The 4th ATiGB 2018
THE 4th NATIONAL SCIENTIFIC CONFERENCE ON APPLYING NEW TECHNOLOGY IN GREEN BUILDING
Đơn vị tổ chức: Đại học Sư phạm Kỹ thuật - Đại học Đà Nẵng
Thời gian: Ngày 9 - 10 tháng 11 năm 2018

Low-Power Wireless Technologies for Smart Building

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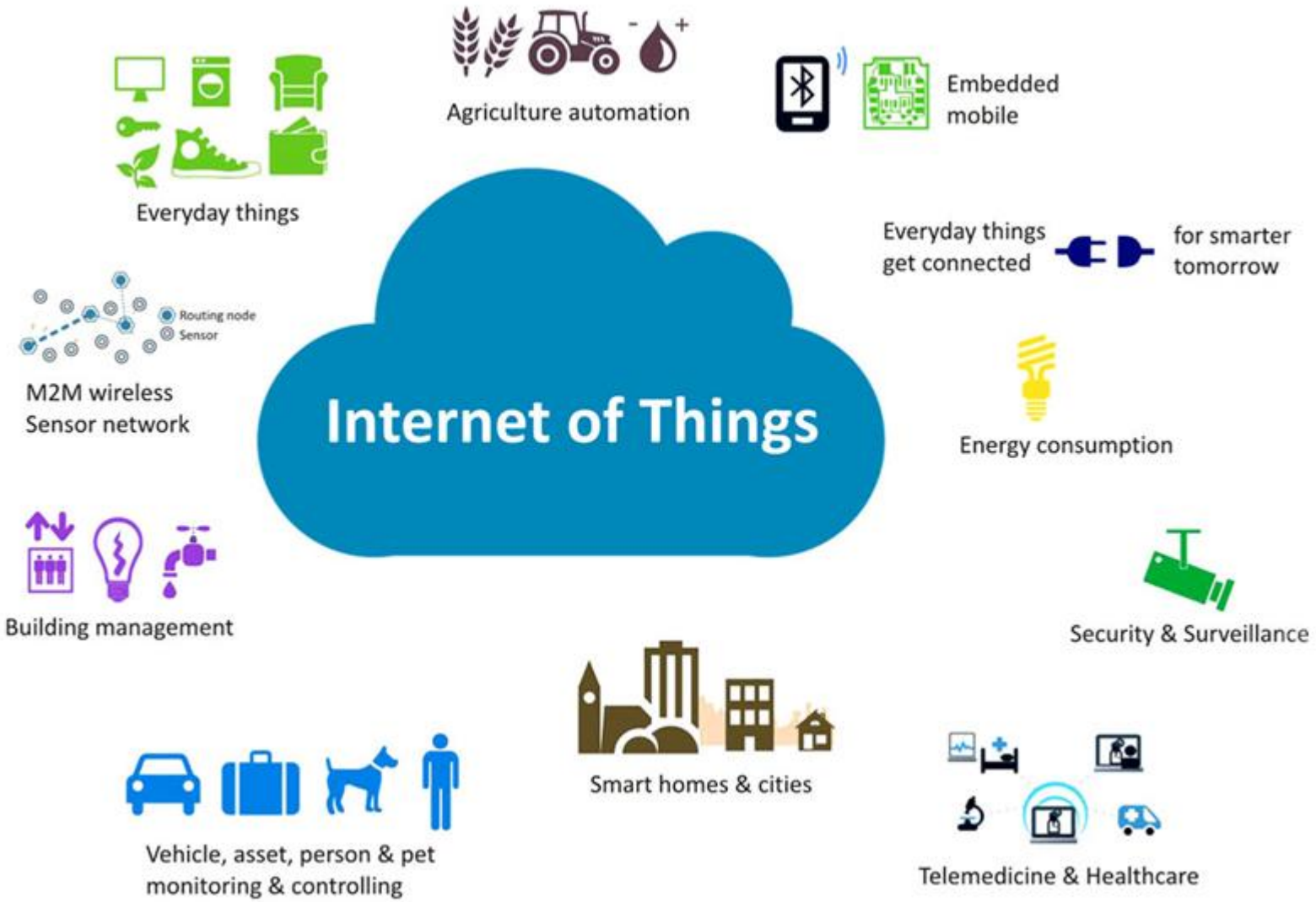
DNIIT DANANG INTERNATIONAL INSTITUTE OF TECHNOLOGY
INITIATIVE OF THE EXCELLENCE - INVESTMENT FOR THE FUTURE

UNIVERSITÉ CÔTE D'AZUR

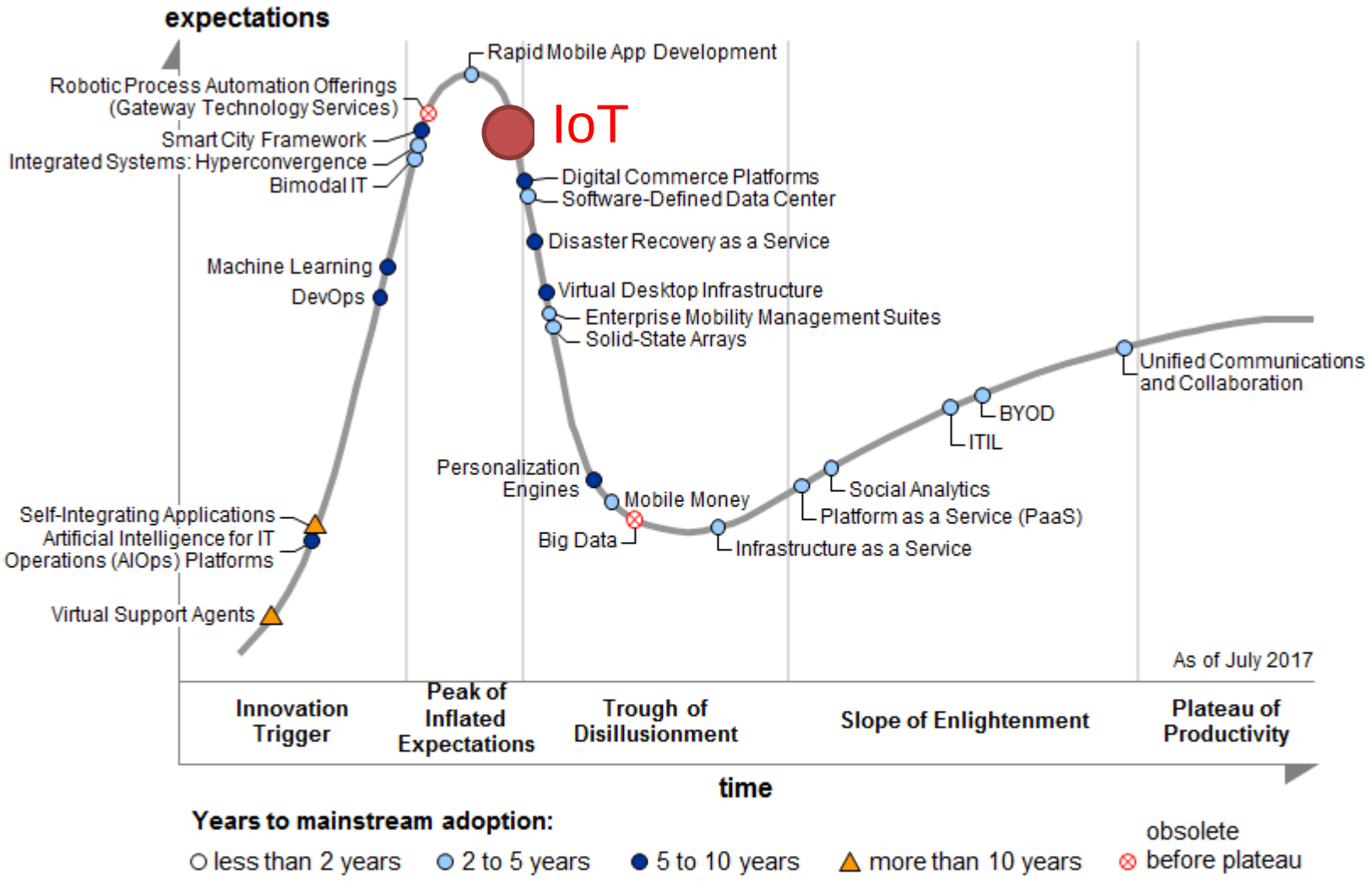
Outline

- LP-WAN motivation
- Smart Campus Campaign 2018-2019
- Channel measurement in a Vietnamese Building
- UCA LoRa Node Platform
- SmartCampus UCA Node
- Conclusion and Perspectives

