



Review Open Call SME Experiments *SDR4IoT*



ALEXIS DUQUE

Rtone

REVIEW OPEN CALL F4FP-SME-2

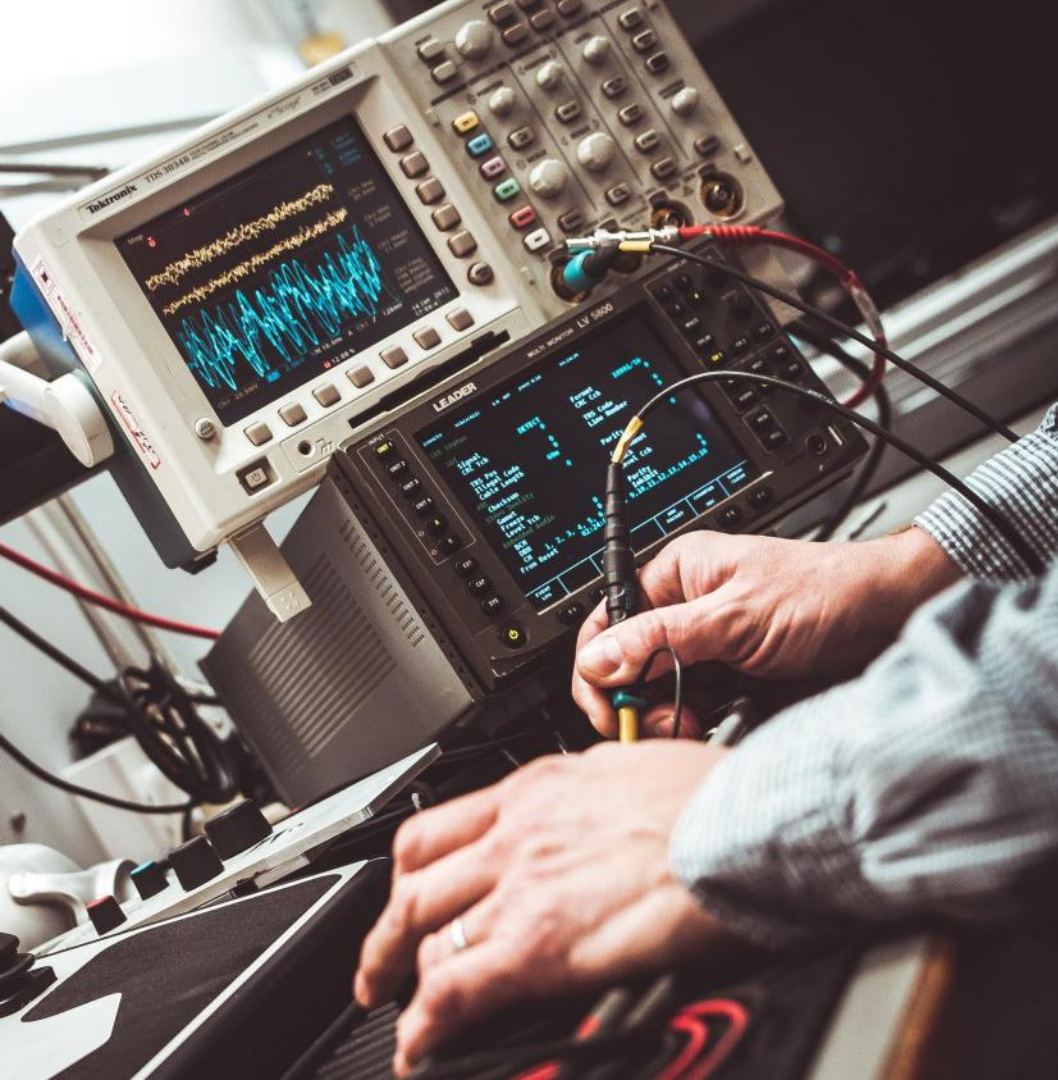
Remotely - Thursday, 27th May



RTONE
IOT MAKERS



Rtone



Experiment Description

Experiment Description

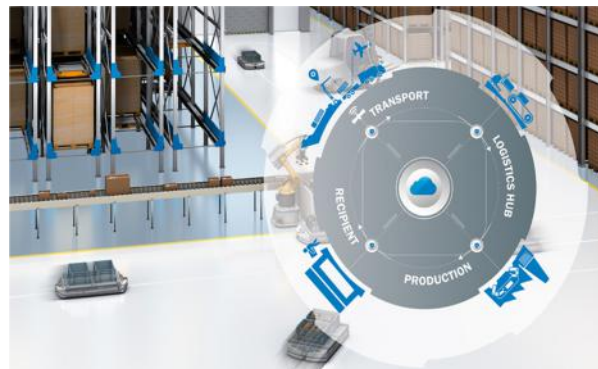
Concepts and Objectives

- ***IoT Device Fingerprinting and Localization Using Software Defined Radio***
- Use off the shelf emitter from true IoT nodes
- Widely used RF protocols in 2.4 GHz ISM band
- **SDR-based** receiver
- Collect and share a large dataset and reproducible RF fingerprints
- Further rely on Machine Learning for authentication and localization

Experiment Description

Background and Motivations

- **SDR** hardware is popularizing
- Software library are maturing (e.g. **GNU Radio**)
- Lot of interest and work in academia. New for industry
- **Indoor IoT devices** need passive auth & localization



Experiment Description

Experiment Setup

1. Make a **reservation** on the testbed Web UI
2. Setup the experiment **scenario** and **provision nodes** using **our automation scripts**
3. Use mobile nodes equipped with a Huawei **Nexus 6P** to run a **custom Bluetooth Low Energy App** that advertises as an HRM Peripheral
4. Use **nRF52 nodes** to run a **BLE** or **Zigbee** firmware

