosas es un término que refiere a que todo lo que pueda ser conectado va a estar conectado a Internet.
- Unos de los objetivos de internet de las cosas es conectar a bajo costo.
- En redes con restricciones se utiliza un protocolo que comprime IPv6 llamado 6LoWPAN.

¡"To be, or not to be, Conscious of IPv6, that is the question!!"... Hamlet v. 2019

Muchas Gracias! :)

IoT & IPv6

Preguntas

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