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eXperimental Infrastructures for the Future Internet



Telecommunication Networks and
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“Cloudification of experimentation infrastructures for Internet of Things and Software Defined Networks”

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PiraeusU Cloudified Experimental Infrastructures

PiraeusU Node includes 2 different experimentation infrastructures: a) IoT Infrastructure and b) SDN Infrastructure. Each infrastructure includes a set of different devices that offer various capabilities, such as the provision of measurements of environmental conditions in Smart Buildings. The installation of the devices for both infrastructures, has been performed in the TNS Laboratory headquarters, with the different devices to be installed in the Smart Building of the Laboratory.

The external user gain access to the infrastructures through the FIWARE Cloud PaaS infrastructure, by using different Generic Enablers, such as Orion Context Broker. The end-users can develop their own custom experimentation algorithms that interact with the PiraeusU experimentation infrastructures in terms of measurements retrieval, the performance of queries on registered/available SDN devices such as USRPs, etc. For the development of the custom algorithms, PiraeusU node provides two different open-source APIs, over GitHub public repositories. Table 1 provides the git links for the open access to the open-source PiraeusU APIs. Essentially, there is one master repository that includes two (2) different source code projects that can be downloaded by developers. Consequently, this repository, includes the java APIs that have been developed by PiraeusU node development team so as to allow the end-users/developers, that aim to use the PiraeusU node so as to perform their particular experiments on IoT and SDN fields, to interact with the node infrastructures. The APIs integrate heterogeneous IoT and SDN devices, by using the FIWARE GEs, such as the Orion Context Broker.

Table 1: PiraeusU open-source APIs

Open-source API	Git Repository link
PiraeusUfiwareIoTAPIClient	https://github.com/dimitriskel/piraeusu-xifi-fiware-apis.git
PiraeusUfiwareSDNAPIClient	https://github.com/dimitriskel/piraeusu-xifi-fiware-apis.git

PiraeusU Node OpenStack Deployment & FIWARE Node

- PiraeusU is an official FIWARE node:
 - ▶ **Federated** by using **WiFi EU FP7 Project FI-Ops** that enable cloud infrastructure and monitoring infrastructure installation, setup and configuration.
- Cloud Infrastructure:
 - ▶ Integrates the node with **FIWARE platform**, and make the node available through the **FIWARE Cloud portal**.
 - ▶ Operated on **OpenStack Icehouse release on CentOS 6.5**.
 - ▶ Includes resources: **CPUs: 112, RAM: 225 GB, Storage: 4 TB, Connectivity: 1 GBps**.
- Monitoring Infrastructure:
 - ▶ Integrates the node with the **WiFi / FIWARE Monitoring infrastructure** and it makes the node visible in the **FIWARE Infographics** and **FIWARE status page**.

- For the monitoring, are used the **Nagios Monitoring system** for the collection of real-time data, and **Apache Ambari** for **Hadoop** installation for the provision of node Historical data.



IoT Infrastructure

The IoT infrastructure of TNS Laboratory includes a set of different IoT Gateways, sensors, actuators and short-field communication devices (e.g. XBee S1 and XBee S2 modules) that compose an integrated Wireless Sensor Network (WSN) for the Smart Buildings Monitoring. The IoT infrastructure initially developed so as to provide external access to end-user by distributing customized APIs, that where continuously modified and updated based on the continuous changes that performed in the context of the IoT infrastructure upgrade. An indicative overview of the existing IoT infrastructure architecture is depicted in Figure 1.

