IOTLAB

2021

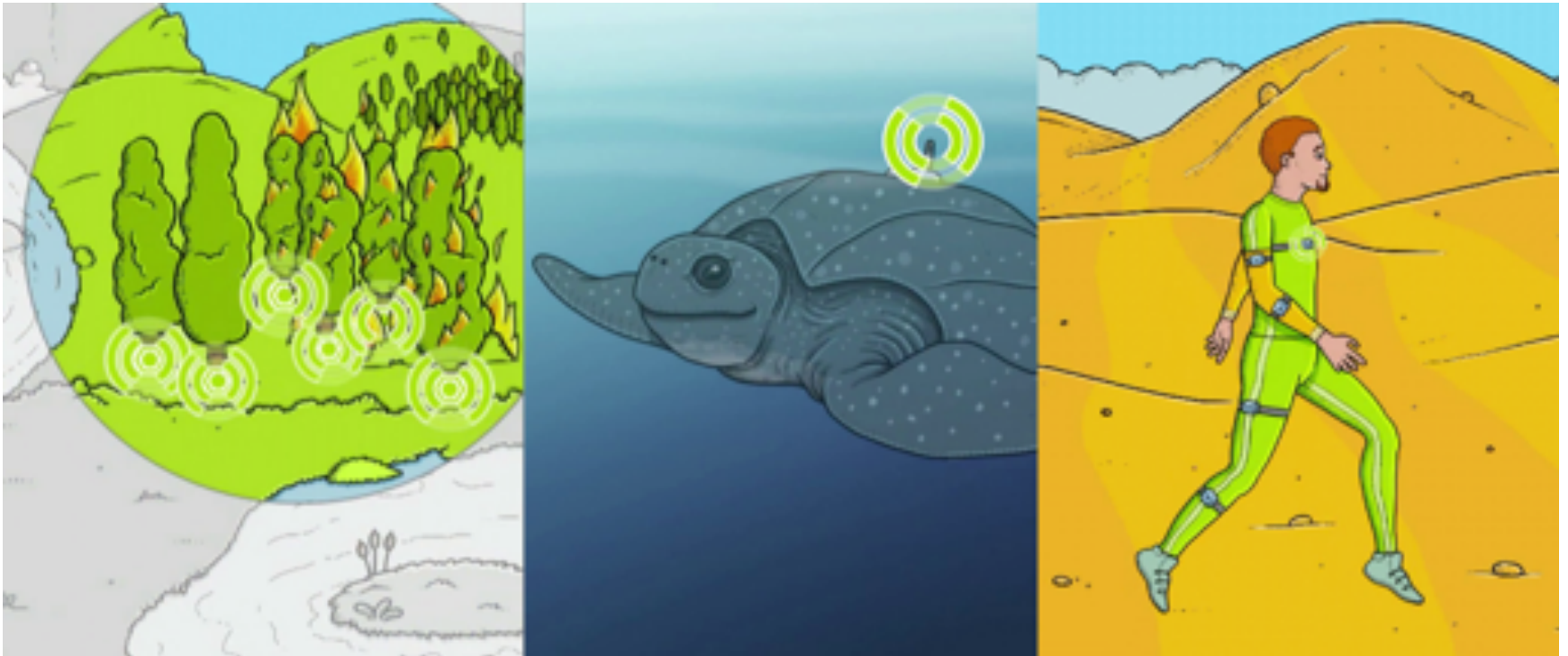**Guillaume Schreiner** (ICube/CNRS)

