Demo: Large-scale Sensing, Mobility, and Monitoring with the FIT IoT-LAB Testbed

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Abstract

FIT IoT-LAB is a testbed distributed over 7 different sites, 4 hardware platforms, and a total of 2446 nodes. The testbed enables large-scale protocol testing on a wide range of topologies. It offers features such as live interaction with remote nodes, per-node packet sniffers, online energy monitoring, programmable mobility, and per-node public IPv6 addressing, to name a few. In this Demo, we show a webcam view of the testbed with remotely controlled lighting (ceiling LEDs and a mobile robot carrying a torch). A tight grid of 256 sensors will be used to collect light information. We display live updates of the resulting heatmap, live energy profiles and other performance metrics.

Video available at `https://youtu.be/DzUPr2jTEw8`.

1 Introduction

Testbeds enable realistic experimentation for low-power wireless networking research. There exists a number of open testbeds, such as Indriya [2] and FlockLab [5], already widely used in our research community. However, no existing solution enables yet large-scale Internet of Things testing (hundreds of nodes) in a variety of environments.

This abstract presents FIT IoT-LAB[1], a large-scale collection of testbeds distributed over 7 sites. All sites can be accessed via a common interface, enabling the evaluation of all network stack layers protocols on a variety of physical topologies with complementary properties. IoT-LAB offers unique features such as per-node packet sniffers and programmable robots. The demonstrator shows mobile robots, remote lighting control, wireless data collection, and live monitoring of power draw, in a single integrated setup.

[1] `https://www.iot-lab.info/`

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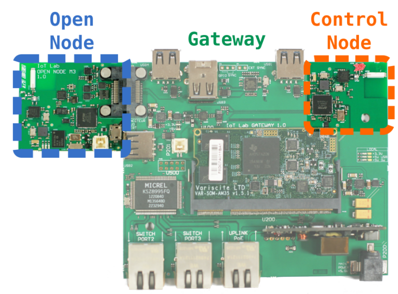


Figure 1. IoT-LAB node components

2 FIT IoT-LAB

This section reviews the IoT-LAB platform. For a detailed overview of the IoT-LAB design, we refer the reader to [1].

2.1 Design Overview

IoT-LAB is a constellation of testbeds with well-defined open interfaces (RESTful API, Web portal, CLI). A central manager enables to create, administer, and gather data from experiments on the different deployments. Each deployment offers its own set of IoT-LAB nodes, physically deployed in different buildings and rooms.

An IoT-LAB node, as shown on Fig. 1, is made of three components: (1) the Open Node; (2) the Gateway; and (3) the Control Node, as described below:

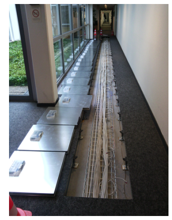
Open Node The Open Node is the IoT device made available to the user. It can be programmed in an unconstrained manner, *i.e.*, with any compatible firmware. There are different types of Open Nodes, covering different application needs in terms of CPU or energy consumption, based on MSP430, Cortex-M3 and Cortex-A8 MCUs. They are equipped with an IEEE 802.15.4 radio chip at 2.4 GHz or 868 MHz. Some of the nodes are mounted on robots, for mobility. Some sites are even envisioned to offer fleets of tens of programmable robots.

Gateway The Gateway connects the constrained device to the infrastructure, and takes care of uploading firmwares and downloading monitoring information. It enables live interaction through sockets mapped to the node's serial interface.

Control Node The Control Node offers fine-grained, non-intrusive monitoring capabilities. During the experiment, it monitors the energy consumption of the Open Node and performs live packet sniffing and RSSI recording. Energy monitoring is done at every node at a resolution up to 3.5 kHz.