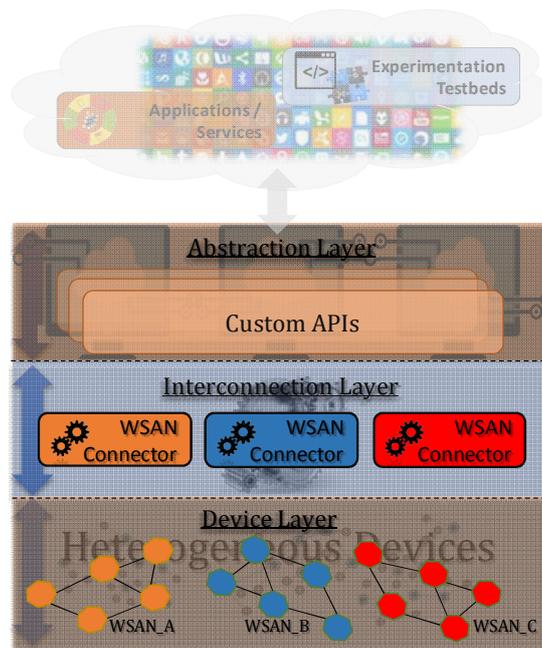


Figure 1: TNS Laboratory architecture of the IoT infrastructure

In particular, PiraeusU node IoT integrated architecture, is structured in three (3) different level (three-tiered architecture): a) Device Layer, b) Interconnection Layer and c) Abstraction layer. Table 2 provides the short description of the corresponding architectural field for the legacy IoT Infrastructure in the TNS Laboratory, which as it is described in the next section has been integrated with PiraeusU OpenStack infrastructure and it is provides as a Cloud-based IoT experimentation infrastructure for the end-user, such as the IoT application developers.

Table 2: Architectural Layers short description

Architecture Layer	Description
Device Layer	Includes WSN heterogeneous devices. Currently includes 3 integrated WSANs.
Interconnection Layer	Includes the reference implementations of WSN connectors, that allow the connection with the heterogeneous devices.
Abstraction Layer	Custom APIs: are provided so as to allow the implementation of application and/or services, as well as the development of experimentation algorithms that will interact with the IoT infrastructure in various ways, such as the retrieval of sensor measurements (e.g.: temperature, humidity, luminosity, etc) .