IoT opportunities : Potential market



IoT opportunities : Hype cycle



Smart Building

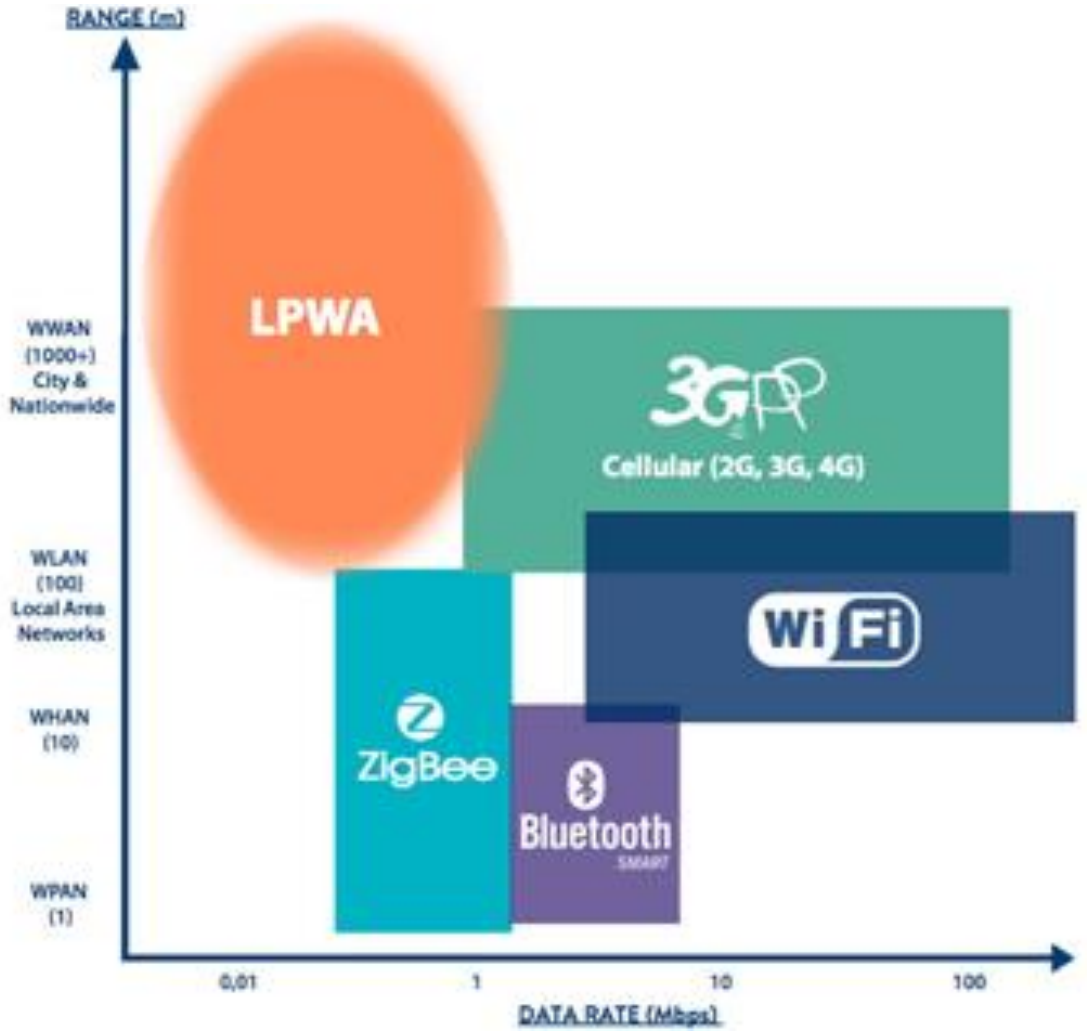
Requirements
Low Power
Long communication range
Simple network structure
Low-Cost

What is the communication needed for smart-building ?

LP-WAN technologies opportunities

LP-WAN provides new capabilities :

Low-power and long communication range



LP-WAN technologies comparison

	LoRa™	SIGFOX	NB-IoT 3GPP
Range (km)	10km (suburban) 3-6km (urban)	30km (Rural) 10km (urban)	
Frequency Band (MHz)	Sub GHz (ISM)	868-900MHz (ISM)	Licensed LTE bands
Max. Coupling Loss	155dB		164dB
Modulation type	Chirp Spread Spectrum (CSS)	Ultra narrow band / GFSK / BPSK	LTE - OFDMA / SC-FDMA
Bandwidth	125 – 500 kHz	100 Hz	180 kHz
Datarate	300 bps – 50 kbps	100 bps	Up to 250 kbps (UL) – low latency
Max /message / day (Uplink)	Unlimited*	140 msg/day – 12bytesmax/msg	Unlimited (lice. Spectrum)
Max /message / day (Downlink)	Unlimited*	4 msg/day (8bytes max/msg)	Unlimited (lice. Spectrum)
Network density	+++ (ADR)	+	+++
Battery peak current	< 50 mA (14dBm)	< 50 mA (14dBm)	~300mA (@23dBm)
Average sensor autonomy	+++ (ADR)	++	+
Interference immunity	high	Low	Sensitive to downlink jamming
Native payload encryption	Yes	Proprietary	Yes
Able to create private networks	Yes	No	No
Location (w/o GPS)	Yes	No	M1 only, not deployed(**)
Commercial availability	Now	Now	Starting in 2017

LP-WAN technologies comparison

- IoT communication standards

Frequency : 2.4GHz
Data rates : 20-250 kbps
Power consumption :
- Tx : 34 mA
- Rx : 24mA

Budget Link : around 100 dB
Range : 50m
CC2538 TI

Frequency : 868MHz
Data rates : 240 bps to 5.5 kbps
Power consumption :
- Tx : 28mA
- Rx : 11mA

Budget Link : around 150 dB
Range : 2 km
SX1272 Semtech

LoRa modulation : Spreading factor

- LoRa Spreading factor

$$R_b = SF * \frac{1}{\left[\frac{2^{SF}}{BW}\right]} \; bits/sec$$

Where:

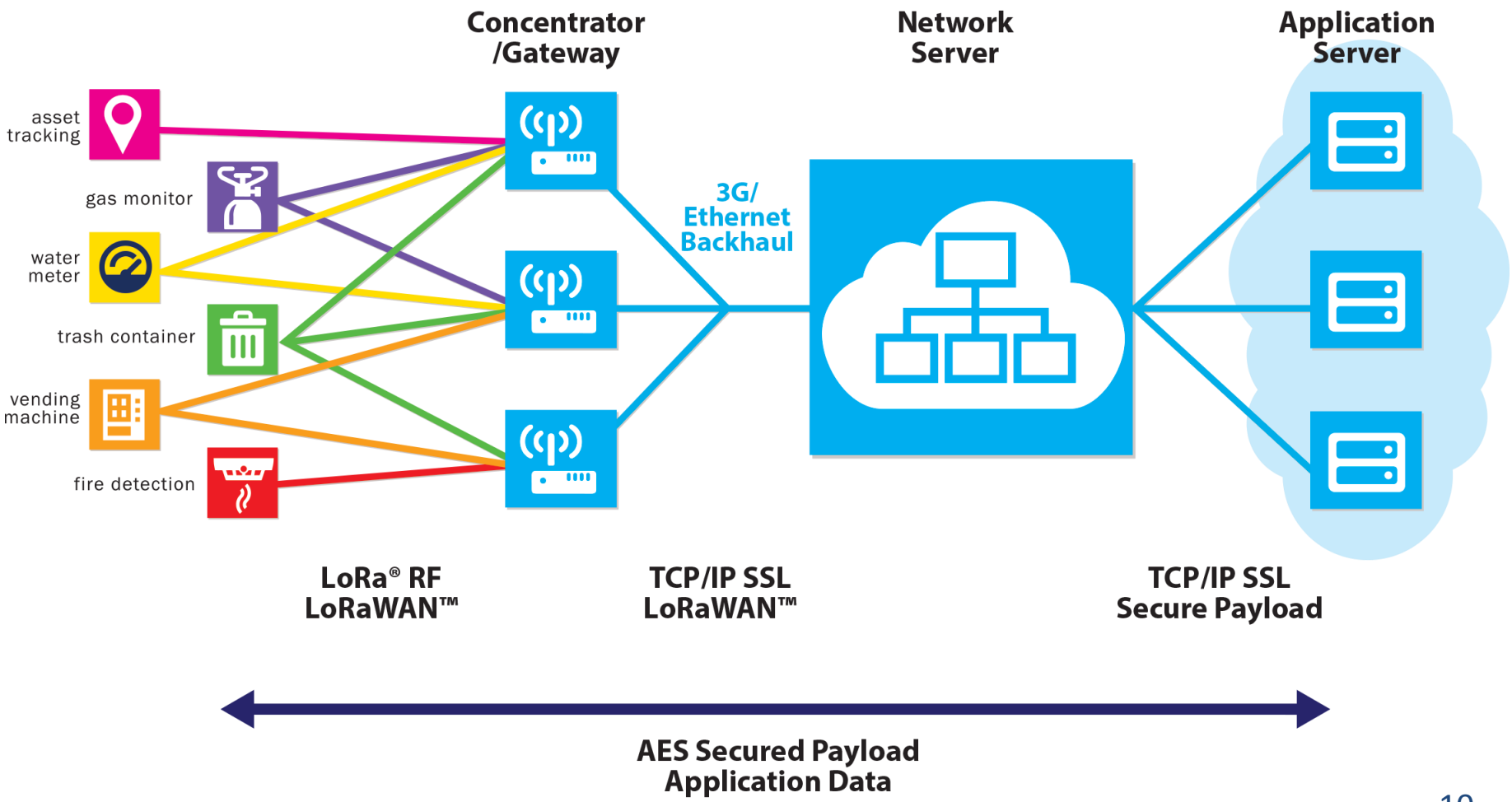
SF = spreading factor (7..12)

