

A glimpse of ne@campus

Facts and lessons learned

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Edge Computing



AIoT

towards the next level

D
A
T
A

L
A
K
E



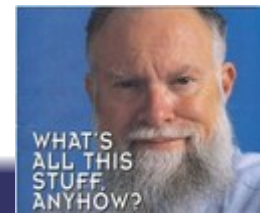
ne@campus

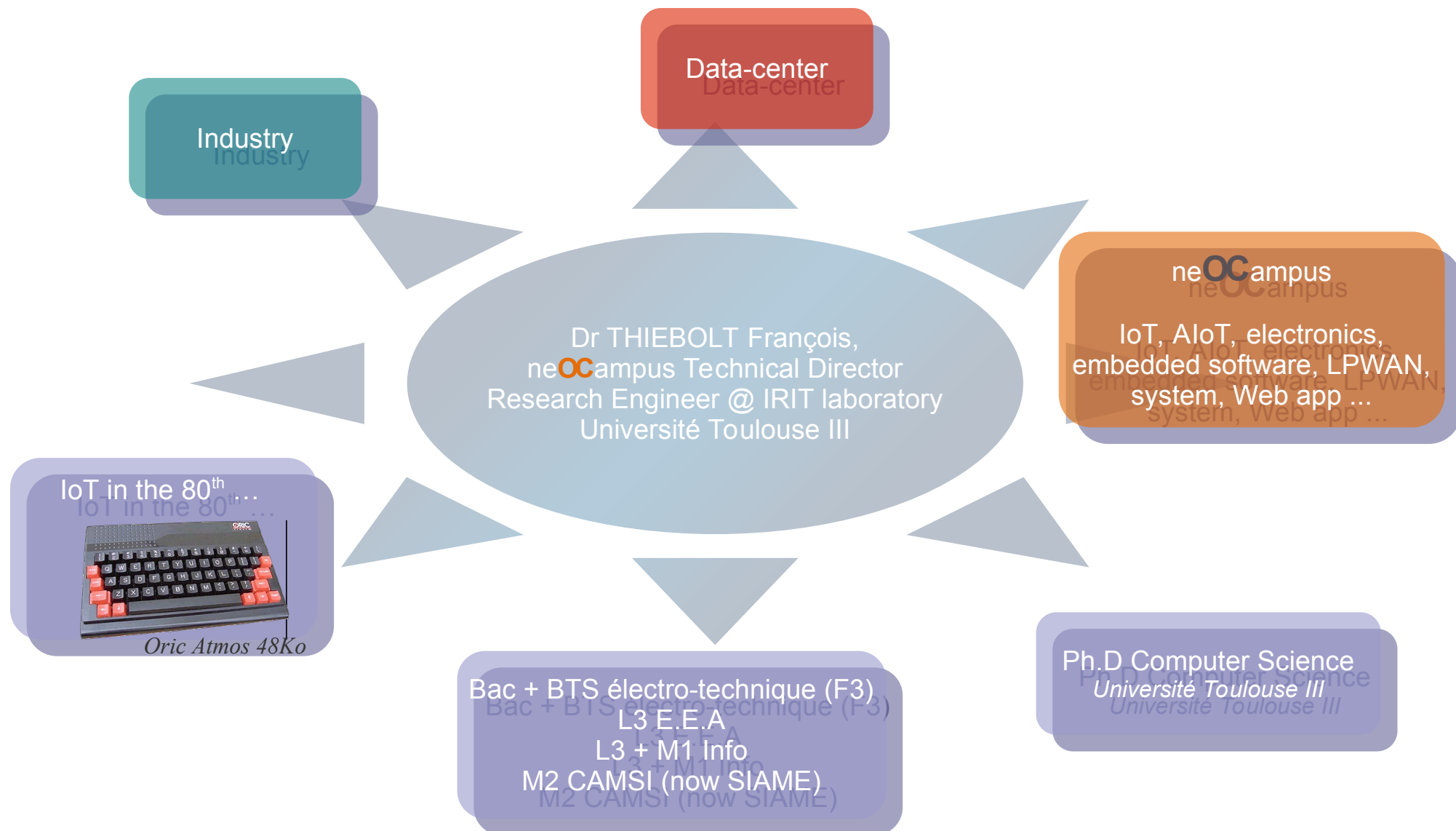


What's all this IoT stuff, Anyhow* ?

- [Foreword] the painful way to deploy connected objects,
- Where is my Data ??
- neOCampus,
- What's next ?

** Remember Ti's great analog engineer, Bob Pease*





The painful way to deploy connected objects ...

➡ Connected objects need:

- Power



... solar panel,
RF energy harvesting,
Temp. gradient ...

- Network



WiFi



Bluetooth



Zigbee



- Infrastructure



AWS IoT



* *Connected objects deployment : the manager's vision ...*

(1) you **buy** (\$\$) a sensor,

(2) you plug,

(3) it works !

...

...

(4) \$ renewal / maintenance

(5) \$ renewal / maintenance

etc etc ...

It \$\$\$\$ a lot, that's normal ... maybe not !



\$\$



LPWAN
subscription

\$



Subscription
renewal &
maintenance

\$

= \$\$\$\$\$...

* *Connected objects deployment : the researcher's vision ...*

- (1) power is everywhere and costs nothing (!),
- (2) network ... hey, it's already there :)
- (3) you buy cheap components (from far far away),
- (4) you build your cheap wonderful sensor,
... it works ...
... but ...

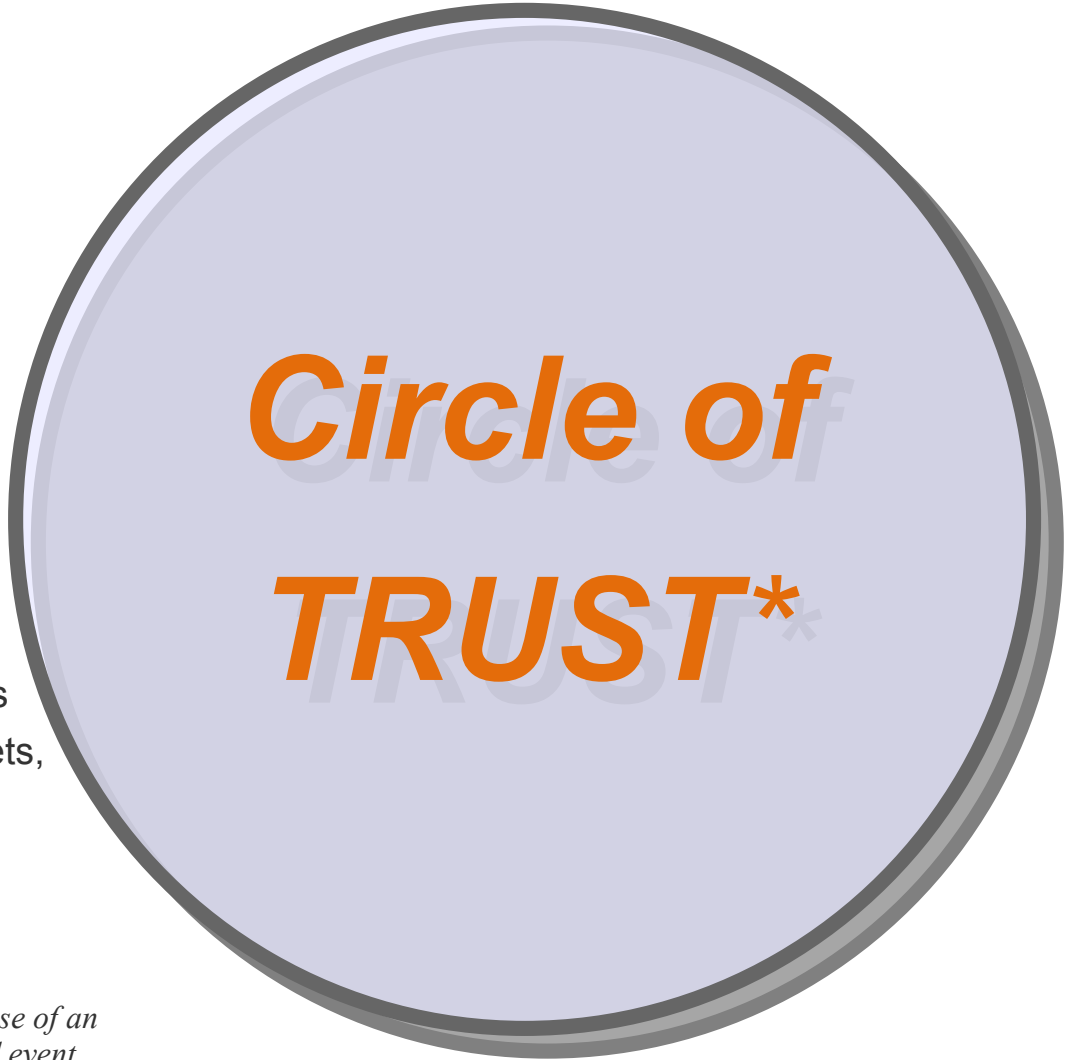


You just forget the most important thing ...

= di\$a\$ter..

... the uttermost ingredient you need is ... TRUST!

YOU 



**Circle of
TRUST***

Managers don't care about how cheap your sensor is
... they're accustomed to tens of millions Euro budgets,

they want:

- availability,
- maintenance,
- certifications,
- ...