Scientific Context

Introduction

WIRELESS SENSOR NETWORKS
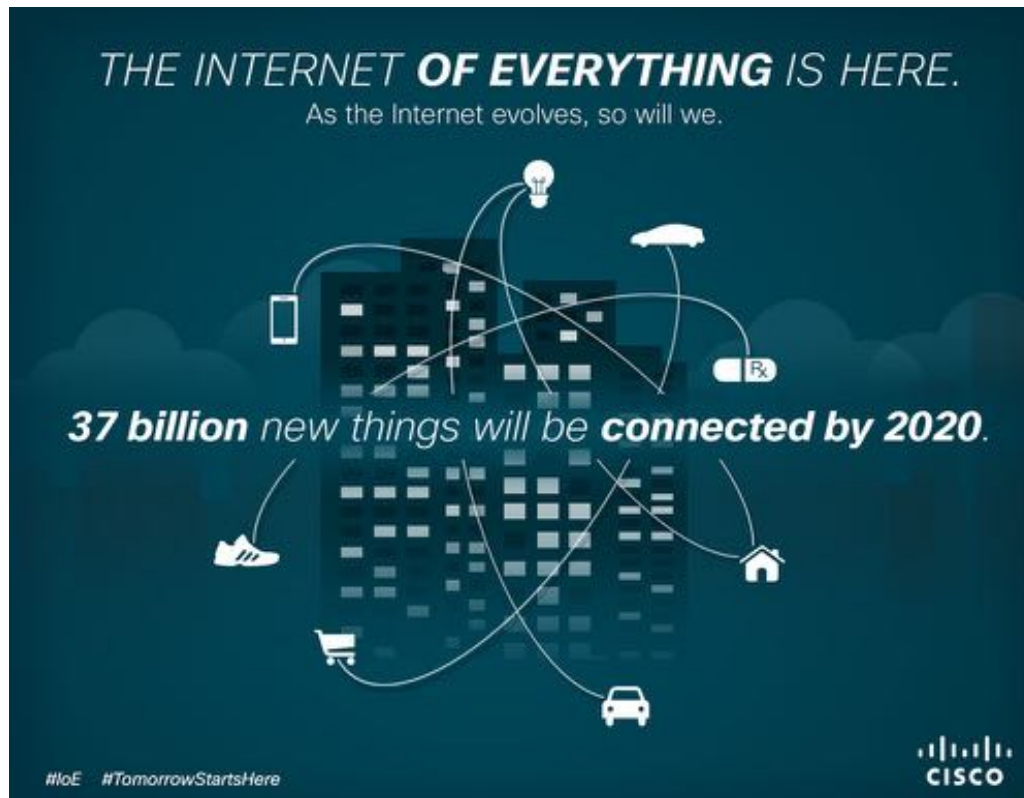
APPLICATIONS

INTERNET OF THINGS

- *Internet of Everything…*
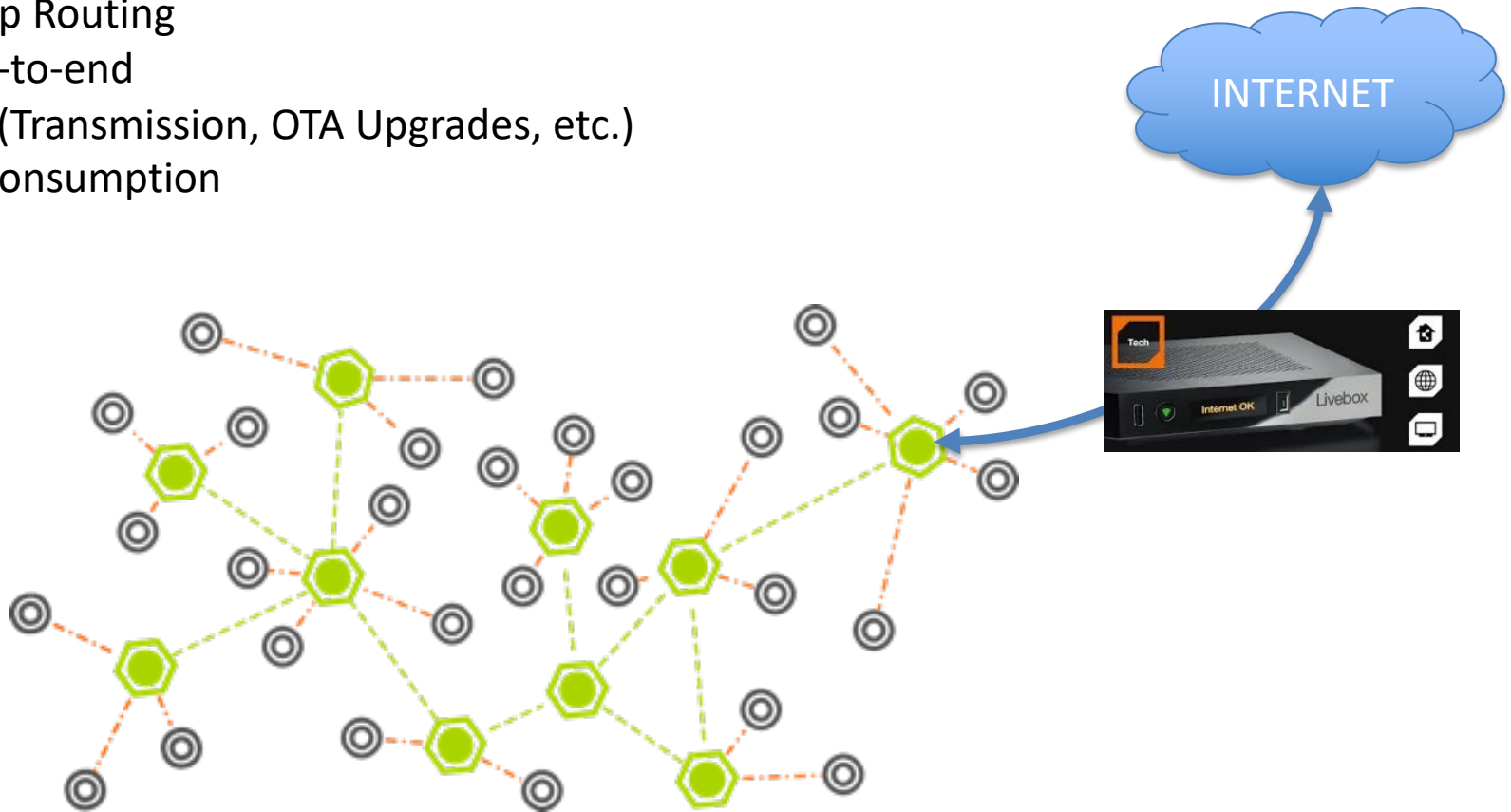