BW = modulation bandwidth (Hz)

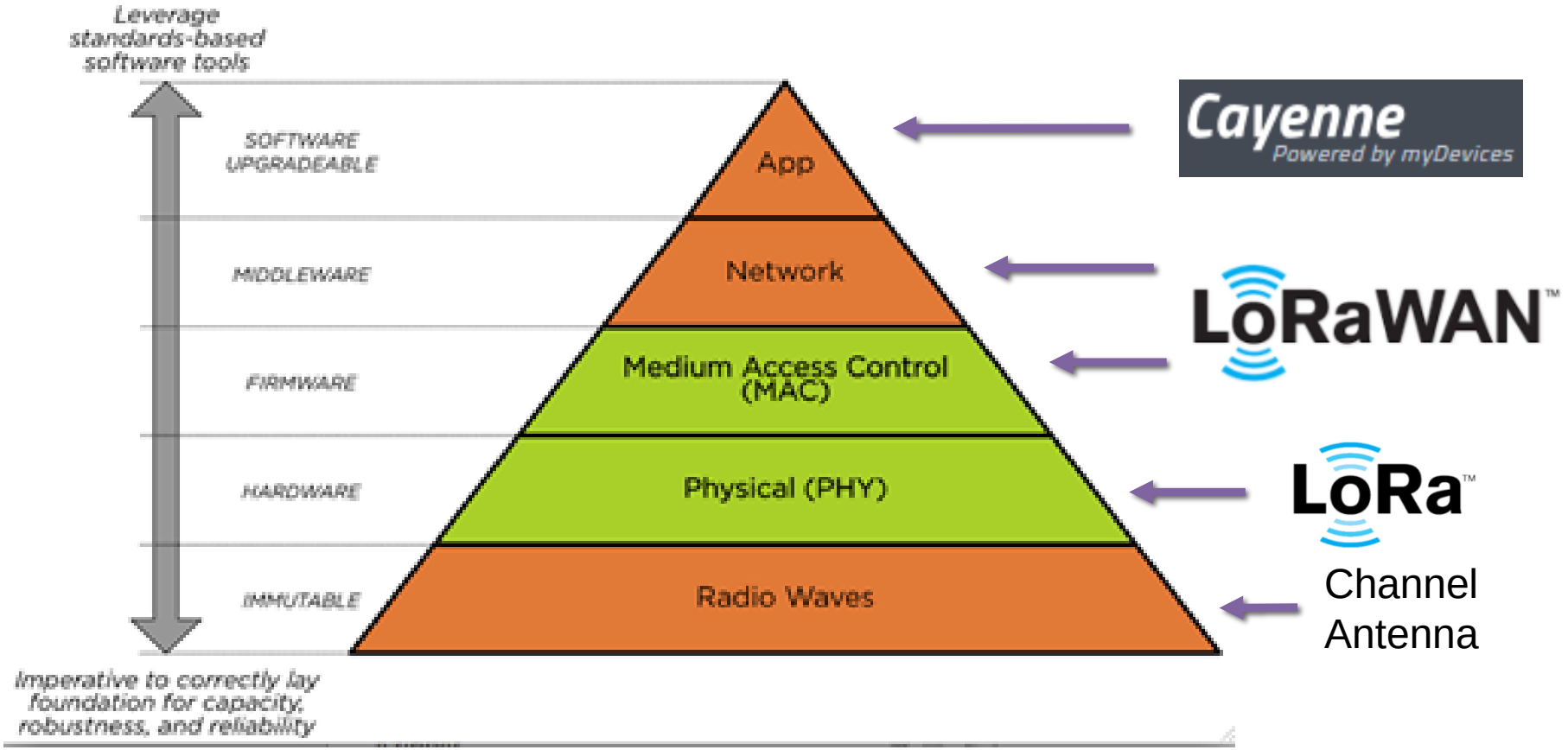
Mode	Equivalent bit rate (kb/s)	Sensitivity (dBm)	Δ (dB)
FSK	1.2	-122	-
LoRa SF = 12	0.293	-137	+15
LoRa SF = 11	0.537	-134.5	+12.5
LoRa SF = 10	0.976	-132	+10
LoRa SF = 9	1757 b/s	-129	+7
LoRa SF = 8	3125 b/s	-126	+4
LoRa SF = 7	5468 b/s	-123	+1
LoRa SF = 6	9375 b/s	-118	-3

Table 1: Link Budget Comparison for Narrowband FSK

LP-WAN network



LoRa vs LoRaWan



LoRaWan Class A

FRMPayload size (Bytes)	240 bps SF12/125k	1 kbps SF10/125k	5.5 kbps SF7/125k
4	~5 uA	~2.2 uA	~1.2 uA
16	~7 uA	~2.5 uA	~1.3 uA
30	~9 uA	~3 uA	~1.4 uA

Assumptions: Pout = +14 dBm, Average Current

- 10 packets / day
- Sleep current ~1uA (includes the MCU)
- MCU is mostly Off during Tx
- No ACK received
- The energy usage of the 2 unused Rx windows is low (<10%)
- Pout = +14 dBm, IDDTX = 32 mA

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Smart Campus Campaign : General objectives

- Memorandum between on August 22, 2017 between :
  - The University of Danang- University of Science and Technology
  - Danang International Institute of Technology (DNIIT)
- Objective is to promote research toward the **Industrial** Revolutionary 4.0, **Internet of Things** and **Artificial Intelligence**
  - Set up, on UD campuses wireless IoT networks (e.g. LoRa technology) and intelligent services of connected objects.
  - Innovation platform mobilizing students, lecturer-researchers and companies
  - Four campuses of The University of Danang: **DUT, UTE** and **CIT** campus and the headquater of UD.
- Competition of innovative projects
  - Annual Call for Proposals
  - Development by project groups with the support of **lecturers/researchers**
  - Project development : 5 months (beginning of **Nov – April**)
  - Jury rankings and awards (board of judge: members from univ., industry, investors,...)
  - Awards

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Measurement Building

Measurement place:

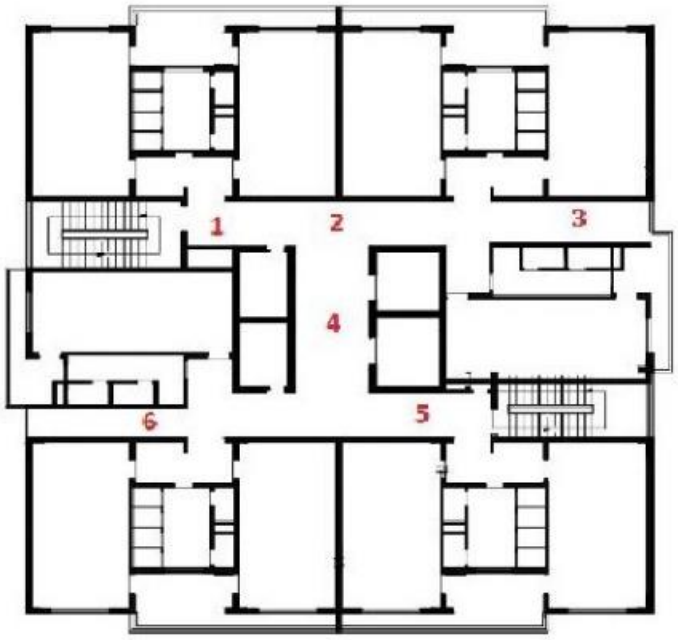
Dormitory B of Vietnam National University Ho Chi Minh City