Experiment Description

Experiment Setup

4. **Move** the mobile node **robot** to a fixed position
5. Use the **USRP N210 node(s)** to **receive** and demodulate the **BLE Advertising** or **Zigbee** packet using GNU Radio
6. Save **raw IQ** and advertising packet as **PCAP + SigMF**
7. **Exploit** the dataset on **JupyterLab**

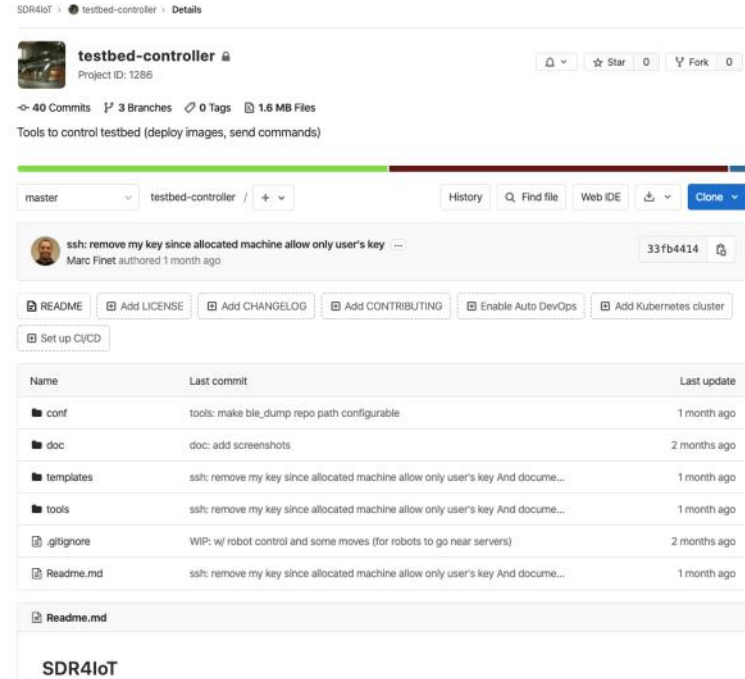


Project Results

Project Results

Automation Script

- Tools written in Python and Bash
- Generate ESPEC
- Easily **choose nodes**, create a scenario, provision server node, mobile nodes, **USRP(s)** and **smartphone(s)** on w-lab.2 testbed

A screenshot of the GitHub repository page for 'testbed-controller' by SDR4IoT. The page shows the repository name, project ID (1286), and statistics: 40 commits, 3 branches, 0 tags, and 1.6 MB files. The description is 'Tools to control testbed (deploy images, send commands)'. The current branch is 'master'. A commit by Marc Finet is highlighted with the message 'ssh: remove my key since allocated machine allow only user's key'. Below the commit are buttons for 'README', 'Add LICENSE', 'Add CHANGELOG', 'Add CONTRIBUTING', 'Enable Auto DevOps', and 'Add Kubernetes cluster'. A table lists the repository's files and their last commit details.