SCIENTIFIC ISSUES

MAC Layer, Routing Layer
Multi-hop Routing
IPv6 end-to-end
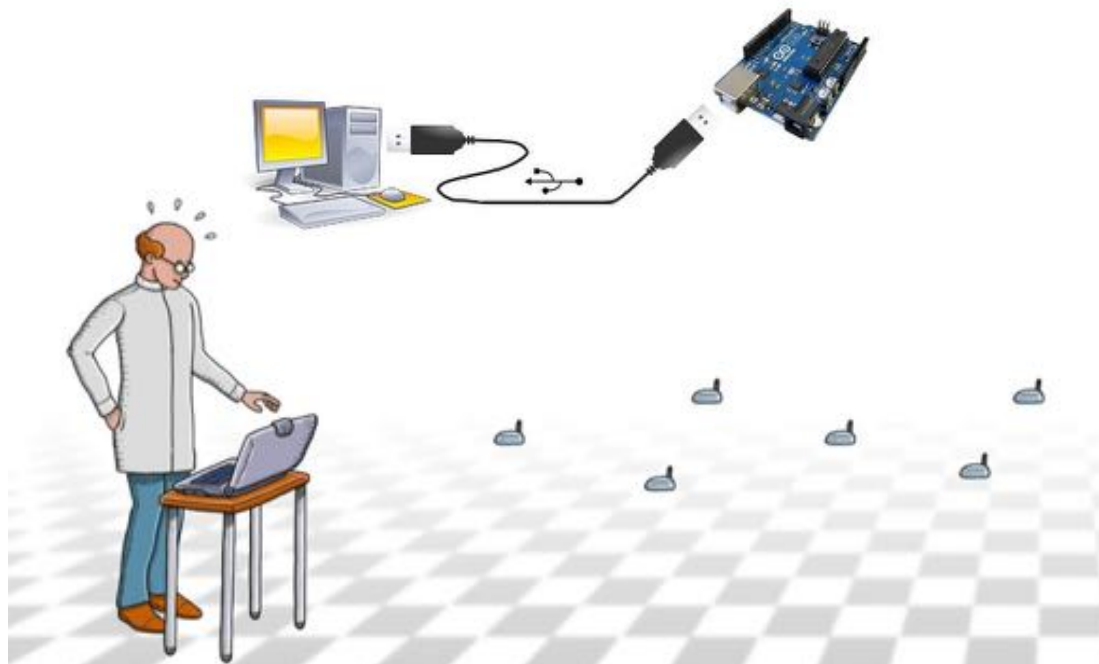Security (Transmission, OTA Upgrades, etc.)
Energy Consumption