	Grenoble	Lille	Saclay	Strasbourg	Rennes	Paris	Lyon	**Total**
WSN430 (868 MHz)	256	-	-	256	-	-	-	512
WSN430 (2.4 GHz)	-	256	120	-	256	-	-	632
M3	380	256	12	62	-	69	18	797
A8	228	-	175	14	-	62	11	490
Mobile M3 on robot	2	3	-	10	-	-	-	15
Total	866	515	307	342	256	131	29	2446

(a) Per-site node count



(b) Grenoble

(c) Lille

Figure 2. Overview of the IoT-LAB nodes and robots available at the time of writing. The Grenoble picture shows M3 nodes before they were hidden under the floor. The Lille picture shows M3 nodes including two mobile robots.

2.2 Key Features

During experiments, IoT-LAB provides the user with the following features:

- Socket I/O access to individual nodes: can be used to collect logs, send commands, or connect a node to the Internet via a public IPv6, *e.g.*, as a RPL border router;
- Mobility: certain nodes are mounted on robots. Robots follow pre-recorded tracks selected by the user;
- Fine-grained monitoring: users can access power samples, RSSI samples and packet sniffed at runtime;
- OS support: the platform offers mature support for Contiki, RIOT, OpenWSN and FreeRTOS.

2.3 Deployments

FIT IoT-LAB offers a large variety of deployments, covering many different application scenarios. The deployments vary in scale (up to 866 nodes spanning a building), density (up to 342 nodes in a room), physical topology (building or single room, on ceiling, walls, or under the floor), and capability (static or mobile). In total, there are 7 different sites and 2446 nodes. Fig. 2 sums up the available deployments.

2.4 Future Evolutions

FIT IoT-LAB is constantly evolving, and the following new features are currently planned:

- Long-range communication: deploy a testbed of IEEE 802.15.4g compliant nodes;
- General-purpose I/O pins: support for fine-grained control and monitoring via I/O pins;
- Custom nodes: offer the ability for users to plug their own hardware to a testbed (requires physical access);
- Robots: extend robot deployments (up to 40 nodes) and add mobility models and user-controlled mobility;
- Benchmarking: support automated benchmarking of low-power communication protocols [3].

3 Demonstration Description

To illustrate the capabilities of IoT-LAB, we will run an experiment on the Lille testbed, with live monitoring of luminosity and performance metrics. The nodes perform low-power data collection using Orchestra [4], an autonomous scheduler for RPL+6TiSCH networks. We use the Lille testbed's remote light controller to vary luminosity at runtime. A Web application retrieves light sensor data from the sink node and displays a real-time updated heatmap of the room (see Fig. 3). Finally, a live video stream provides visual feedback from the testbed room. Alongside, we will also use some robots carrying a torch to showcase mobility and increase lighting dynamics. This demonstration makes use of many features, as detailed next:

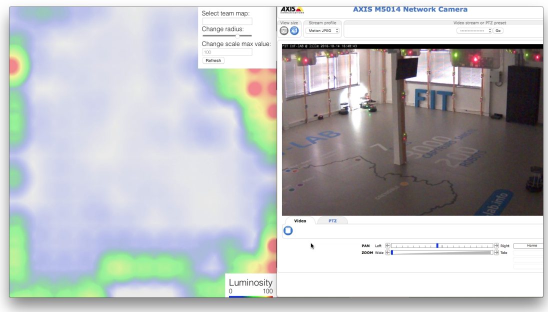


Figure 3. Heatmap web application and real time stream from the Lille site.

Large Scale We demonstrate the ability to experiment at large scale with over 200 M3 nodes involved.
Mobility The robots will showcase mobility features.
Live Monitoring We exploit energy monitoring as well as robot localization features.
OS Support For low-power data collection, we run one of our readily-available solutions: Contiki with RPL+6TiSCH.
Serial Link Aggregation With the `serial aggregator` tool, we gain remote access to all nodes' socket I/O and collect relevant network performance metrics.
Command Line Tools We show the CLI tools that interact with the RESTful API to manage experiments, draw consumption graph and robot trajectory.

4 Acknowledgments

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5 References

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