Name	Last commit	Last update
conf	tools: make ble_dump repo path configurable	1 month ago
doc	doc: add screenshots	2 months ago
templates	ssh: remove my key since allocated machine allow only user's key And docume...	1 month ago
tools	ssh: remove my key since allocated machine allow only user's key And docume...	1 month ago
.gitignore	WIP: wj robot control and some moves (for robots to go near servers)	2 months ago
Readme.md	ssh: remove my key since allocated machine allow only user's key And docume...	1 month ago

<https://github.com/Rtone/sdr4iot-testbed-controller>

Project Results



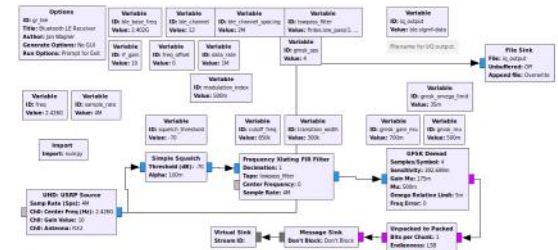
Emitter

- Mobile App to advertise BLE packet & nRF52 firmware
- CSV and script to **move** and **track robot position**



Receiver

- GNURadio Companion application
- 2 export formats
 - **PHY** layer: raw IQ
 - **APP** layer: BLE packet
 - **WIP**: sigMF



Project Results

Dataset

- 100+ Go of data collected
- 3 scenarios (more in Phase 2)



Apply a display filter ... <Ctrl-/>

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
2	1.074137	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
3	2.143532	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
4	3.054244	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
5	9.421540	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
6	13.246563	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
7	16.233006	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
8	17.947419	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND
9	18.007432	69:89:d0:3c:da:e7	Broadcast	LE LL	35	ADV_IND

Frame 2: 35 bytes on wire (280 bits), 35 bytes captured (280 bits)

- Bluetooth
- Bluetooth Low Energy RF Info
- Bluetooth Low Energy Link Layer
 - Access Address: 0x8e89bed6
 - Packet Header: 0x1040 (PDU Type: ADV_IND, ChSel: #1, TxAdd: Random)
 - Advertising Address: 69:89:d0:3c:da:e7 (69:89:d0:3c:da:e7)
 - Advertising Data
 - CRC: 0xe288ab

```
0000 00 ff ff 00 d6 be 89 8e 37 3c d6 be 89 8e 40 10  ....7<----@
0010 e7 da 3c d0 89 09 02 01 1a 02 0a 01 03 03 0d 18  <<--i-.....
0020 47 11 d5                                         6...
```