*.. just in case of an
unexpected event ...*

** Meet the Parents ;)*

The painful way to deploy connected objects ...

► How can our sensors escape our labs ?

Public IP
server

Wireless
network

Power to
sensors



[> 6 months] IoT vlan + 1st switch
[> 2 years] spreading across the campus.

Fails to deploy @ BU ...
... but DC network @ MRL
... future LMDC renewal





Plan

- [Foreword] the painful way to deploy connected objects,
- Where is my Data ??
- neOCampus,
- What's next ?

Where's my Data ?

* ... *probably the first question you'll get asked ...*

► You finally convinced someone about your cheap, neat and wonderful sensor ...

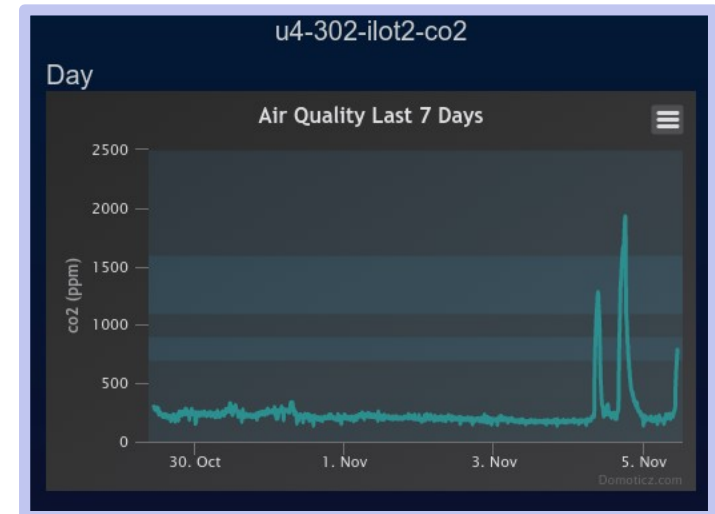
... they accepted to give it a try ...

... you found power and network ...

... but now ... they want to **see** the data !



*a **HUGE** gap !!*



Where's my Data ?

* now you try bridging such gap via different paths:

[1] the Jedi way ...

- A fully featured Linux server with nginx/apache, 
- A broker (MQTT) to collect the data, 
- A database to store the collected data, 
- A web application to see the data ! 

@neOCampus

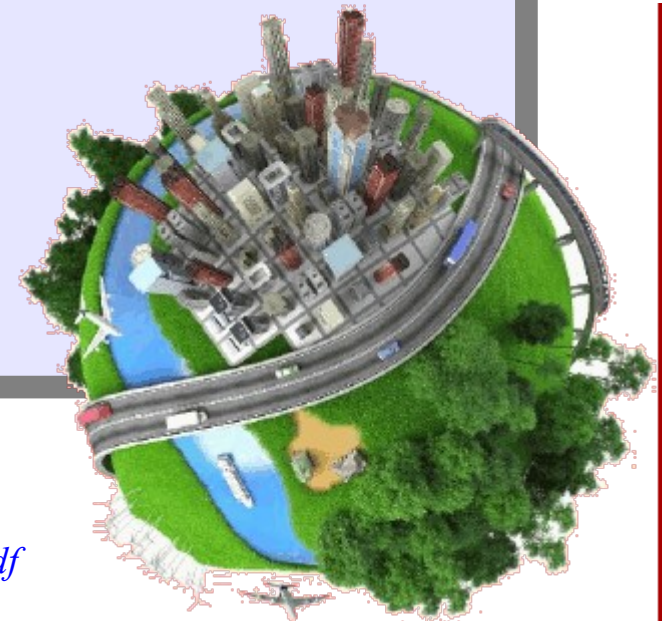
2 years

... with a lot of background
in Linux system, network,
web server, databases,
containers, ...

[2] the lazy (right?) way ...

- \$\$ to rent an IoT server,
- Configuration of existing tools,
- It works !

- [Foreword] the painful way to deploy connected objects,
- Where is my Data ??
- neOCampus,
- What's next ?



M2-SIAME IoT course at https://m2siame.univ-tlse3.fr/teaching/francois/IoT_course.pdf

- 2013, June, kick-off,
- ECO-CAMPUS Toulouse,
- B. Monthubert President



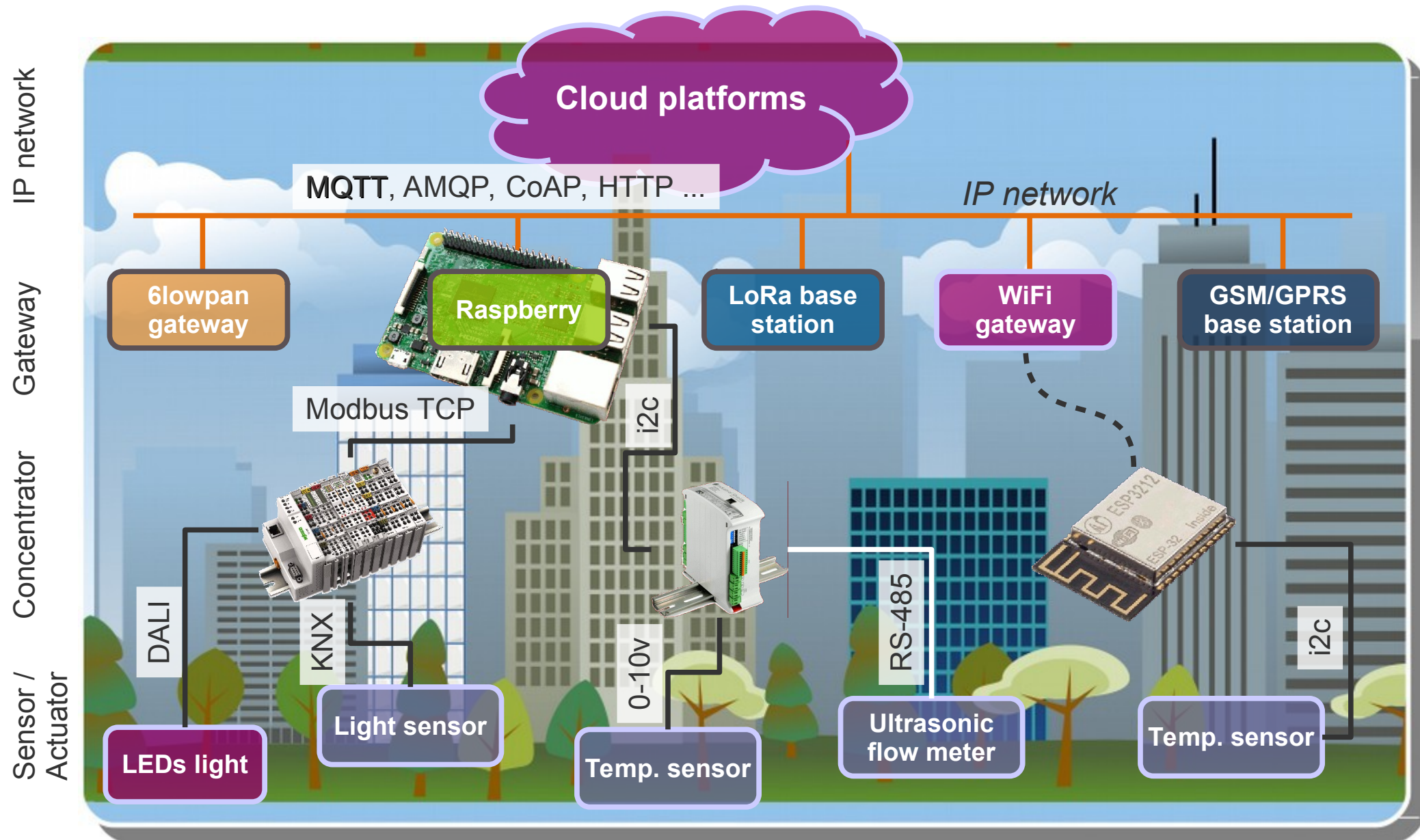
- Buildings ~ 407 000 m²,
- People ~ 36 000

- Well-being for users in the university community,
- Improvement of the ecological footprint of our buildings,
- Reduction of operating costs, especially for fluids.



Our campus is a small-sized town like Périgueux.

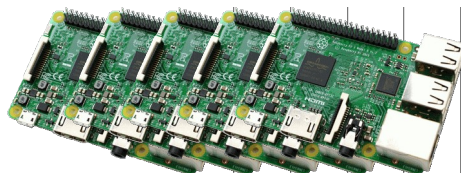
B. Monthubert



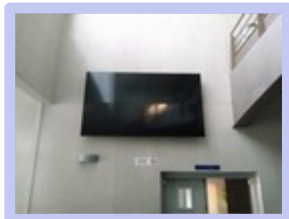


neOCampus infrastructure

~ 40 x Raspberry Pi
~ 3 x Concentrators
(RPI + industrial Arduinos)



neOCom
(connected displays)



myGates
(automatic fences for
autonomous vehicles)

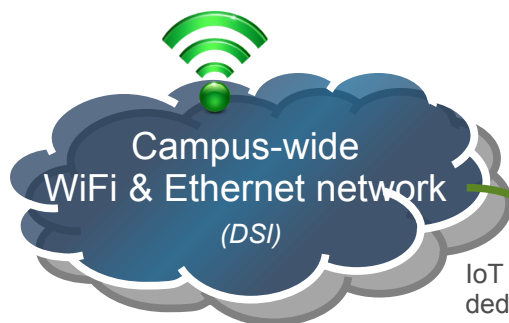


Federated
LoRaWAN network
(868MHz, 3 gateways, BU
santé & sciences, Ecolab)



Note: LoRa deployment is a
joint work with Pr R. Kacimi.

neOTraffic@BU, U4
(attendance measurement)



IoT end-devices
dedicated vlan

<https://neocampus.univ-tlse3.fr>

LoRaWAN server

<https://lorawan.univ-tlse3.fr>

~100 million data

Comms
(MQTT)

~500 access / s

Apps.