12 floors

6 measurement areas/floor

Reinforced concrete

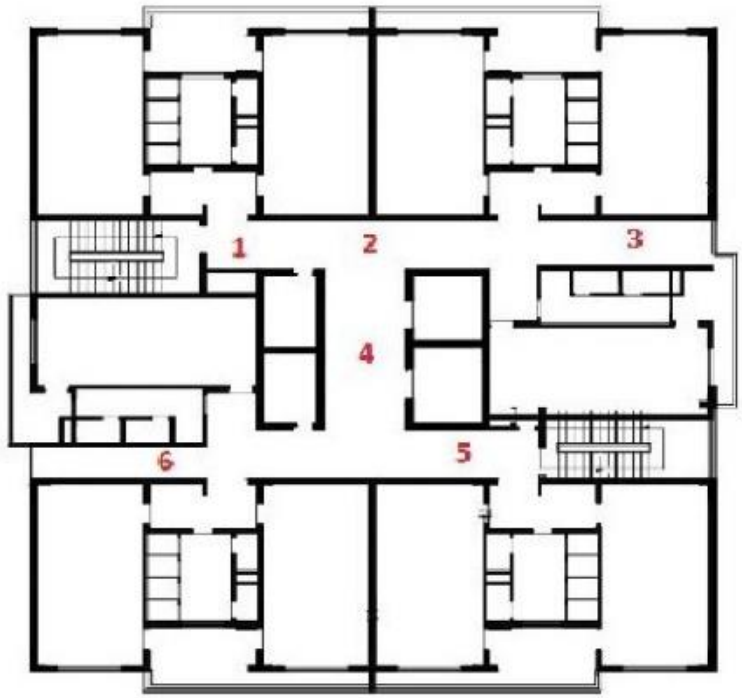
Size 12*12*40m



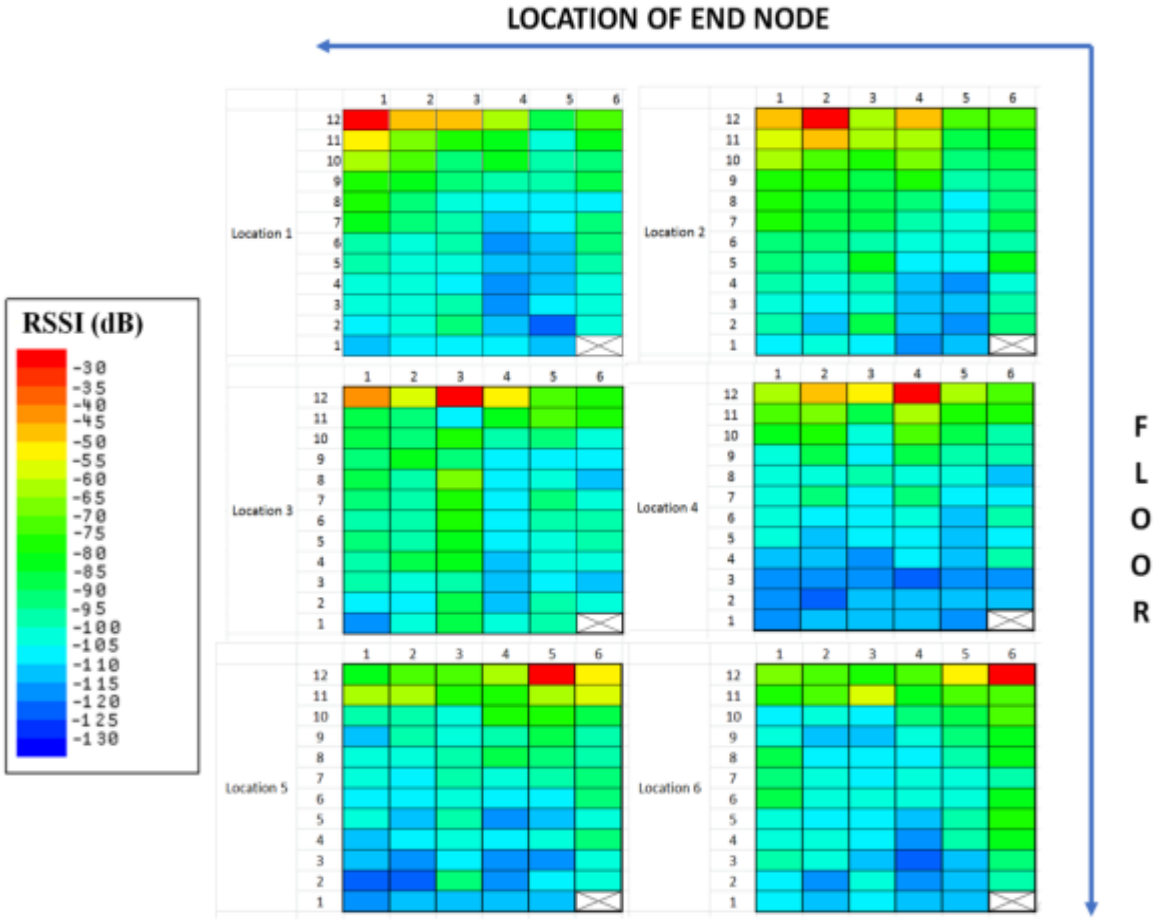
Measurement Building

Scenario:

1. LoRa Gateway is placed at 12th floor at 6 different positions.
2. 6 LoRA End nodes are placed at 6 positions of each floor.
3. RSSI level is measured then uploaded to webserver
4. Data processing and display



Measurement Building

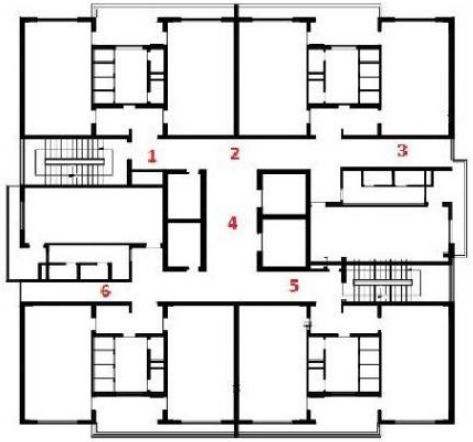


In all case, the full building is covered

COMPUTER ENGINEERING

VNU - HCM

- LoRa communication zone
- Ideal gateway location
- Indoor effect analysis
- Extracted channel path loss n=7.2