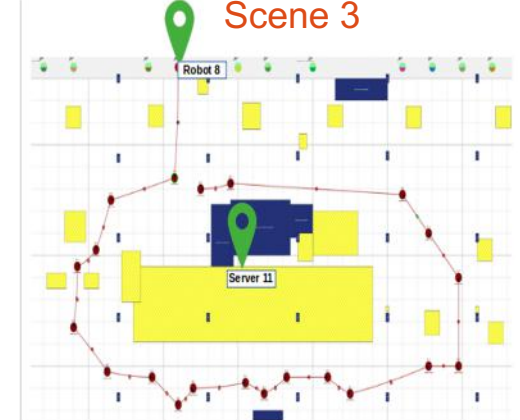
Scene 1



Scene 2



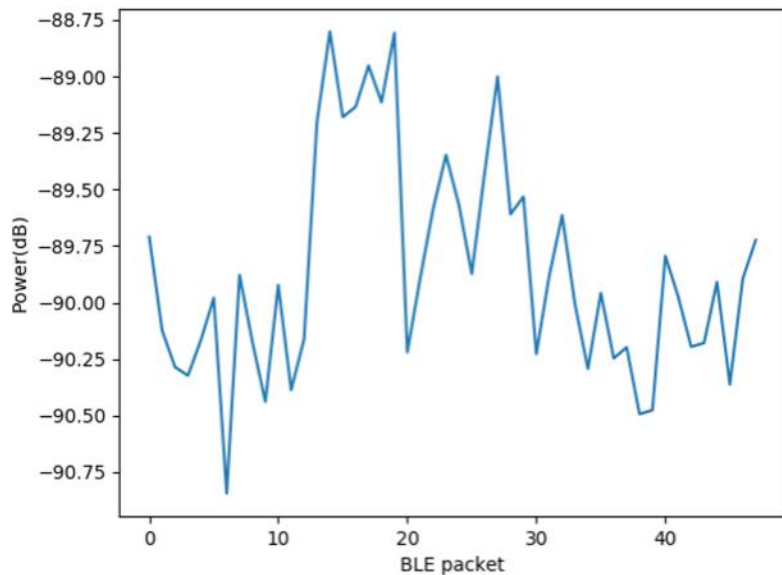
Scene 3



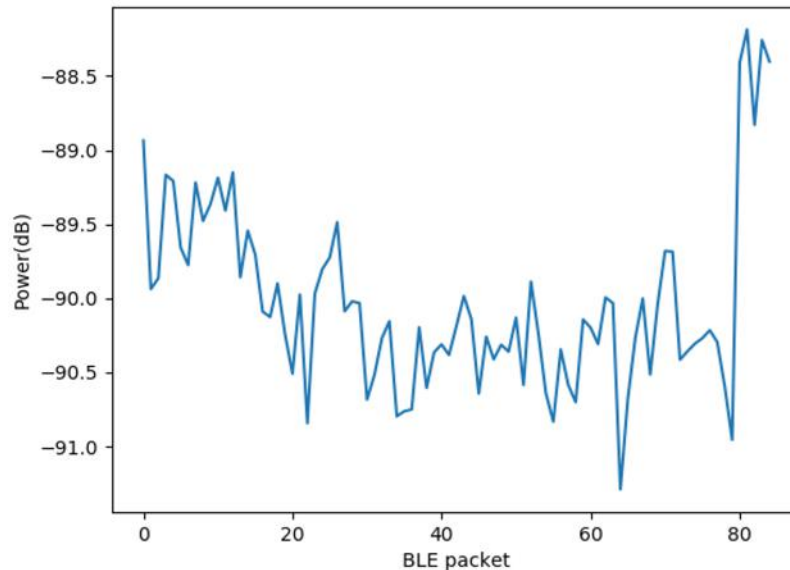
Project Results



Scene 2



Scene 3

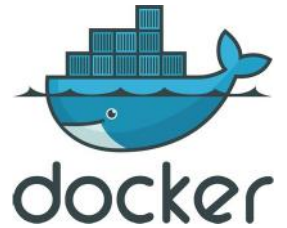
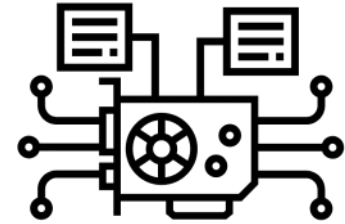


Project Results



Tools used for machine learning

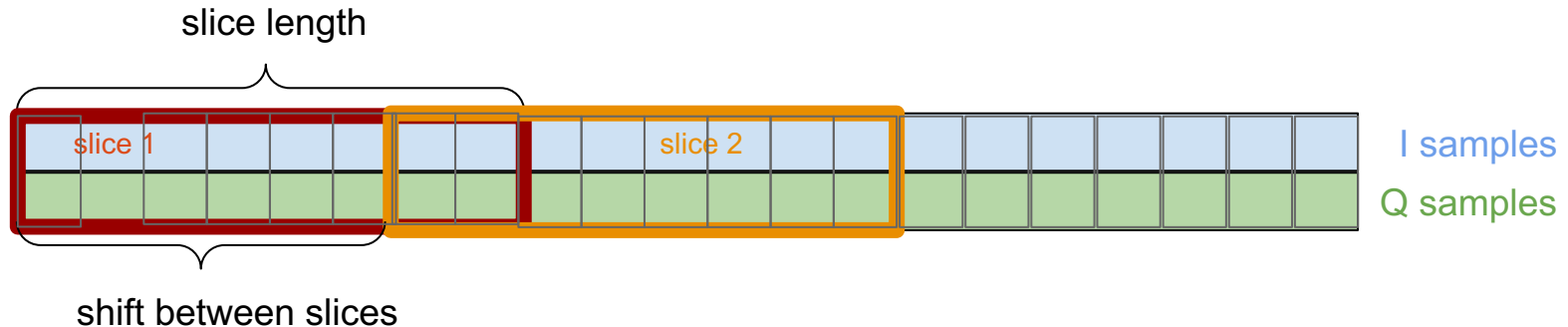
- VirtualWall
- GPU Lab
- JupyterHub with Docker container
- TensorFlow
- Keras Tuner