1 x Dell R730 @ DSI

Connected hives
(Rucher université)



neOSensors @BU
(noise, temp., lux sensors)



~ 10 x neOSensors

Amilab

(IRIT2-366)

neOCampus R&D area

RPi auto deploy & update

- Network automated install and configuration of our Raspberry Pi(s) :)



- ✓ FAT32 formatted SDCard
- ✓ Unzip <http://neocampus.univ-tlse3.fr/images/noobs.zip>
(custom NOOBS tailored to suit our needs)



- ✓ Download & install latest neOCampus-Raspbian
- ✓ Git retrieval of fully automated setup of the OS & application to deploy.
+ works at home (depends on your internet provider)

neocampus.univ-tlse3.fr

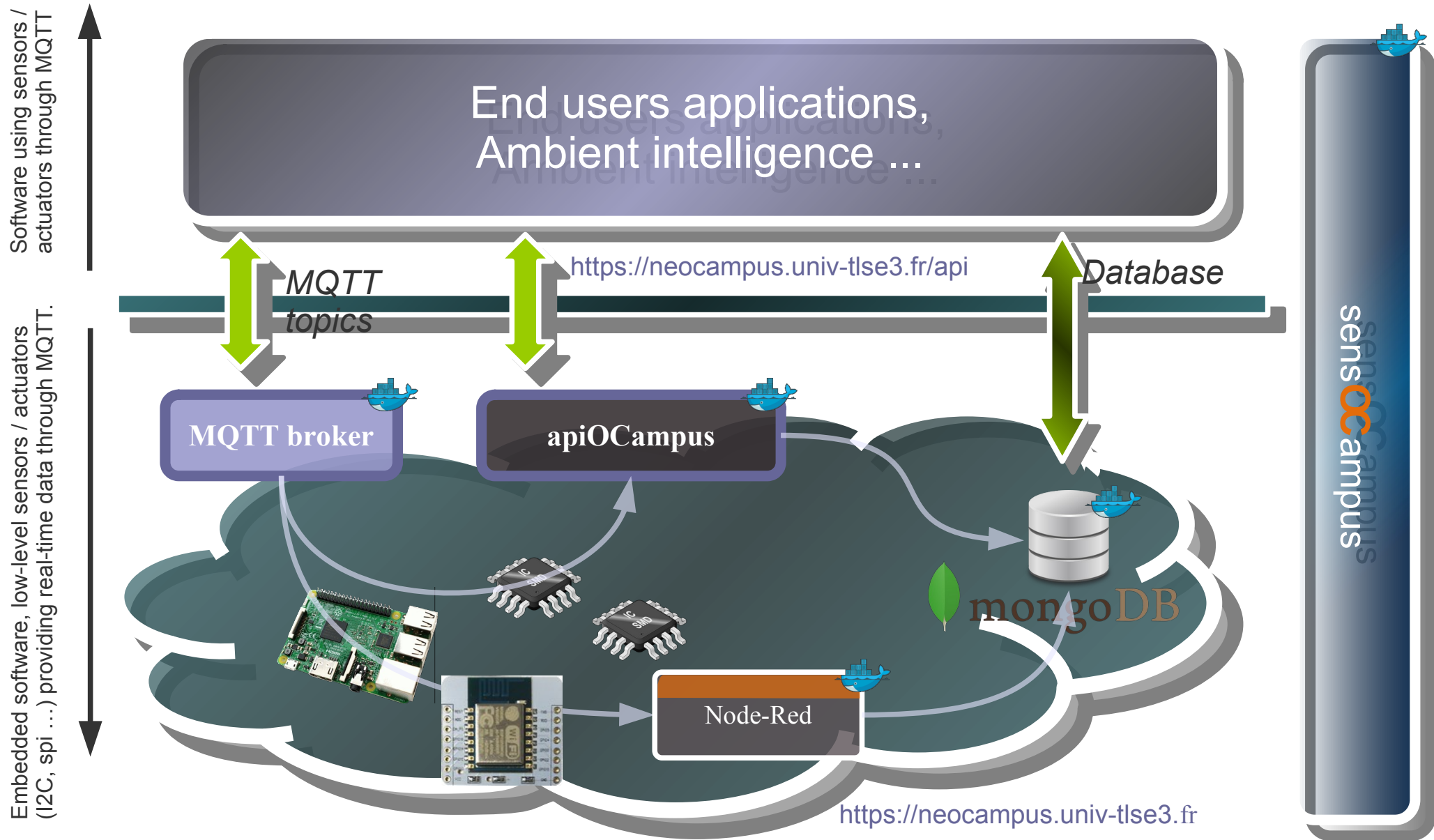


DHCP

Network automated installation of our customized Raspbian has been successfully tested on RPi, RPi2 and RPi3 :)