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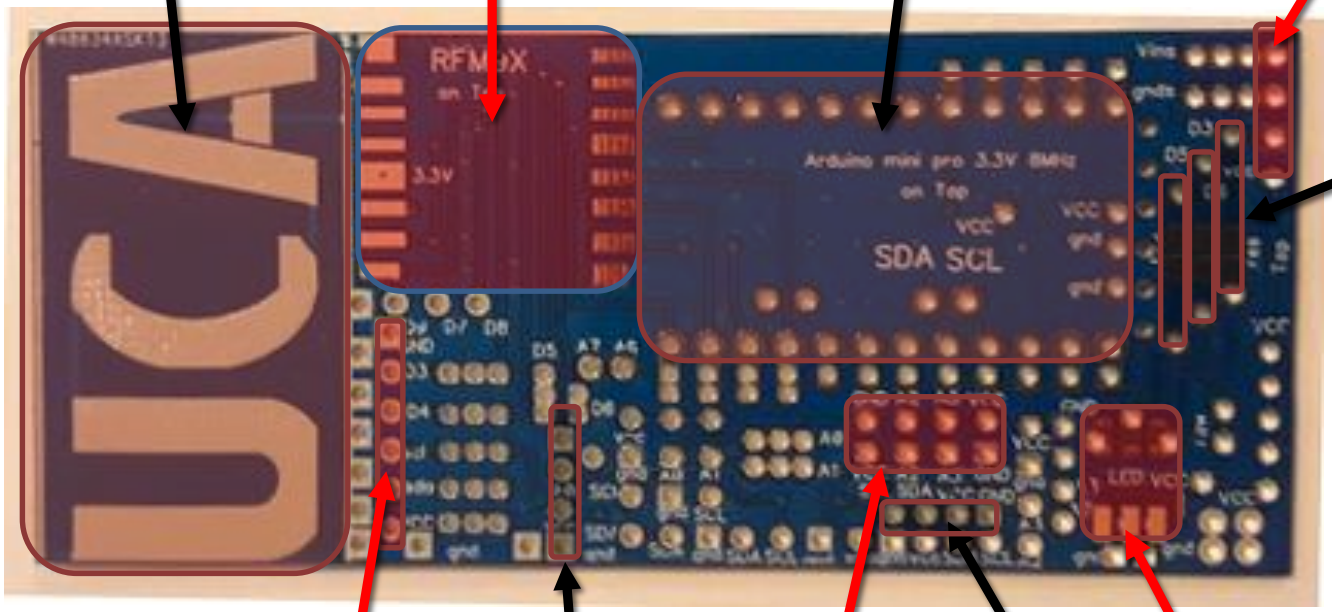
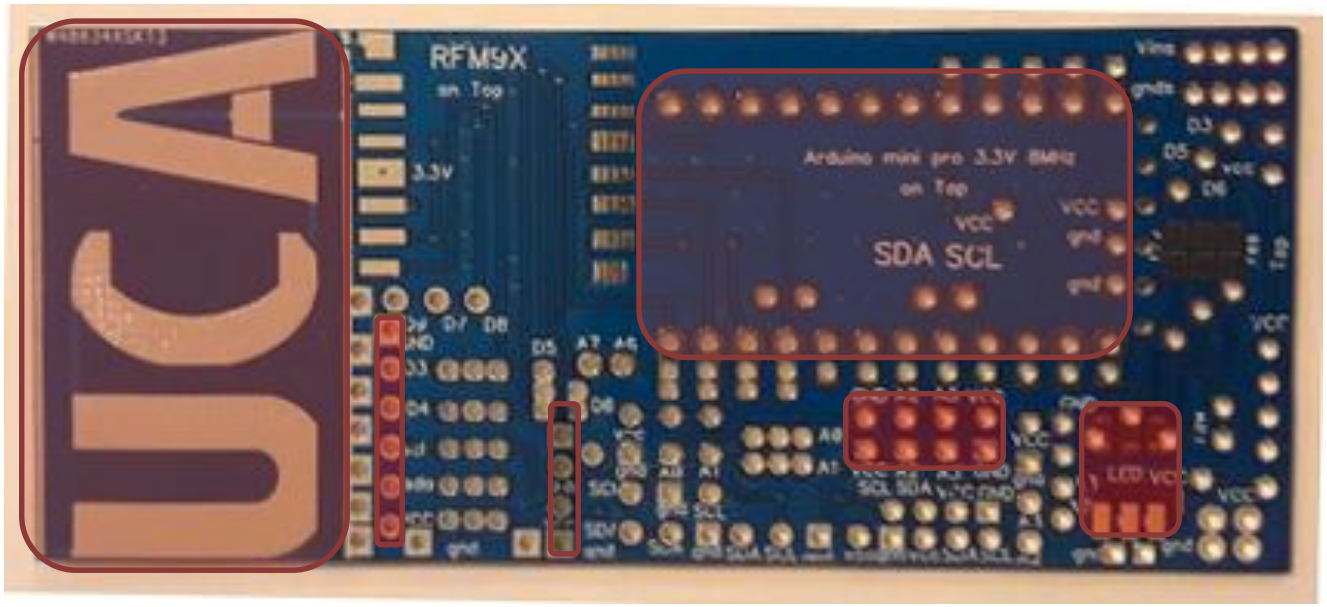
UCA IoT Plateform



UCA IoT Plateform



- Communication up to 15 km
- Power consumption when Transmitting : 100mA on 3.3v
- Power consumption when Sleeping : 10 uA on 3.3V
- With a single AA Lithium battery : Autonomy from 1 to 3 years

https://github.com/FabienFerrero/UCA_Board/

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Smart Campus UCA : Sensor list

Light sensor
TEMT 6000

T°c and Humidity
Si 7021

Sound Sensor

PIR Sensor

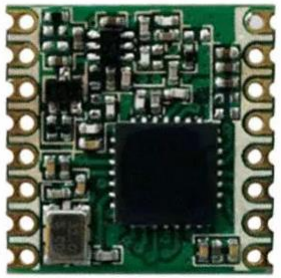
Lithium Battery

https://github.com/FabienFerrero/UCA_SmartCampus

Smart Campus UCA : BOM

Bill of Material & Power Consumption for 3.3V :

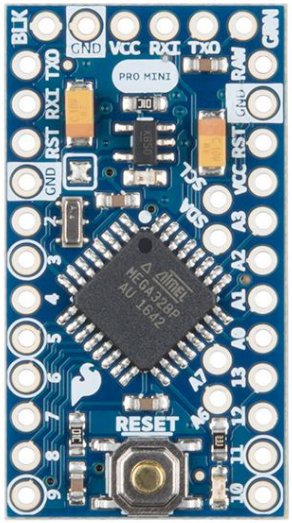
- LoRa Sx1276 (RFM95)
  - Cost : 5$
  - Rx : 10mA
  - Tx : 50 to 100 mA
  - Sleep : < 200 nA



Average Power consumption mainly depend on the Tx interval, Spreading factor and Payload size.

$$P_{av} \sim 3.3 * (Isleep + ITx * \frac{Time_{onAir}}{Tx_{interval}})$$

- ATMEGA 328p 8MHz (Mini Pro)
  - Cost : 1.7$
  - Active : 4mA
  - Sleep : 9 uA

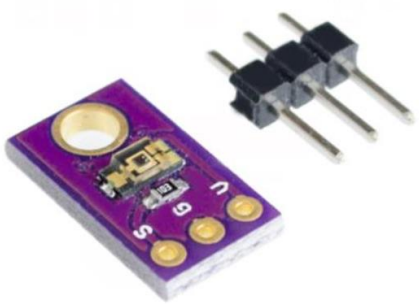


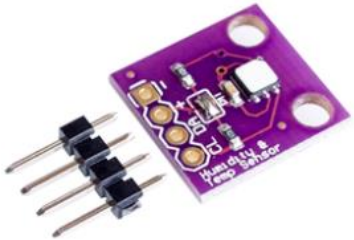
$$P_{av} \sim 3.3 * (Isleep + Iactive * \frac{Time_{operation}}{Tx_{interval}})$$

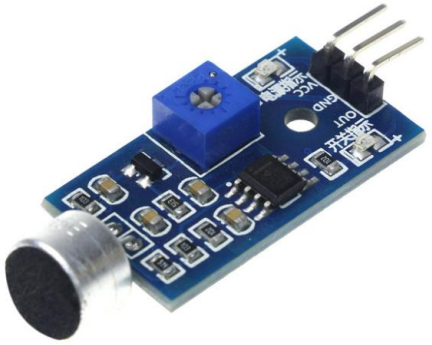
Smart Campus UCA : BOM

Bill of Material & Power Consumption for 3.3V :

- TEMT6000 : Photo Transistor
  - Cost : 0.6 $
  - Active : 330 uA during 10ms
  - Sleep : 0
  - 1 Lux to 10000 Lux
- SI7021 : I2C interface
  - Cost : 1.5$
  - Active : 330 uA during 10ms
  - Sleep : 60 nA
  - ±0.4 °C temperature accuracy
  - ± 3% relative humidity measurements with a range of 0–80% RH
- Sound Sensor : Analog interface
  - Cost : 0.5$
  - Active : 3 mA during 100ms
  - Sleep : 0
  - Must be tuned
- PIR Sensor : Digital Interface
  - Cost : 0.7$
  - Active : 60 uA
  - Sleep : 0
  - Must be tuned