…

INTERNET

EXPERIMENTATION

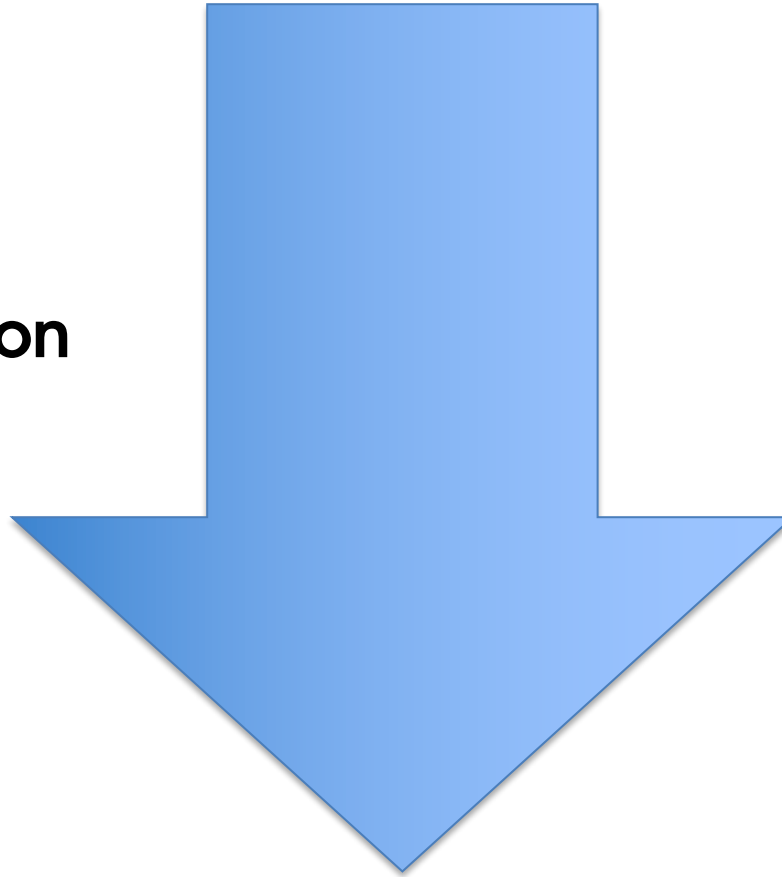- How to easily develop and test a **large scale** IoT application

Testbeds overview

RESEARCH CYCLE

- Idea
- Model
- Simulation
- **Experimentation**
- Deployment

FROM SENSORS TO THE CLOUD

- Complementary testbeds
  - IoT-LAB
  - Grid5k
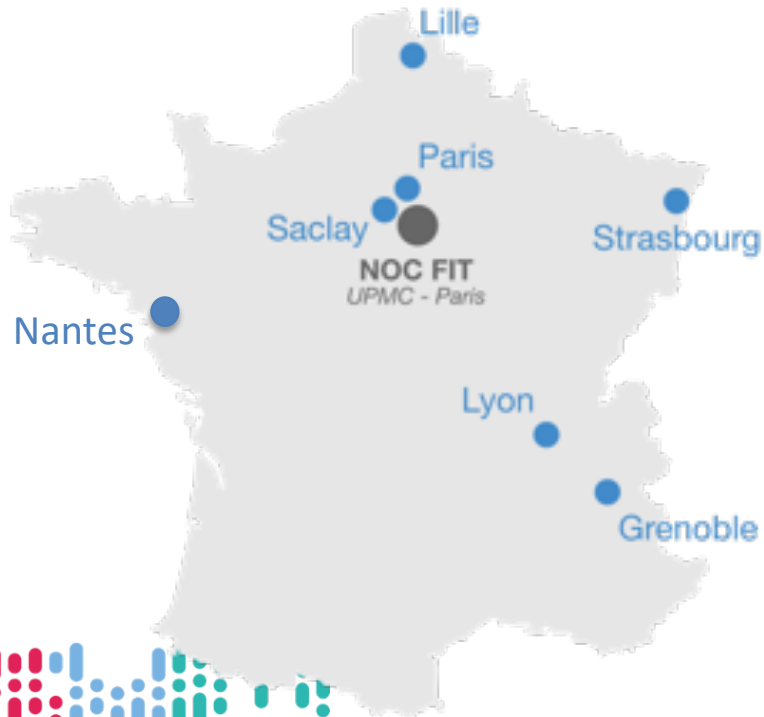- Exemple of experimentation