Project Results

Data preparation for machine learning

- Normalization of raw IQ data (64 bits for each value)
- Creating slices from each packet with a given slice length and shift between slices



Project Results

Fingerprinting

Testing several machine learning approaches to identify an emitter based on the IQ data :

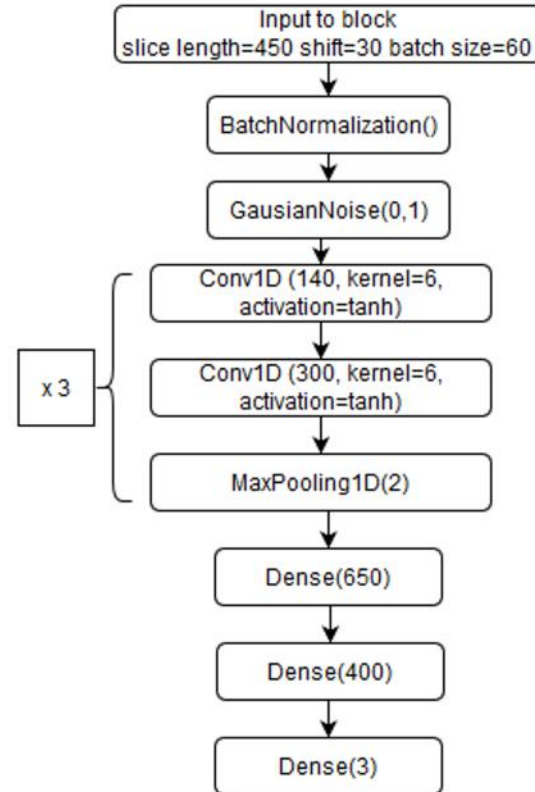
- Various Neural Networks : AlexNet, CNN, ResNet, ConvRNN
- Various input format
- Tuning using Keras HyperTuner

Project Results

Fingerprinting

Final tuned AlexNet model

- Input tensor :
batch size x slice length x 2
60 x 450 x 2

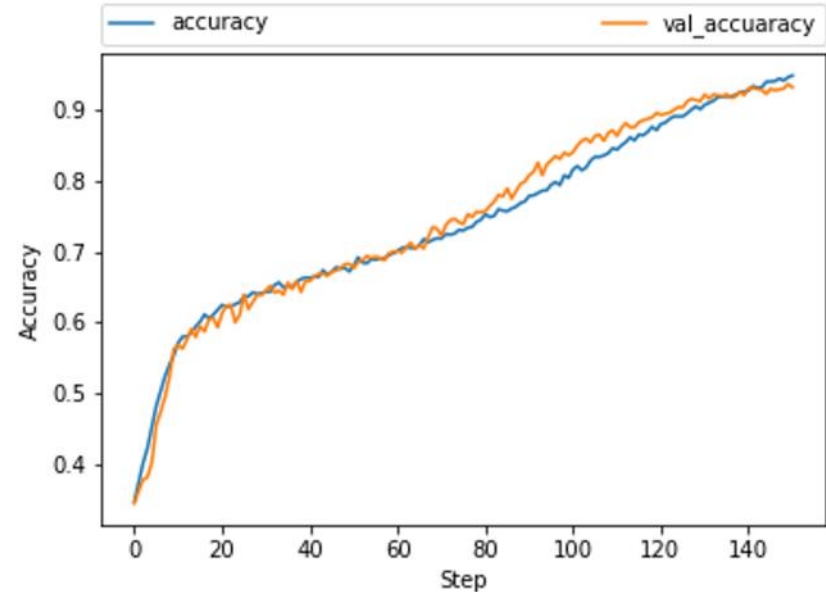
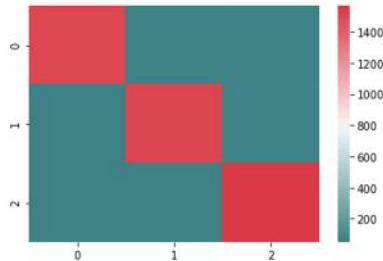