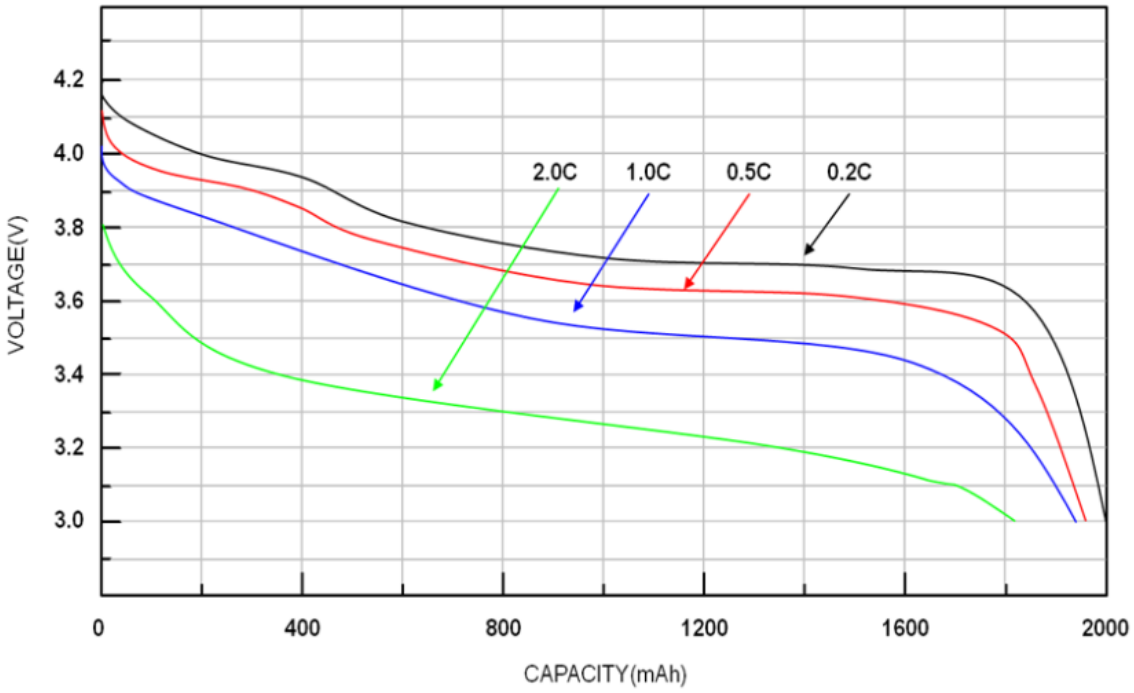




Smart Campus UCA : BOM

Bill of Material :

- No Regulator !
- Lithium Battery 3.7V
  - 14500 (AA) : 750mAh
  - 14500 (AA) : 1200 mAh
  - 16650 : 2400mAh



Smart Campus UCA : Scenario

2 different modes :

- **Active** if a **Movement** or **Sound** detected
  - Uplink sensor information each **5mn**
  - During the 5mn time slot, **each 8s** :
    - Measure Sound level
    - Measure Movement

- **Standby mode** if no sound or movement detected for 5mn
  - Uplink sensor information all **30mn**
  - In a 30 mn tome slot :
    - Each 1mn : Measure light, uplink if large change
    - **Interruption** if Movement detected

Sound level and movement level is **averaged** over the 5mn time frame

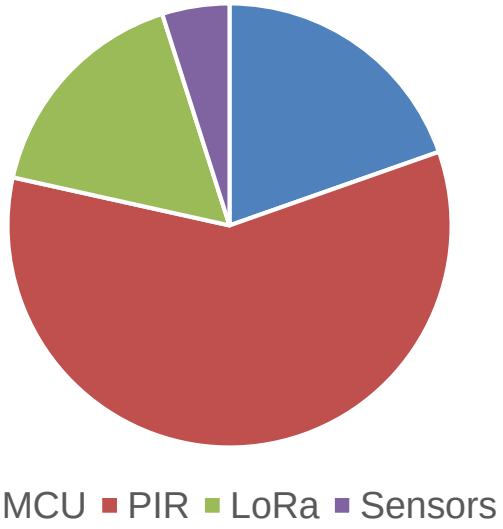
- Sound level is relative
- Movement is expressed in % of detection

PIR Sensor is always ON

Smart Campus UCA : Average PC

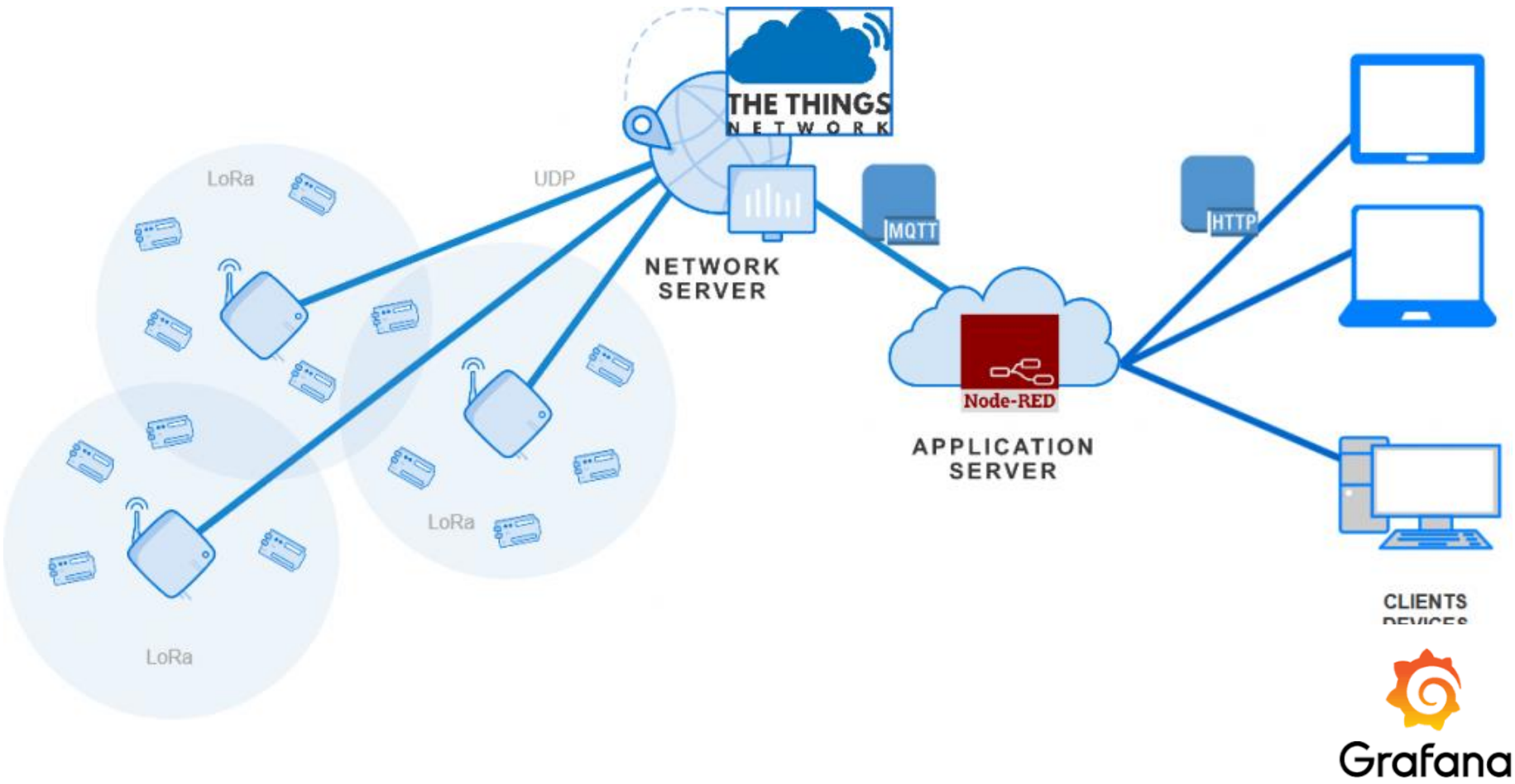
Power Consumption:

- Scenario
  - 5mn Interval
  - SF7 and 26 bytes payload
  - Time on air : 61ms
  - No ACK
- Average Power consumption
  - 102uA on 3.7V = 0.37mW
- Autonomy
  - No considering battery self-discharge