IoT-LAB testbed

IOT-LAB

- The Very Large Scale IoT Testbed
  - **1500** IoT nodes
  - 7 sites located in France

Strasbourg site

Lille site

IOT-LAB

- Fully **automated**
  - Available 24/7
- **Reproductible** experimentations
- Multi-sites
- **Free Access** for everyone
  - Academic (researchers, students)
  - Industrials
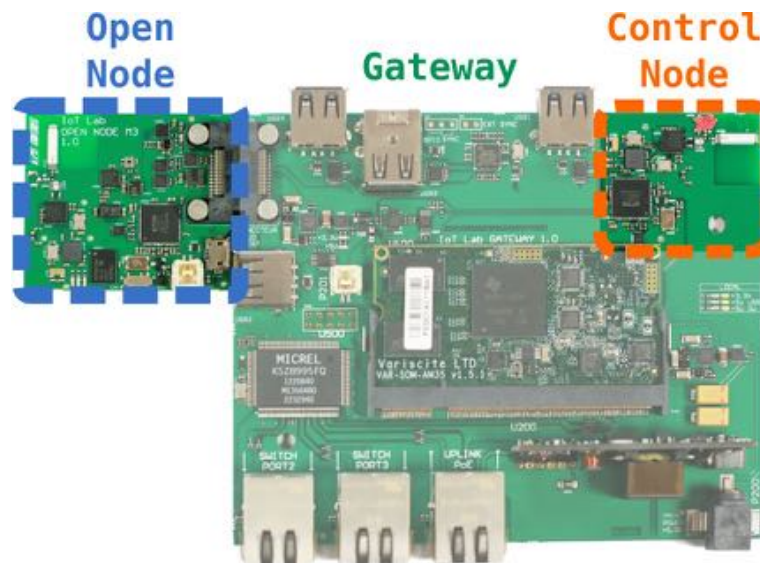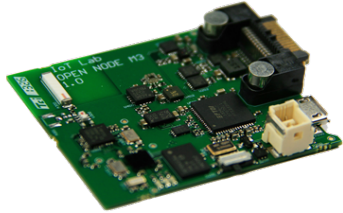
Nodes, Infrastructure

Equipment
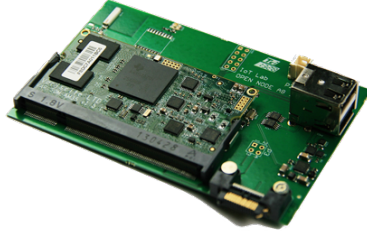
IOT-LAB NODES

- 3 logical components :

  – **Gateway** : uplink to the infrastructure, deploy user firmware

  – **Control Node** : monitoring (energy, radio)

  – **Open Node** : programmable IoT Node

OPEN NODES (LEGACY)

Name (nb)	MCU	Sensors	Radio	
M3 (817)	Cortex M3 (32bits), 72 MHz, 256 kB ROM, 64 kB RAM	• Light • Accelerometer • Pression	• AT86RF231 (2.4GHz)	
A8 (470)	Cortex A8 (32 bits), 600 Mhz, 256 MB RAM	• Light • Accelerometer • Pression	• AT86RF231 (2.4GHz) • Ethernet	

IOT-LAB CUSTOM NODES

- Open Nodes from the market (18 boards)

  – Arduino-zero, Zolertia, ST, nRF, micro:bit, Pycom, etc.