Project Results



Fingerprinting

- Using data from only one server, using AlexNet :
Accuracy : **0,93**
F1-Score : **0,93**
Confusion matrix :



Project Results



Open Source Code & Dataset

- <https://github.com/Rtone/sdr4iot-testbed-controller>
- <https://github.com/Rtone/sdr4iot-zigbee-rx>
- <https://github.com/Rtone/sdr4iot-ble-rx>
- <https://github.com/Rtone/sdr4iot-ai-ml>
- <https://github.com/Rtone/sdr4iot-docker-gpulab>
- <https://doi.org/10.5281/zenodo.4639390>





Business Impact

Business Impact

Team training and learning

- **acquire knowledges and new competences**
 - Software Defined Radio
 - RF
 - Ansible
 - FED4Fire tools
- work on **research project** close to academia

Communication

- **blog** post about SDR 
- **talk** at FOSDEM
- social networks

Business Impact

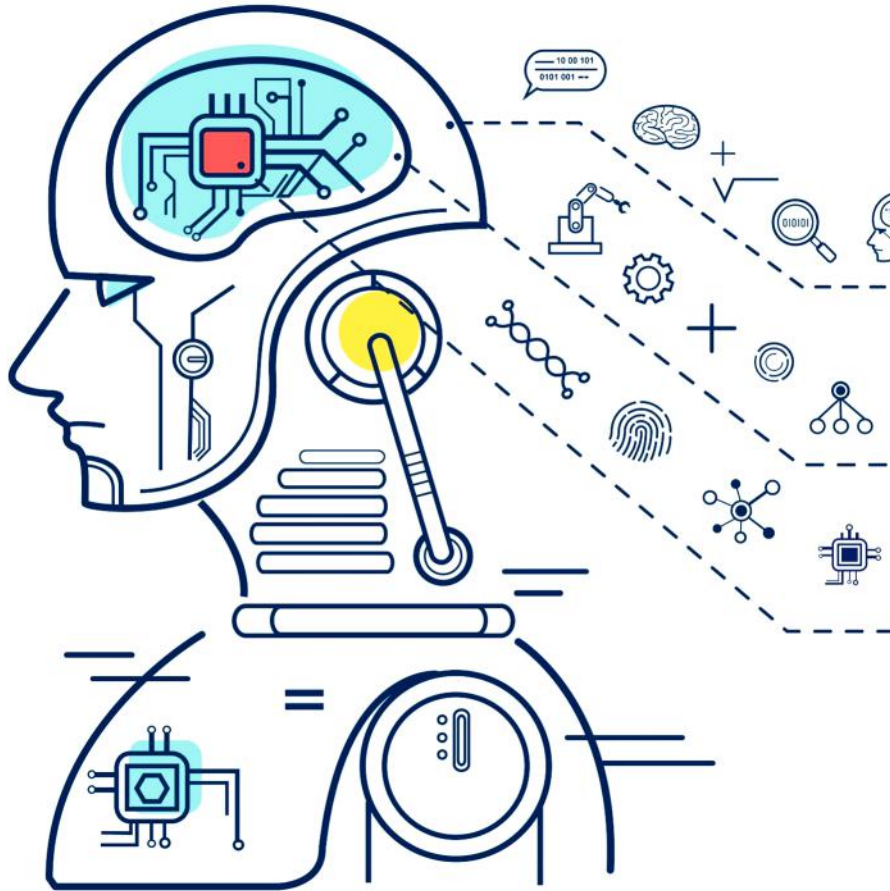
New Business and R&D Opportunity

- **new IP** for our company to provide a secure way to localize and authenticate IoT devices
- **authentication of autonomous vehicles** or robots in a **building** according to their localization
- **driven by industry recent needs**
- working for few months in the development of a **Software Defined Radio based IoT gateway** for a **French industry leader**.