Battery	Autonomy
750mA.h	25 months
1200mA.h	41 months
2400mA.h	81 months

Smart Campus UCA : System



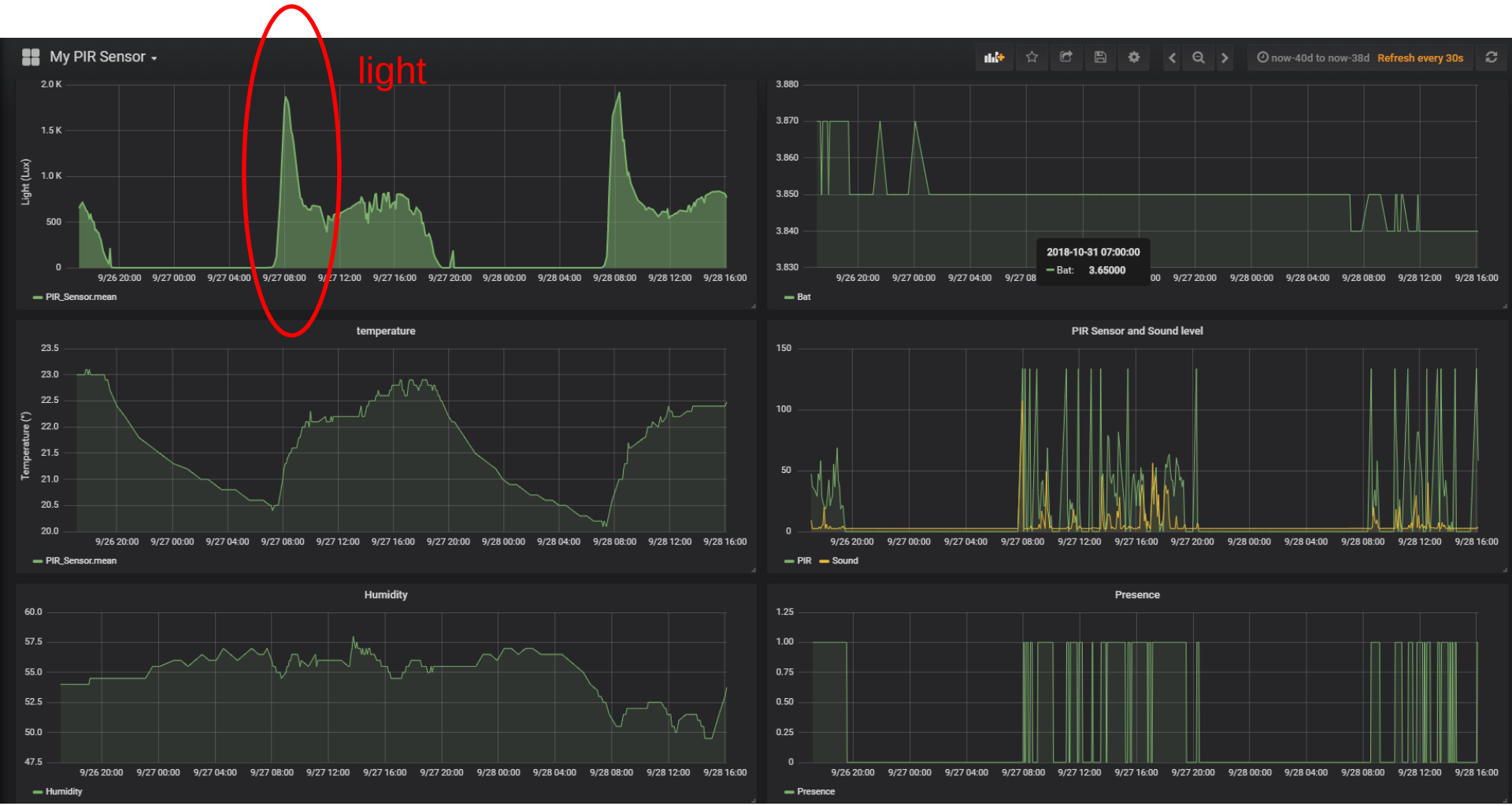
Smart Campus UCA : Results

A UCA board has been placed in my office in Sophia (France) during the last 2 months

Smart Campus UCA : Results

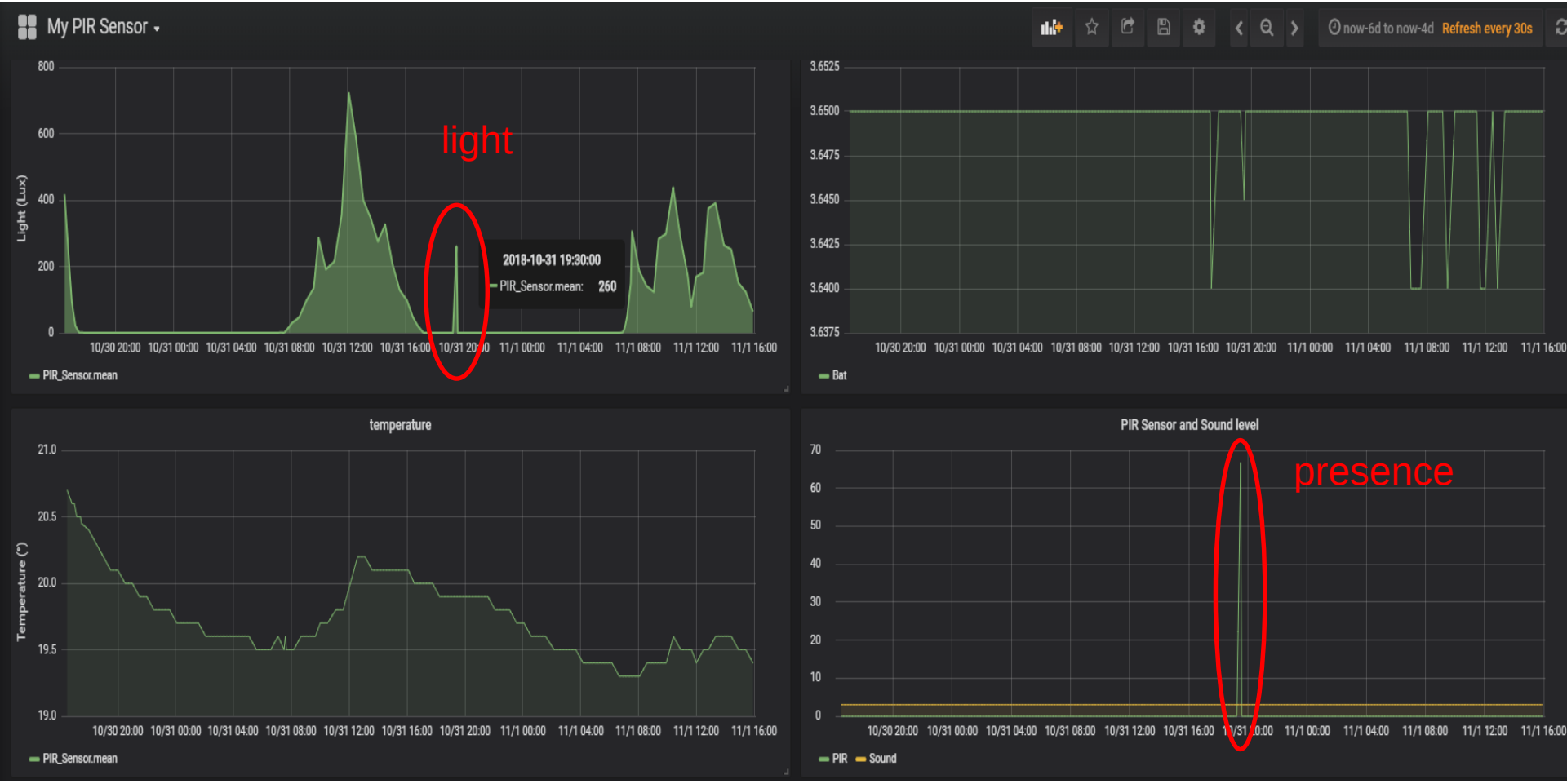
3rd of October : my office colleague forget to swith off his radiator