  – https://www.iot-lab.info/docs/boards/overview/

- Requirements : **USB** interface + **Linux toolchain**

Features, Embedded OS, Tools, Learn, Community

Large Scale IoT Experimentations

FONCTIONNALITES

- Large scale user **firmware deployment**
- Automatic performances monitoring

  - Energy, radio level, radio capture, RTL-SDR

- Serial port and debug port access
- User workspace for development

  - Via remote server trough SSH

  - Via local virtual machine

- Public IPv6 networks
- LoRaWAN Infrastructure

EMBEDDED OS

OS	M3	A8	CUSTOM
FreeRTOS	X	-	X
Contiki	X	-	X
Riot	X	-	X
OpenWSN	X	-	X
Zephyr	-	-	X
Linux Yocto	-	X	-

- Test your own OS on our nodes !

LINUX YOCTO

- Image for Open Node

  - A8, Raspberry PI 3 and 4

- Generate IPK

- Github https://github.com/iot-lab/iot-lab-yocto

GLOBAL OVERVIEW

Webportal, CLI-tools,
HTTP requests, Websockets

API

SSH

SITES

NODES
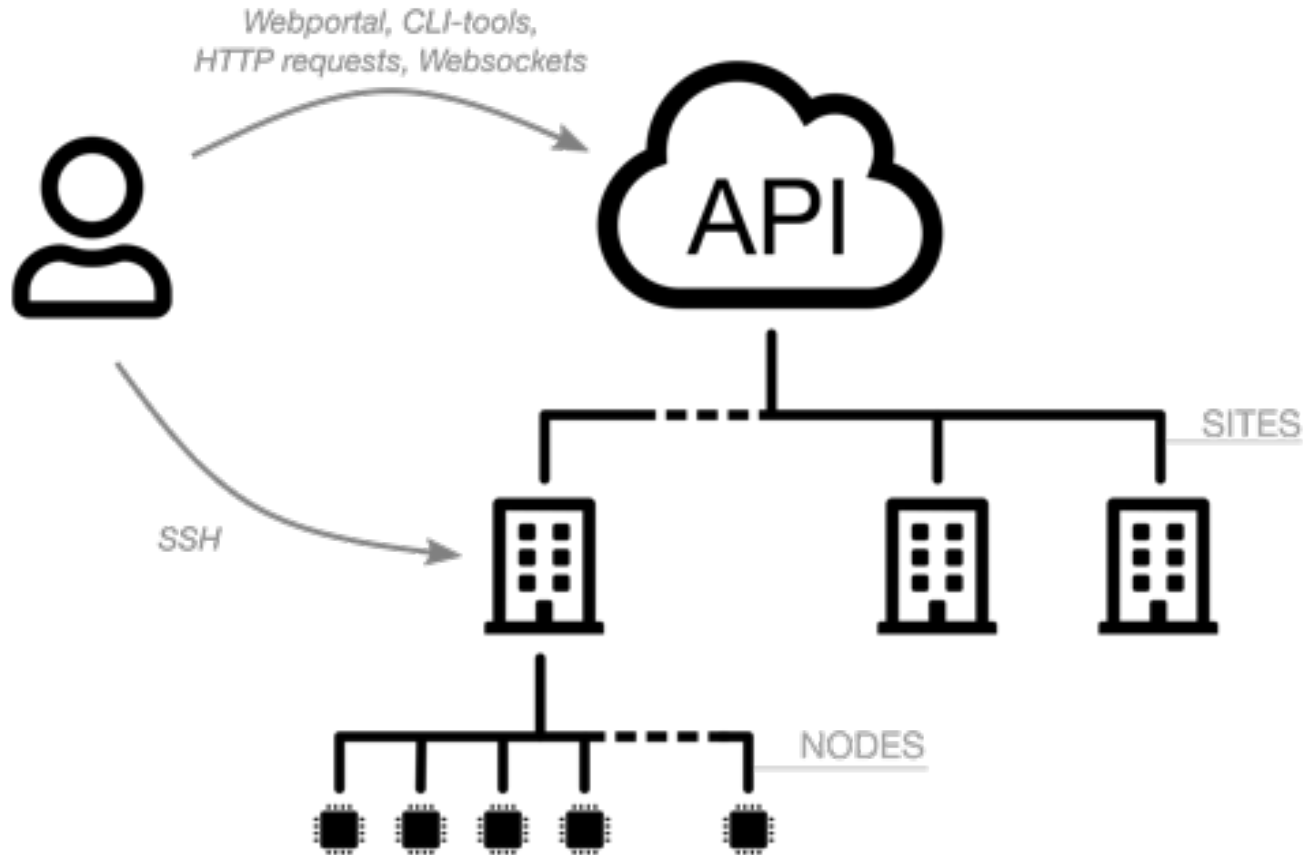
REST API

- Authenticated access
- Experimentation
  - Submit, reload, stop or cancel, resources descriptions, etc.
- Monitoring profile