Business Impact

Value Perceived

- **Support** in terms of **federation** of testbeds available through single account
- **Grant** for successful experiments
- **Technical support**
- Many **infrastructure** and **nodes**
- Proof of **our interests** for the testbeds
- **Scalability**
- Confidence to run **experiments on Fed4FIRE+ in future**



Feedback

Feedback



Used Ressources and tools

- **Fed4FIRE+ Tools**
 - iMinds Authority
 - jFed CLI and jFed GUI
- **w-iLab.2**
 - Mobiles nodes with robots
 - USRP N210 server nodes
 - Huawei Nexus 6P
 - reservation Web UI
 - ***RobotController*** software

- **VirtualWall**
 - JupyterLab
 - GPU nodes



Feedback



jFed CLI

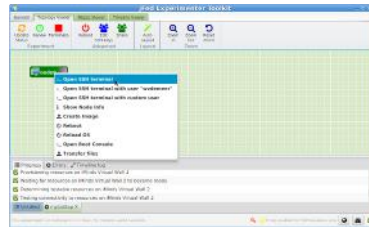
- Provision and manage experiment on testbeds
- Network and resource configuration
- Bootstrap an experiment
- Node provisioning takes a lot of time. Sometime fails
- Requested feature: place a reservation and book nodes with jFed CLI



Feedback

jFed GUI

- Provision and manage experiment on testbeds
- Load RSpec
- Bootstrap an experiment
- Recover an experiment
- Mainly used at the beginning of the experiment to get familiar with the testbed



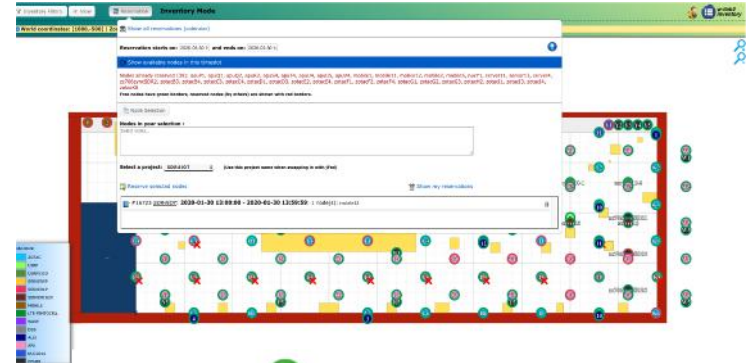
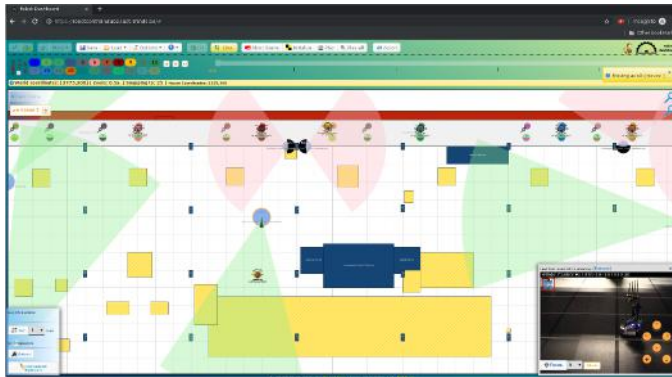
- UX could be improved.
- Quite unstable



Feedback

w-iLab.2 tools

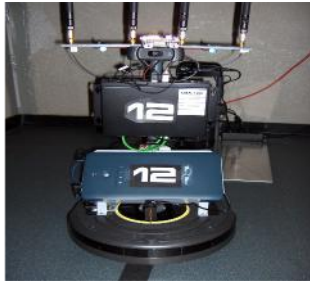
- Reservation Web UI
- *RobotControl* Web UI
- *RobotController* ruby script software



Feedback

w-iLab.2 nodes

- Mobiles nodes with robots
 - USRP N210 server nodes
 - Huawei Nexus 6P smartphones
- mobile nodes availability
 - smartphones and robots often have issues
 - sometimes robot can't move



Feedback

Added Value for FED4Fire+

- **intensive use** and assessment of **mobile nodes**
- suggest **new features**
- suggest **new** type of nodes and **devices**
- **dissemination & communication**
- develop automation scripts that can be reused
- **shared** datasets (on Zenodo)
- use **other testbeds in the future**



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Co-funded by the
Swiss Confederation

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QUESTIONS

WWW.FED4FIRE.EU