Smart Campus UCA : Results



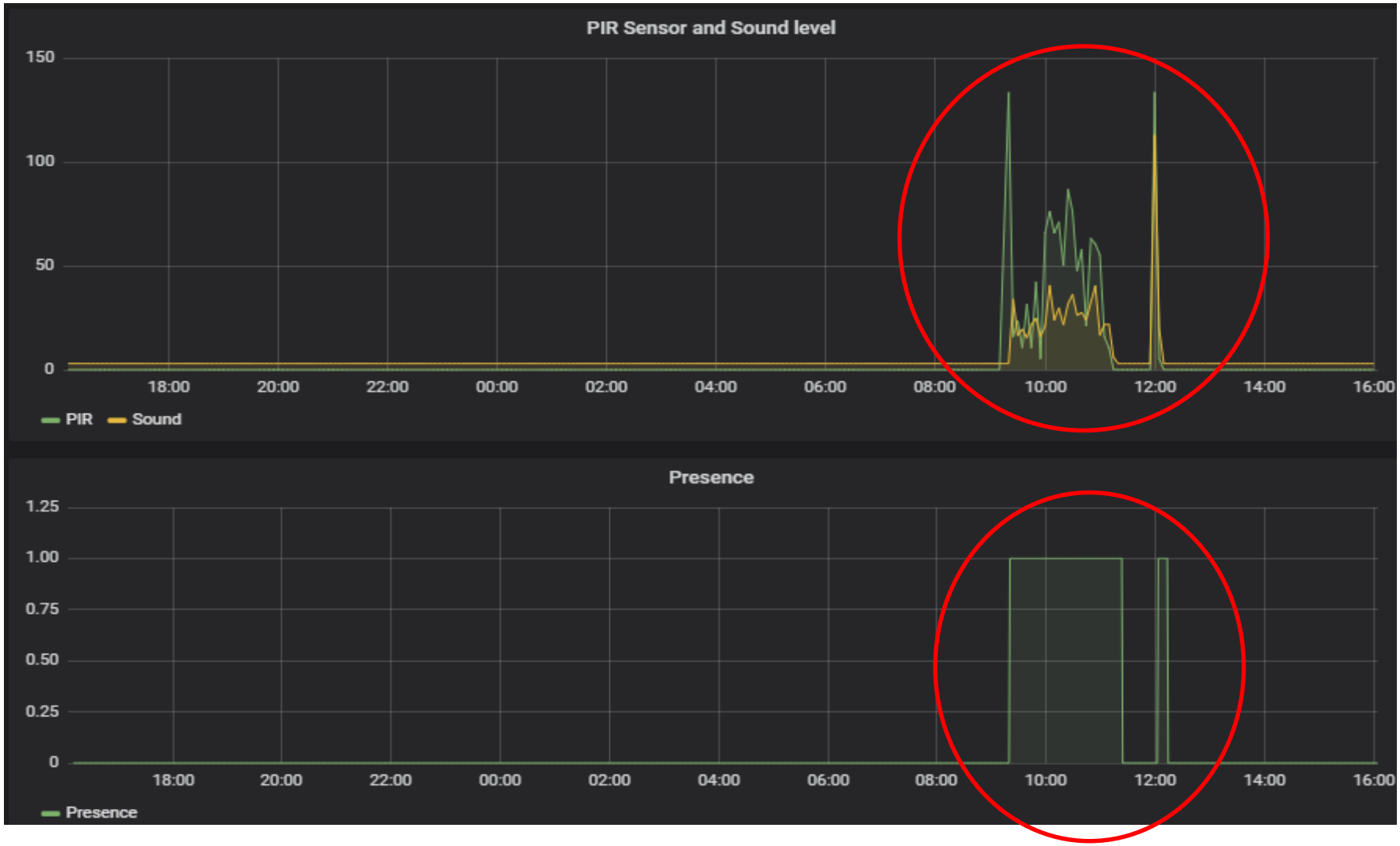
My office window is east oriented : get more sun on the morning

Smart Campus UCA : Results



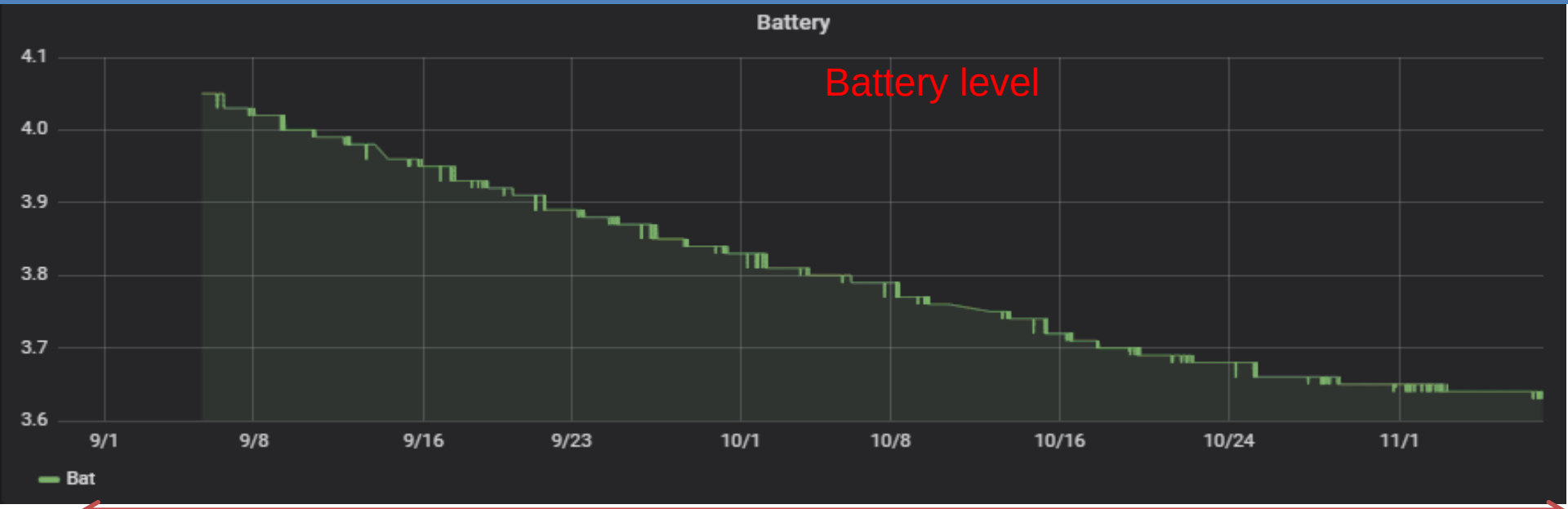
Last week was holidays, so nobody in my office, but the cleaning lady enter shortly in my office to empty the bin

Smart Campus UCA : Results



Just before my plane to DaNang

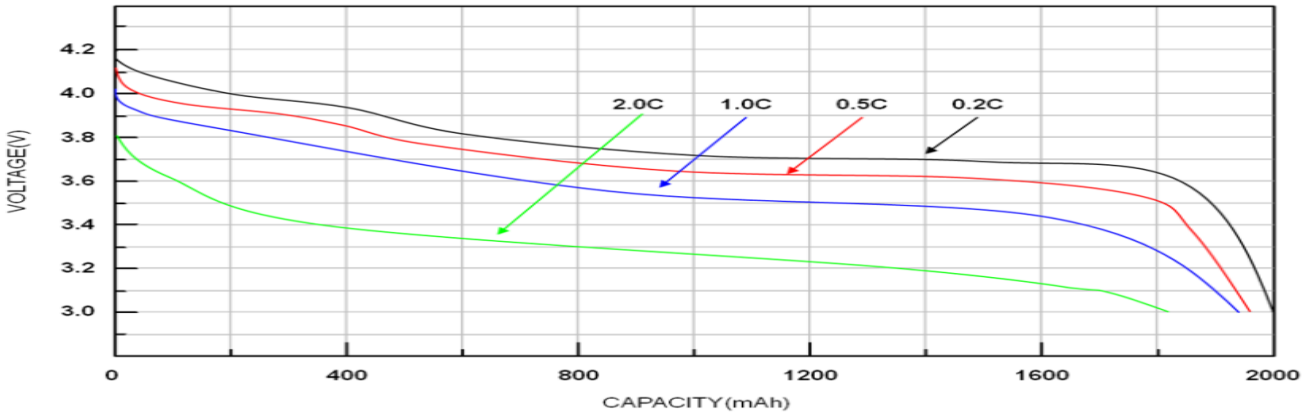
Smart Campus UCA : Autonomy



70 days

With AA 750mAh battery

100 days of autonomy expected !



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Conclusion and Perspectives

- We demonstrate that LoRa technology is relevant for Smart Building applications
- A low-cost and low-power platform can be used for sensing application with several months of autonomy
  - From 100 to 300 days of autonomy depending on the battery
  - Total cost is around 10$
- This live and high resolution (HR) sensor provide rich contents for context-aware services
- Next important steps is the live data analysis from the collected data
- Actuators node will be used to control building equipements
- Smart Campus 2018 is a great occasion to start projects on this topic ！

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