  - Get, create, modify, delete
- User preferences
  - Modify user, SSH keys, password, etc.

TOOLS

- **Web Portal**: quick hands-on for beginners
- **CLI-tools** + **Run Script**: batch your experiment
  - experiment, node, profile, robot
- **Serial_aggregator** : gather nodes serial output
- **OML Plot Tools** : graph monitoring results
- **Remote debugger** : gdb Open Node
- **Sniffer_aggregator** : gather radio capture
- **Radio characterization** : understand radio topology
- **MQTT & Leshan broker** : forward data to Internet

LEARN

- Quickly hands-on IoT-LAB, Jupyter Notebook & Tutorials

    – https://www.iot-lab.info/learn/

- MOOC : IoT with MCU: a hands-on course

    – Second session in 2021

    – https://www.fun-mooc.fr/courses/course-v1:inria+41020+session01/about

COMMUNITY

- Official Site   http://www.iot-lab.info
- Github   https://github.com/iot-lab/
- Mailing list   users@iot-lab.info
- Register a personal account:

    – https://www.iot-lab.info/testbed/signup

IOT-LAB USERS

Total registered users per year
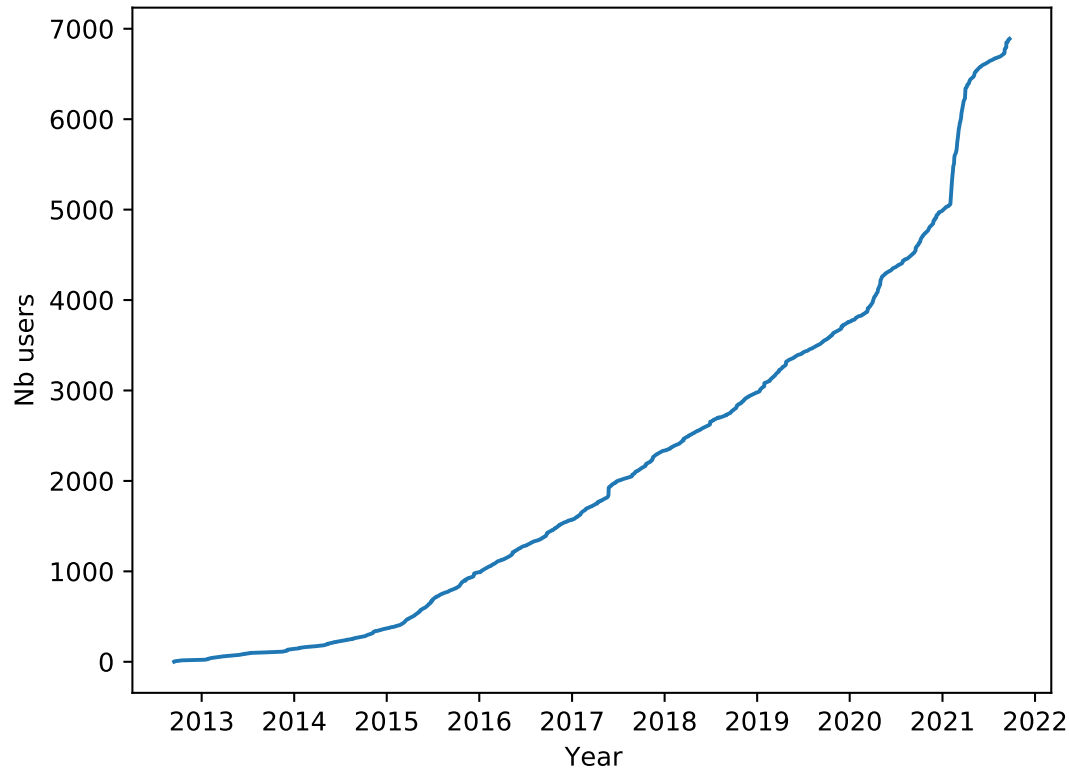
> 7 000 users