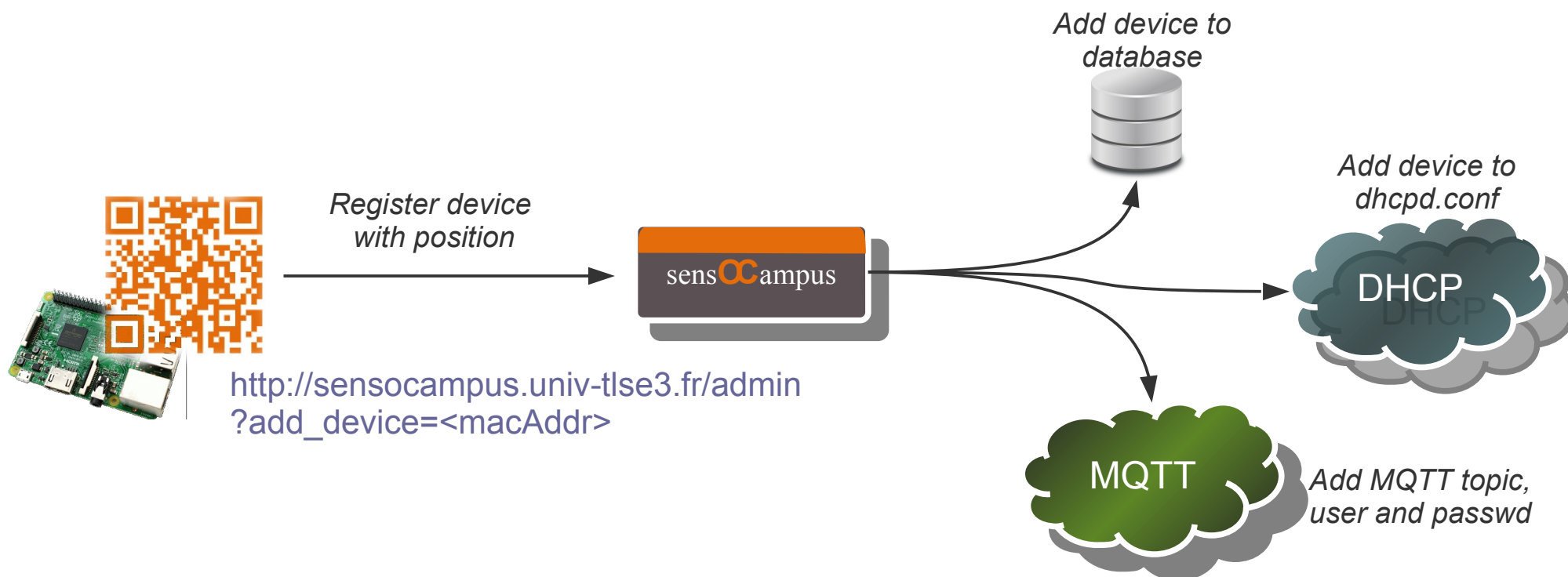


neOCampus infrastructure

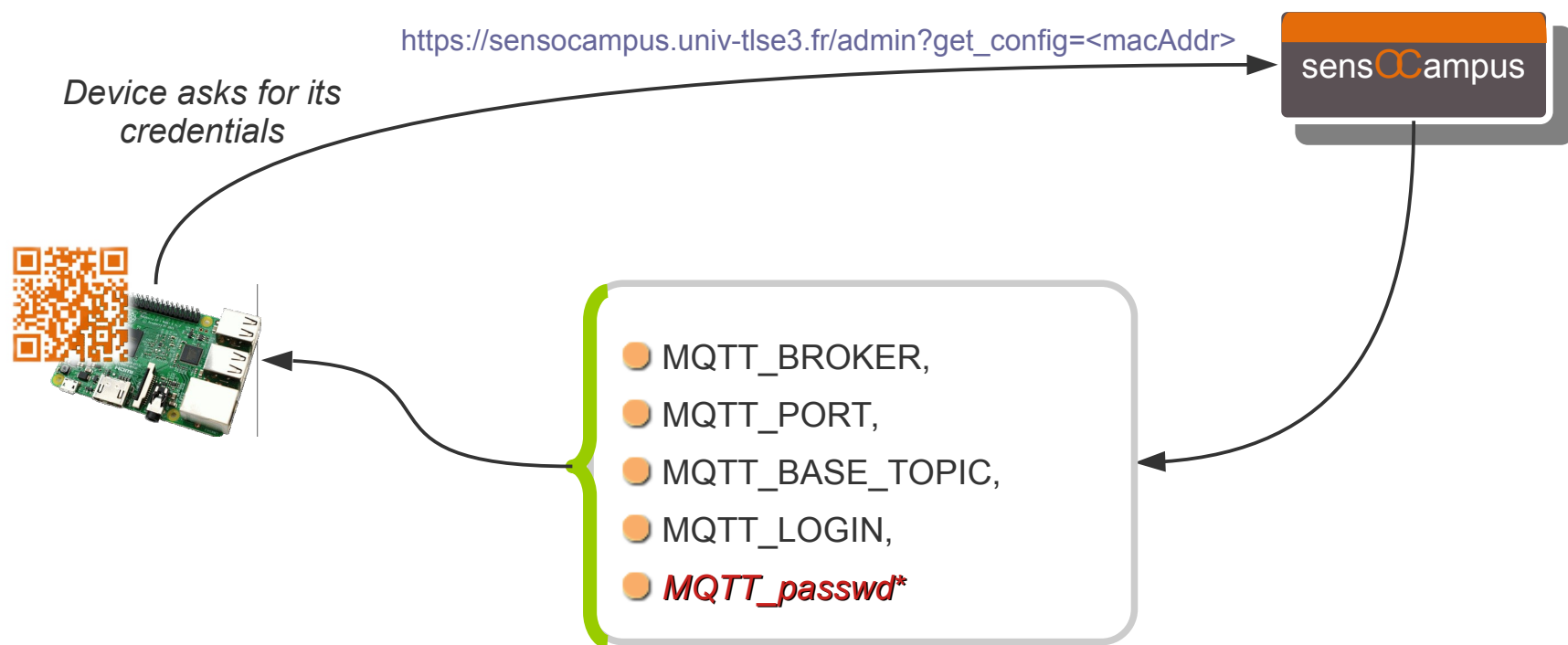


- Device registration | sensOCampus web. App. (Django)

A **device** is a physical embedded system connected to a network (eg. Raspberry Pi, esp8266, stm32 ...).



- ... then registered device fetches its configuration from sensOCampus

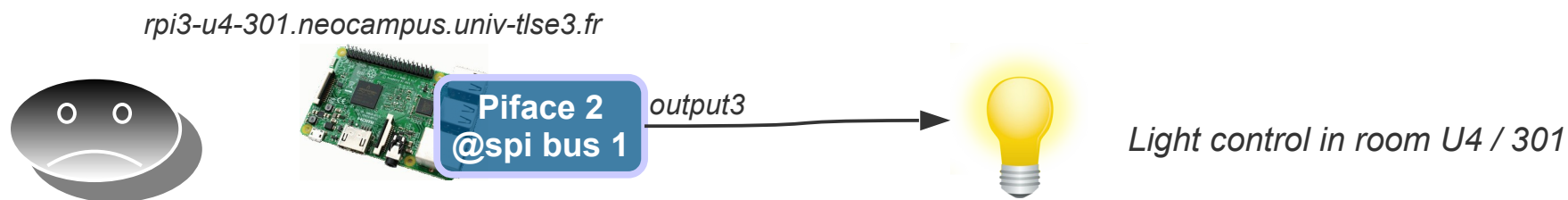


Minimum configuration sent from sensOCampus to a device

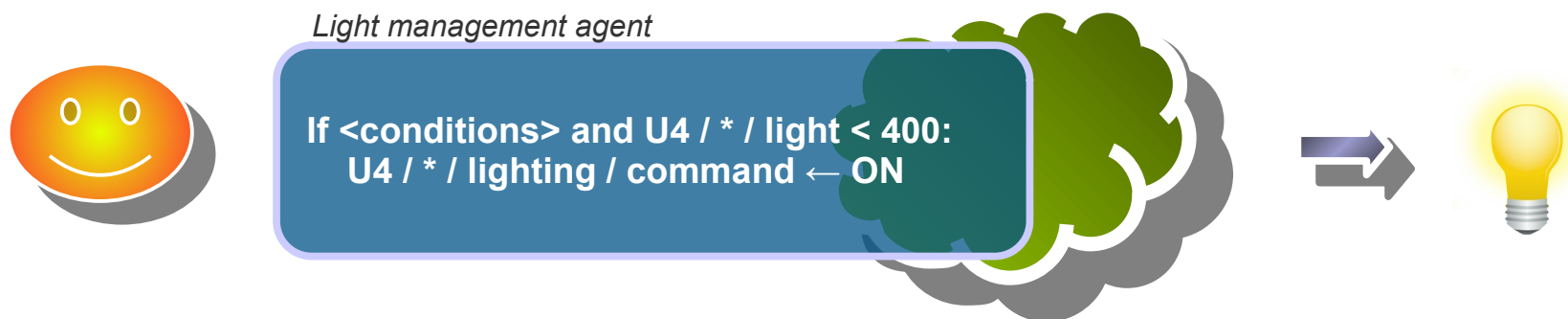
*MQTT passwd is only sent on **first call** (admin action required to create a new one otherwise)

● neOCampus gives users / applications access to useful data without hassle about networks, sensors technology or underlying embedded systems.

✗ High level of hardware details



✓ Useful data





Data acquisition

- MQTT, almost the 'de facto' IoT protocol ;)
 - Network addressing independent,
 - Works behind firewalls,
 - publish / subscribe paradigm (no more pooling),
 - embedded security (login / passwd) + TLS,
 - Support for WebSockets,
 - Bindings for almost all languages,
 - Paho-mqtt (python client), Mosquitto (C written client & server),
 - MQTT bridges for multiples brokers setup,
 - Topics based real-time exchanges,
 - Topics are arbitrary tokens separated with '/'
 - Payload agnostic (mainly json).



MQTT data trade-off:
topic vs payload content.

*You may also have a look to AMQP (e.g RabbitMQ) or CoAP (Constrained Application Protocol)
Adafruit provides a free MQTT broker with a data visualisation GUI on a per-user basis.*

- Topics segmentation in neOCampus

u4 / campusfab / shutter / command



Base | type | [optional] command

Base : defined at device registration time according to location

e.g u4 / 300 or bu / hall ...

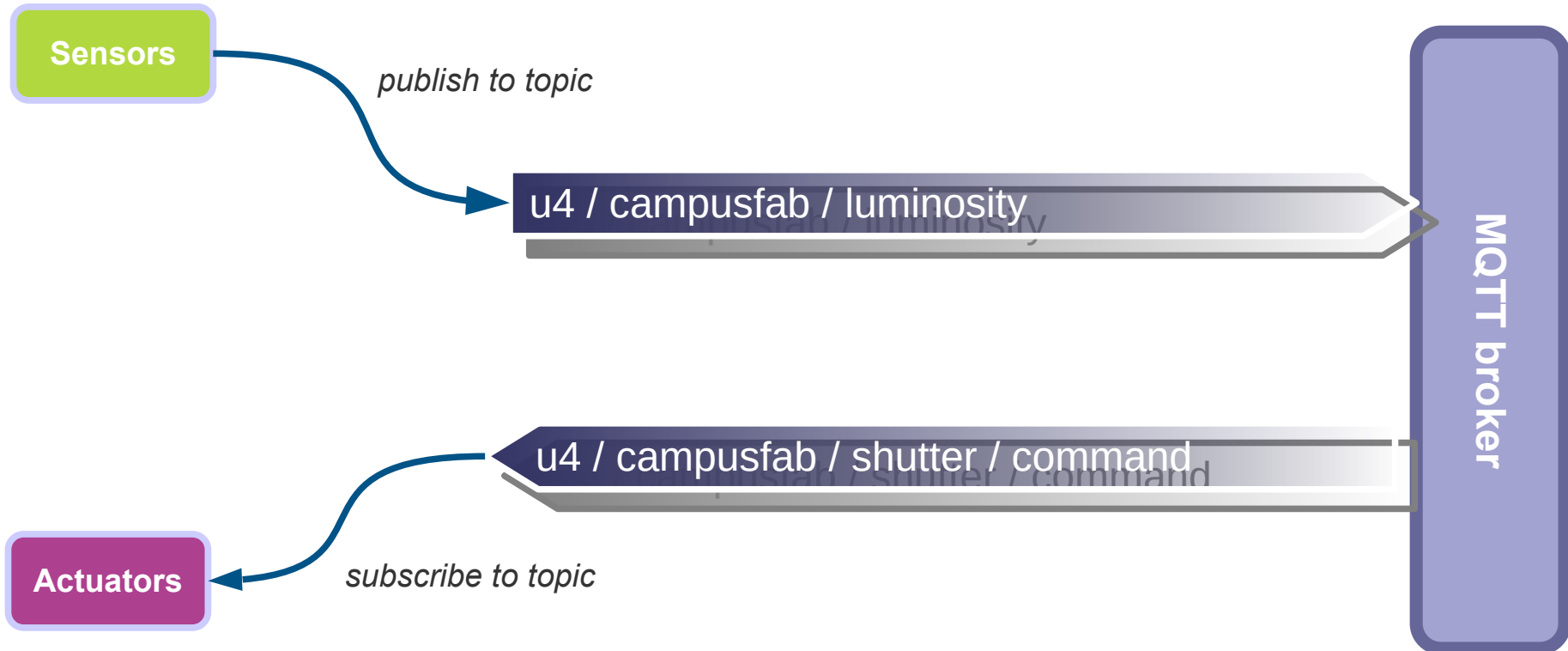
Type : kind of sensor / actuator (module) defined by sensOCampus or automatically detected

e.g shutter, luminosity, temperature, sound, lighting ...

Command : to send orders to a sensor / actuator (module)

e.g orders to shutter like UP, STOP, DOWN

- Real-time data exchange through topics



Since actuators initiate a TCP connection to the broker, they can be sent data back from the broker even when they are located behind a firewall (e.g Internet box).

- MQTT payloads @ neOCampus

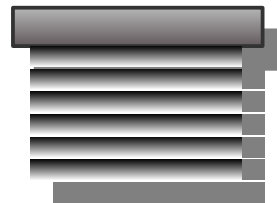
- ✓ Sending order to a shutter (with proper mqtt login / passwd)

```
order: "up"  
dest: "all"  
      or "<shutter_ID>"
```

Json frame as mqtt payload

u4 / campusfab / shutter / command

Shutter



- ✓ ... then shutter publish its status back

```
order: "idle"  
unitID: "<shutter_ID>"  
status: "open"
```

Json frame as mqtt payload

u4 / campusfab / shutter

One caveat is that you can't send an order to a single module (shutter), hence the `dest` field.

- Wildcards for multi-topics subscribing

u4 / # / temperature

multi-level subscribing (e.g u4 / campusfab / temperature, u4 / hall / box1 / temperature)

u4 / + / temperature

single-level subscribing (e.g u4 / campusfab / temperature, u4 / 301 / temperature)

- Single topic publishing



MQTT specifications does not allow to publish to topics containing wildcards.

The `multiple` method enables you to publish multiple data to multiple topics in a one-shot way.



Flow processing

● Node-RED

IBM open-source technology preview,

NodeJS written,

Will glue IoT elements together (e.g connecting IFTTT to MQTT, Amazon Echo to Domoticz etc etc).



Open-source,

Large range of inputs / outputs (MQTT, HTTP, TCP, UDP, LoRa),

... lots of functions (nodes) for storage (MongoDB, files), javascript user code, email, social networks ...,

Dockerized version available.



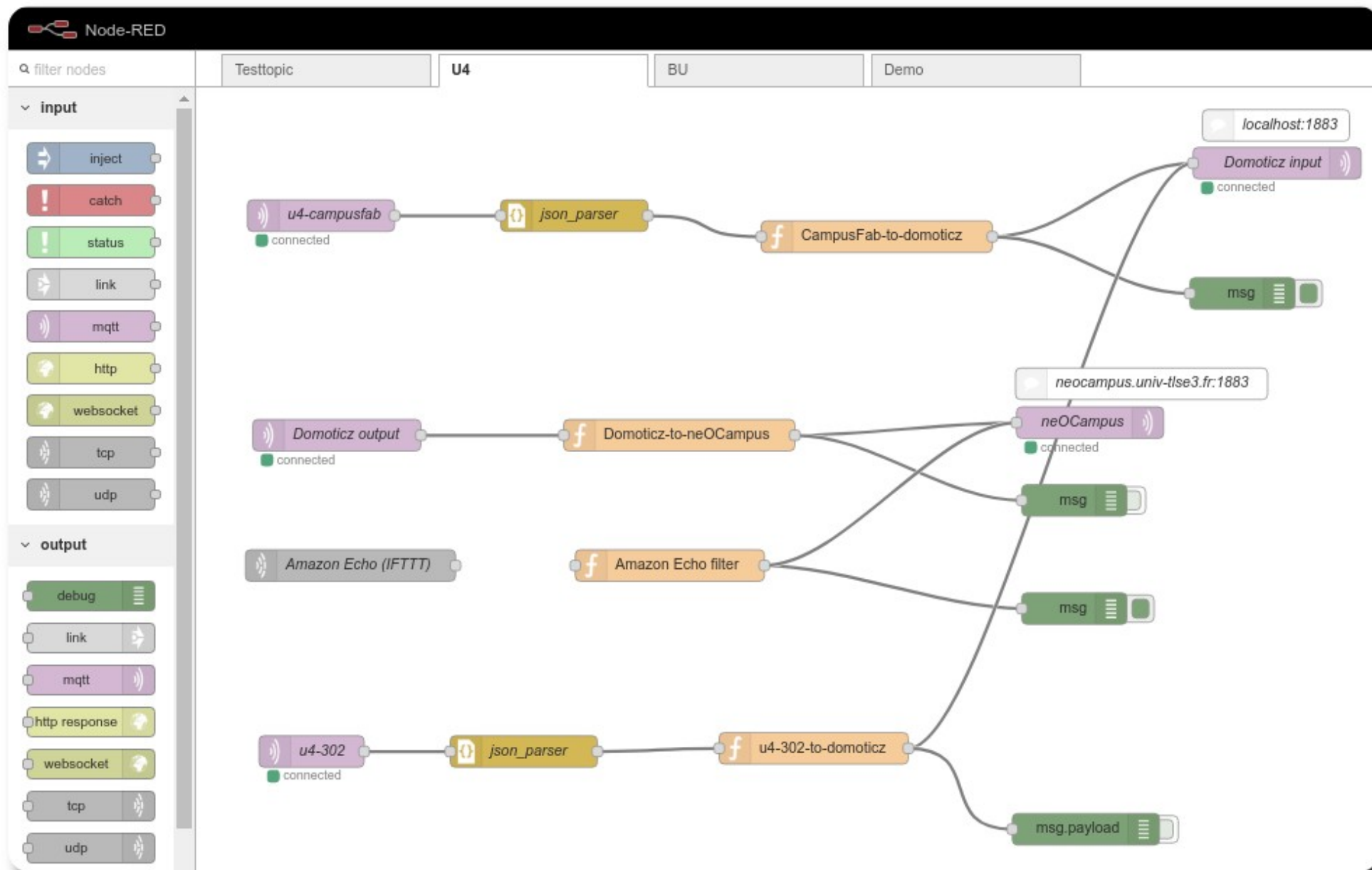
Server-side execution of scripts (!),

No per-user flows,

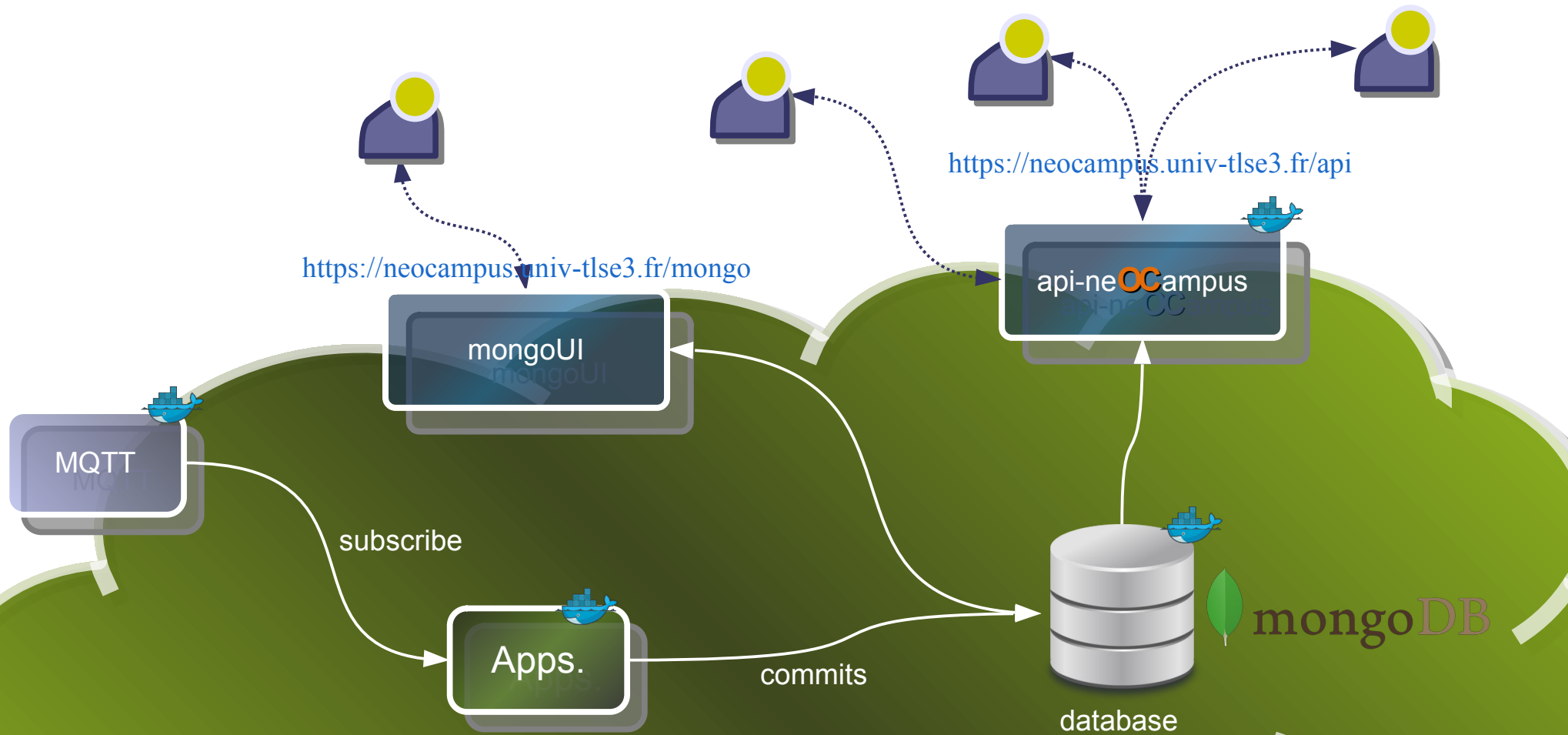
Still < v1.0

You may also have a look to IFTTT (i.e If This Then That)

Flow processing



Data storage & access



... maybe we'll later switch to Apache HBase



Presentation

● Domoticz

NodeJS written,

Dockerized version available.