🇫🇷	FRA	32 %
🇮🇳	IND	13.4%
🇩🇪	GER	3,5%
🇮🇹	ITA	3,2%

IOT-LAB USAGE RATIO

Total resources exp. ratio per year
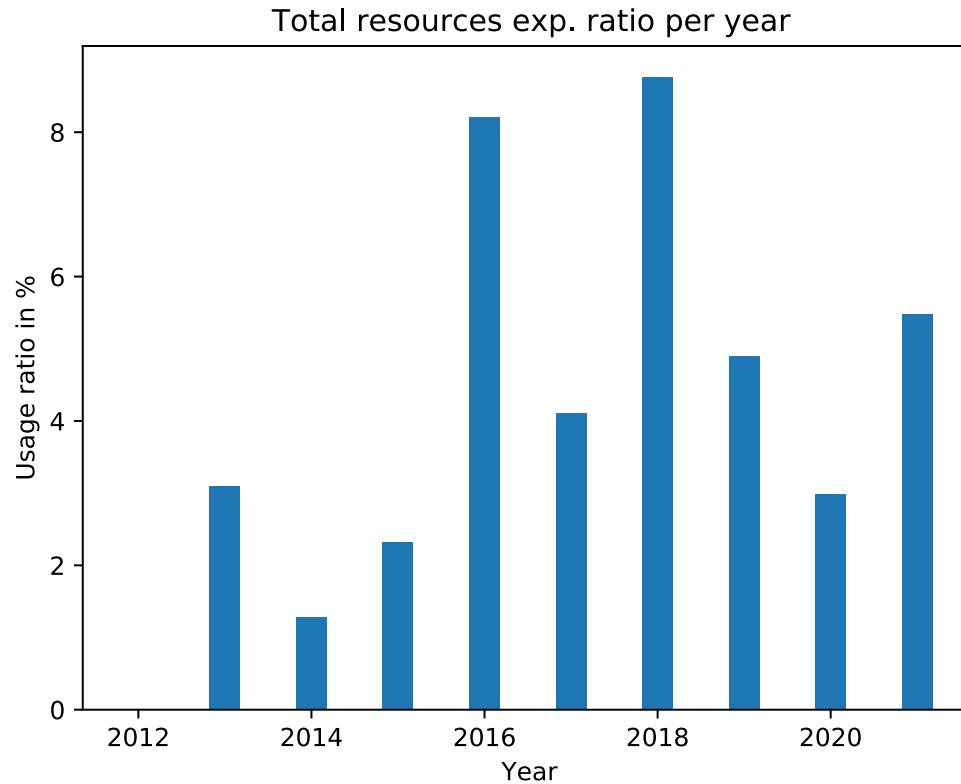
>270 000 experimentations

IOT-LAB PUBLICATIONS

- Publications https://www.iot-lab.info/community/publications/

  – Publications using/citing IoT-LAB **299**

  – https://scholar.google.com/citations?user=RLklob4AAAAJ

    - **2021**: 7

    - **2020**: 15

    - **2019**: 39

    - **2018**: 57

    - **2017**: 36

REPRODUCIBILITY

- Ability to run the same setup several times
    - Firmware
    - Nodes id
    - Monitoring
    - Duration

REPRODUCIBILITY

- Radio interferences issues
    - From others IoT-LAB users (same techno and radio chanels)
        - Solution:
            - book all the site

REPRODUCIBILITY

- Radio interferences issues
  - From outside the testbed (Wi-Fi, Bluetooth, etc)
    - Solutions:
      - Schedule experiment outside office hours (night, weekend)
      - Use an anechoic chamber (expansive, small)

Packet loss
During workhours