Open-source,

Simple, efficient and very popular,

Lua programming mode available,

Alarm panel integrated,



Difficult to map sensors / actuators (idx based),

Fails to upgrade,

SBC oriented.

You may also have a look to EmonCMS, OpenHAB and Grafana.



Presentation





Ambient applications

- Ambient intelligence ...

Ambient systems are not a collection of technological objects that communicate but a multidisciplinary, user-centred, approach.

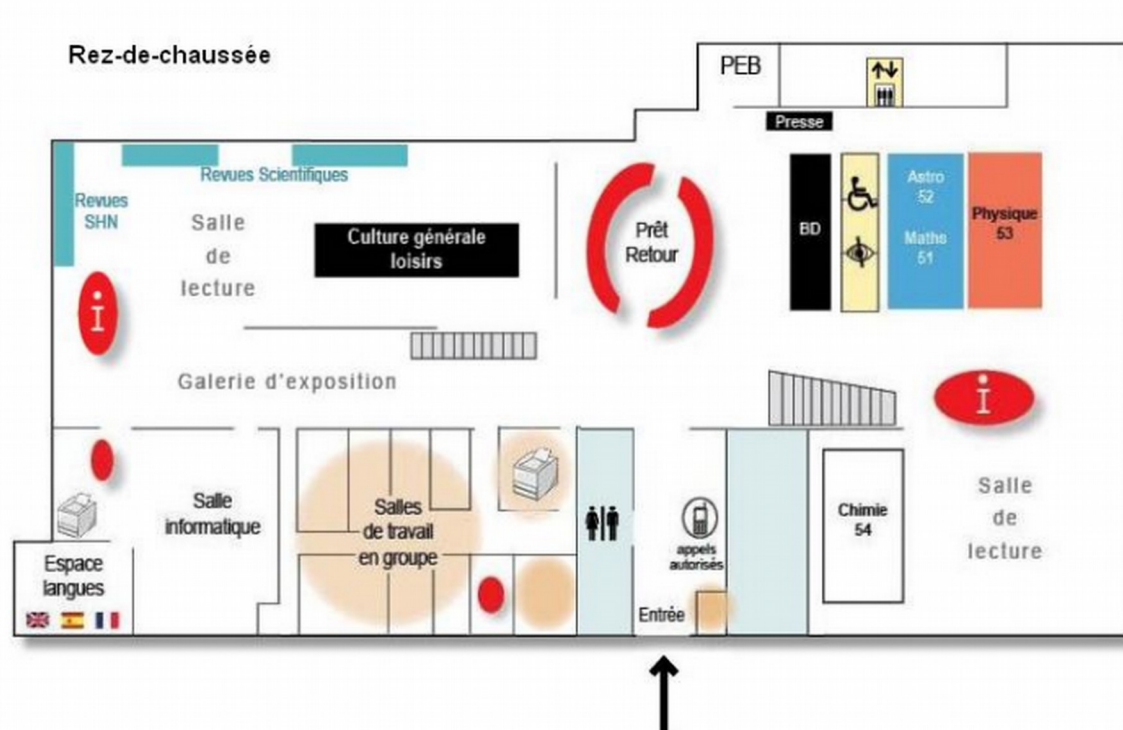
Ambient intelligence provides a service through cooperation between agents spread across the network.

- ... applied to Edge/FOG computing

Deployment of agents within the network nodes and/or end-devices ...

*... but how to ensure in-between applications insulation ?
==> Linux containers !!*

● Noise detectors @ BU Sciences



Zone

hall ▼

Paramètres avancés

Sensibilité

Durée de détection

Nombre de pulses

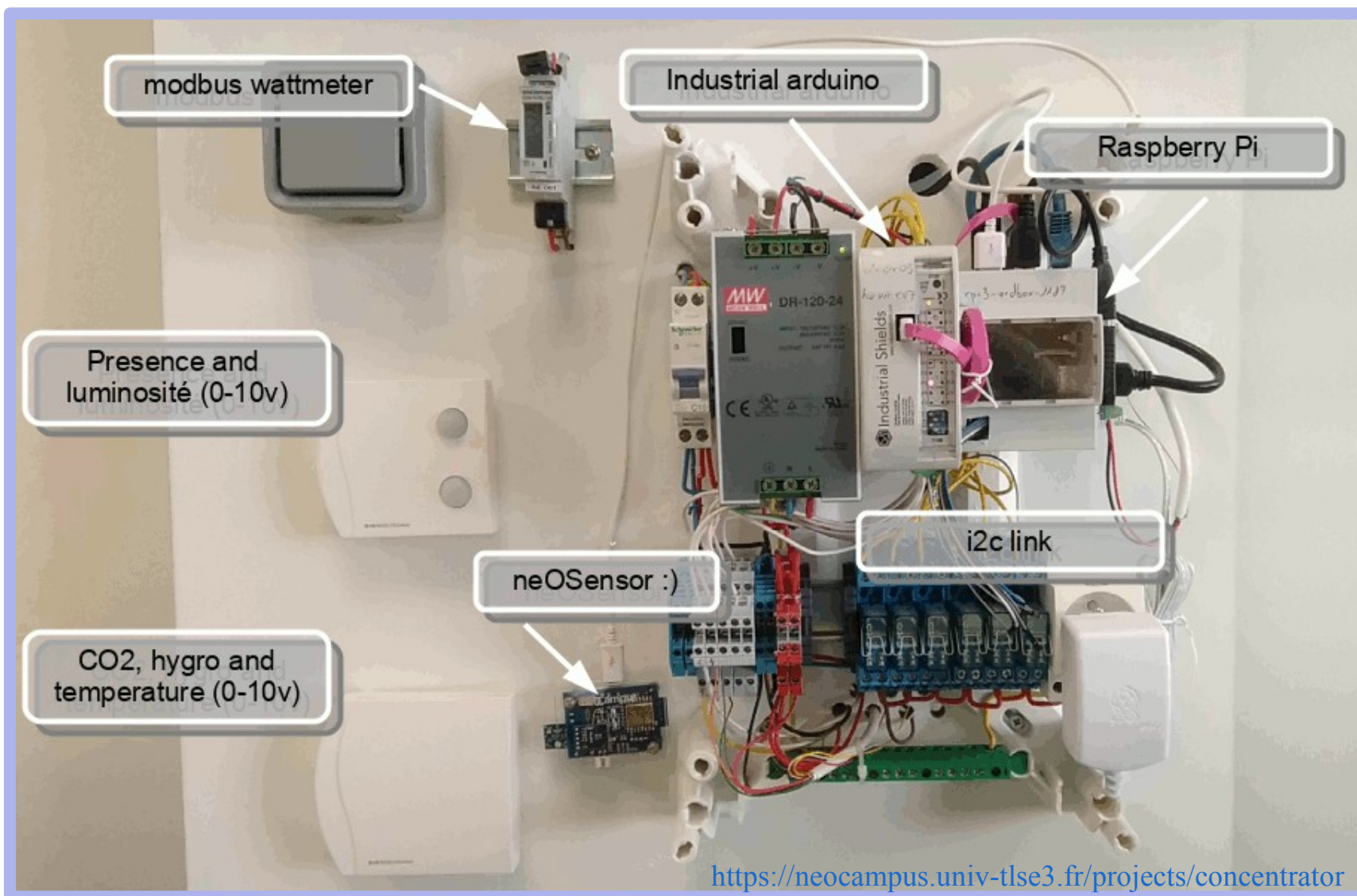
Envoyer

ne@campus

MQTT

<http://affluences.univ-tlse3.fr>

- An open-source PLC that works!



Control Panel*Group of sensors: 3 times per room*

- Luminosity,
- Temperature,
- Humidity,
- CO2,
- Presence.



LoRa usecase: myGates

Raspberry Pi with camera +
License Plate software +
LoRa module

- License plate,
- Timestamp,
- Others...

neOCampus' LoRa
gateways



neOCampus' infrastructure

Comm.
service

Authorization mikro-
service

LoRa
relays

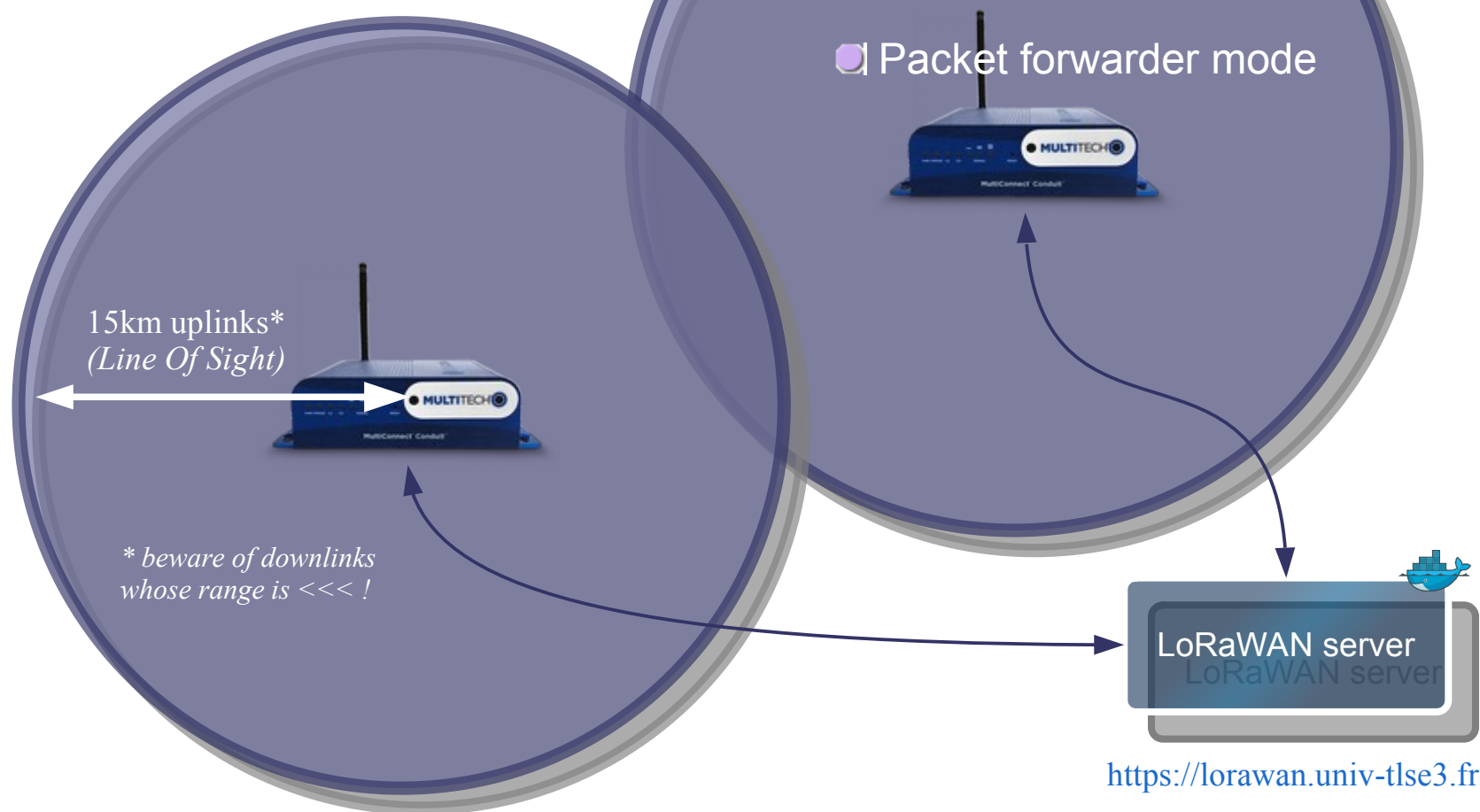
open

License
plate
scan



Model: Tesla
Plate ID: XX-007-YY

LoRaWAN infrastructure



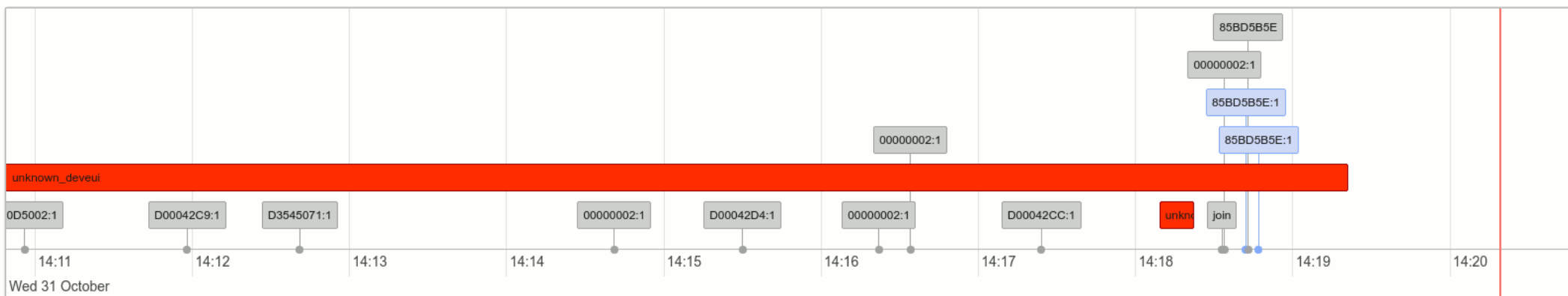
Federated LoRaWAN gateways → centralized authentication & authorization

... ok, but what about **inter-operability** ??



LoRaWAN server

● Dashboard <https://lorawan.univ-tlse3.fr>



Servers				
Name	Version	Memory	Disk	Status
lorawan@neocampus	0.6.3	1 GB (2%)		⚠

Events				
Last Occurred	Entity	Eid	Text	Args
2018-10-31 14:18:33	device	DEADDEADDEADDEAD	join	<<"85BD5B5E">>
2018-10-31 14:18:22	device	70B3D5B100000054	unknown_deveui	
2018-10-31 14:16:19	device	000171FA4167656E	unknown_deveui	
2018-10-31 14:09:46	server		http_error	{404,"/api/nodes/85BD5B5E", <<"admin">>,"172.17.0.1"}
2018-10-31 14:07:48	node	85BD5B5E	repeated_reset	6
2018-10-31 14:07:48	device	DEADDEADDEADDEAD	join	<<"85BD5B5E">>
2018-10-31 14:05:20	device	00016B5D4167656E	unknown_deveui	

Gateways				
MAC	IP Address	Dwell [%]	Last Alive	Status
008000000000C2F1	172.27.12.248	0.146	2018-10-31 14:19:02	✓

Nodes				
DevAddr	Profile	Battery	D/L SNR	Last RX
85BD5B5E	profileNeocampusTest	255	-5	2018-10-31 14:18:47

Connectors			
Name	Application	URI	Status
neOCampus-TestTopic	neOCampus-test	mqtt://frontal.neocampus.univ-tlse3.fr:1883	✓

Frames					
Dir	Time	Application	DevAddr	MAC	U/L SNR
↑	2018-10-31 14:18:47	neOCampus-test	85BD5B5E	008000000000C2F1	6.8
↓	2018-10-31 14:18:43	neOCampus-test	85BD5B5E	008000000000C2F1	
↑	2018-10-31 14:18:42	neOCampus-test	85BD5B5E	008000000000C2F1	4.5
	2018-10-31 14:18:34		00000002	008000000000C2F1	-1.2

* How to create your own end-device ??

- Latest Arduino IDE,
- stm32duino
https://github.com/stm32duino/Arduino_Core_STM32
- BSFrance variant files
https://github.com/fthiebolt/bsfrance_stm32duino
- LMIC library + samples 😊

```

Blink | Arduino 1.8.5

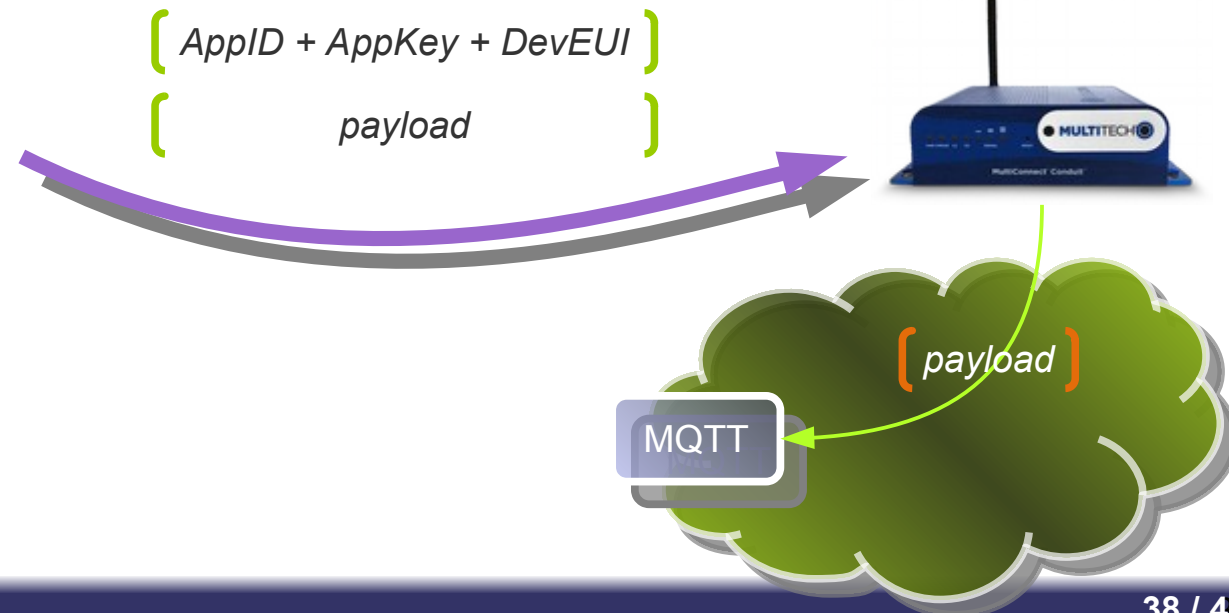
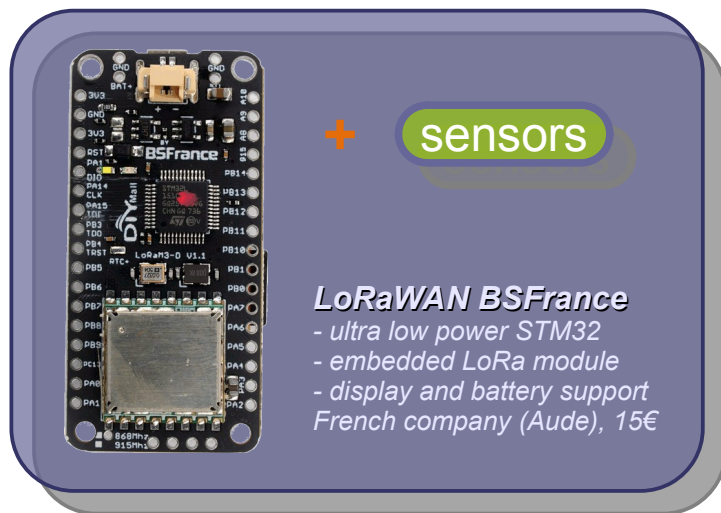
This example code is in the public domain.

http://www.arduino.cc/en/Tutorial/Blink

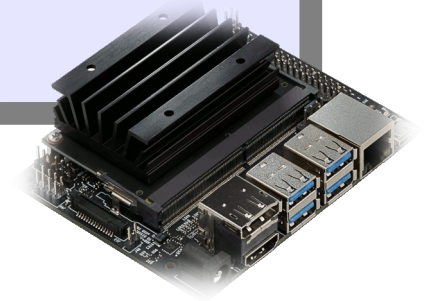
*/

// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000);                     // wait for a second
  digitalWrite(LED_BUILTIN, LOW);  // turn the LED off by making the voltage LOW
  delay(1000);                     // wait for a second
}
  
```



- [Foreword] the painful way to deploy connected objects,
- Where is my Data ??
- neOCampus,
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What's all this autOCampus stuff, anyhow* ?

autonomous vehicles going in and out of our campus

- myGates automation for autonomous vehicles,

License plate has been recognized and
neOCampus gave authorization :)

Vehicle model recognition

(Vincent Nam-Dang ---M2 internship)

- V-to-X 5G infrastructure deployment,
(Orange & R.Kacimi)

Fast-data (i.e low latency) from vehicles (raw
cameras, sensors, CAN bus ...)

- toward an **AIoT** infrastructure ...



neOCampus main server

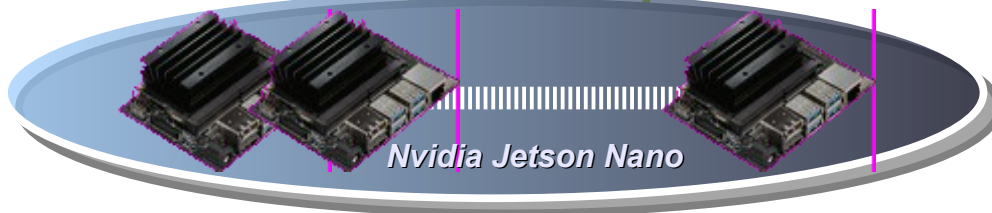


50TB NFS server shared with CloudMIP

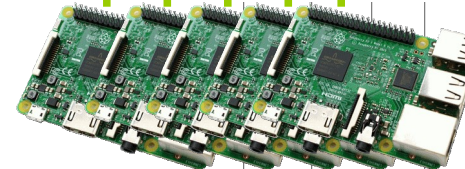


Public network

neocampus dedicated vlan



Nvidia Jetson Nano

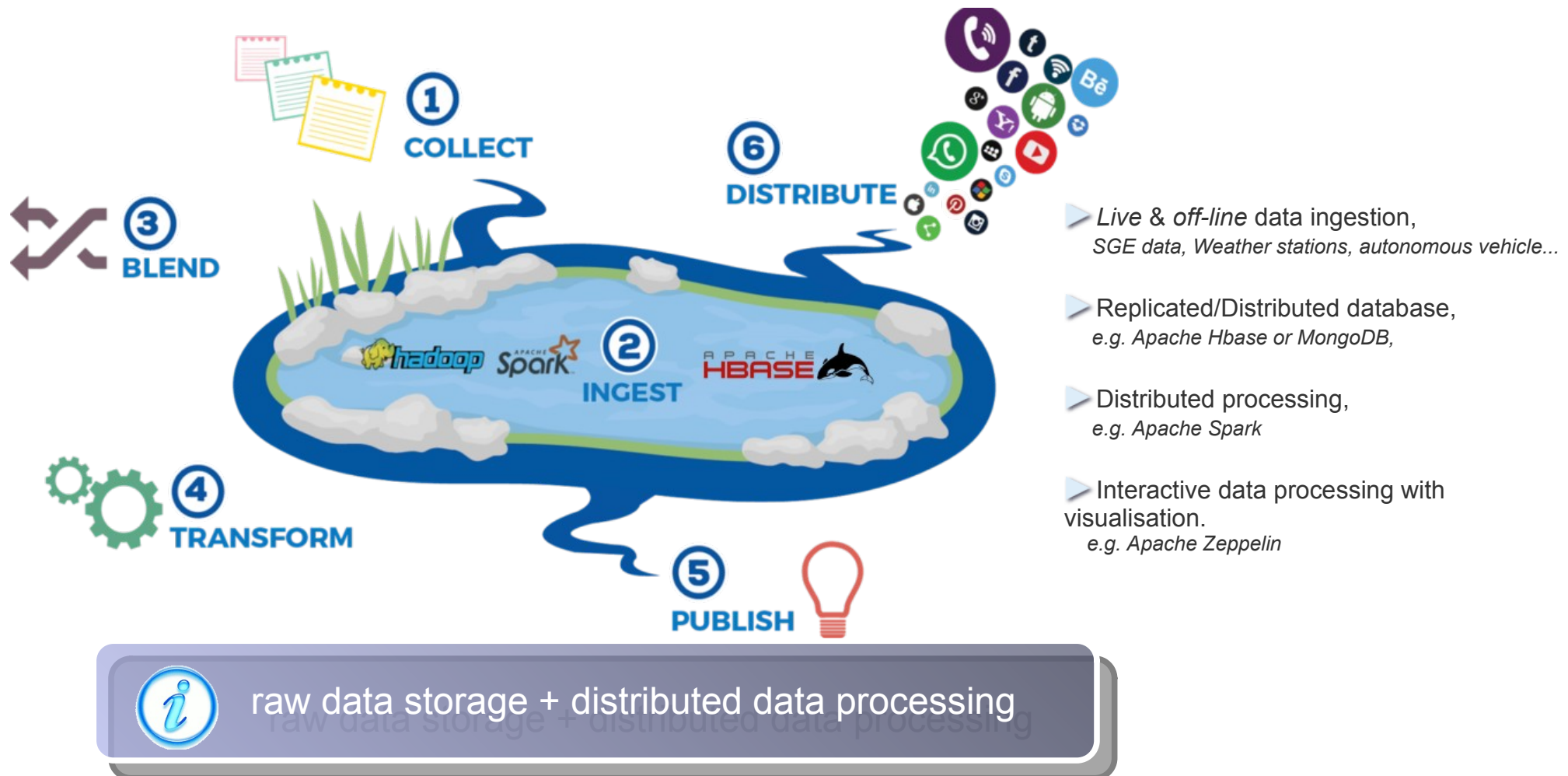


* Remember Bob Pease

towards a Data Lake

- A major concern for both University's services, SGE ... and neOCampus

➡ towards a **data lake** ...



- [IoT] neOCampus High Availability (*part of future data lake*),
- [IoT] APIcampus connected hives infrastructure,
- [end-devices] neOSensor v5,
eConnect* LoRaWAN environment sensors, ...
- [buildings infra] DC networks deployment**, LoRaWAN extension @ Ecolab,
neOCom connected displays @ MRL ...
- new DGS patrimoine & *future* neOCampus GIS → tighter integration with University services, part of building renovation/construction planning teams
... and BIM integration later :)



* Feder project jan.20 - dec.22, 1.8M€, mostly about biodiversity, leader: Ecolab.

** is a SEC & STI university services joint effort.

● Proposal for new buildings :



Hey, that's the law!

1% for art (**200K€**)

Proposal for our local PME/PMI and labs !

1% for **local** innovations



Nvidia Jetson Nano

- 4GB RAM
- 4 x ARM 64bits CPU
- 128 cores GPU up-to 472GFlops
- 10w max.

autOCampus Edge computing horsepower
Jun. 19 worldwide availability, #100€



MyOpenCam project

- custom built firmware
- M1 UE projet
- cheap open-source IP camera



LoRaWAN BSFrance

- ultra low power STM32
 - embedded LoRa module
 - display and battery support
- French company (Aude), 15€



Google TPU

- USB3 NN accelerator
- soon ...