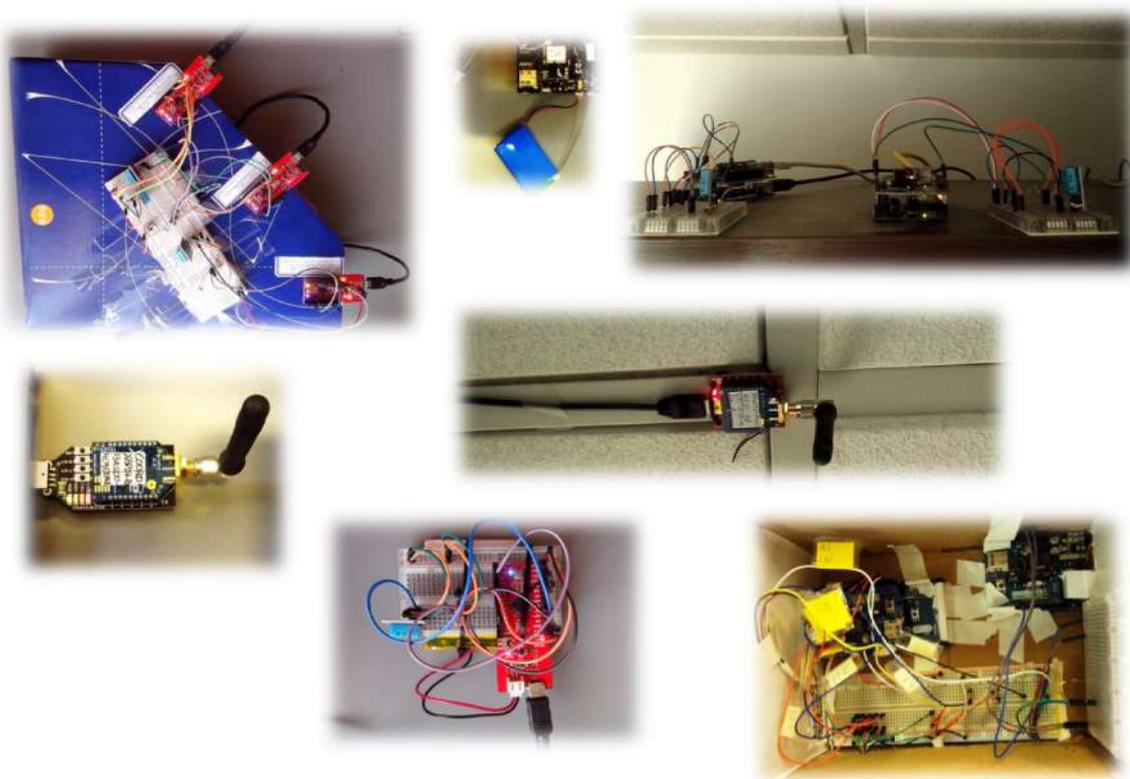


Figure 2: Indicative deployments of the WSN devices in PiraeusU IoT Infrastructure

By introducing OpenStack infrastructure on TNS Laboratory, as well as by constructing the PiraeusU node through the deployment of particular FIWARE Operations and Generic Enablers on the existing OpenStack Icehouse infrastructure, it was facilitated the cloudification of the existing IoT infrastructure. Thus it was achieved the improvement of the IoT Infrastructure architecture by integrating its abstraction layer with the FIWARE GEs, as well as by providing open-source Java APIs to the end-users / developers who aim to develop their own, custom experimentation algorithms.

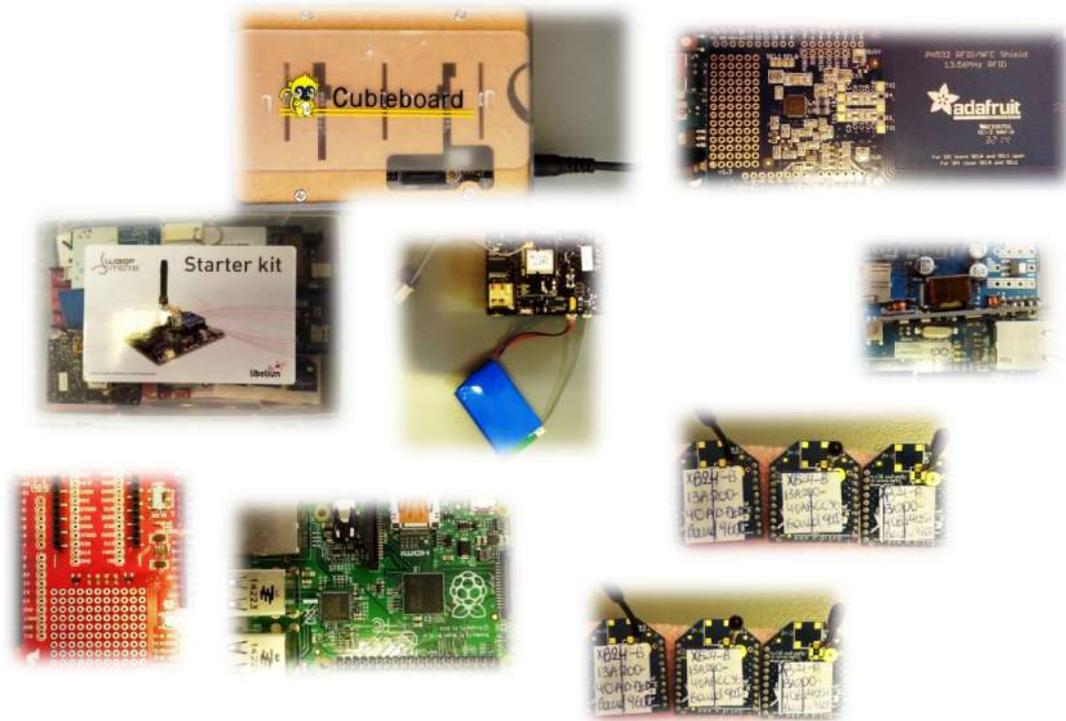


Figure 3: PiraeusU IoT Infrastructure indicative parts of devices

SDN Infrastructure

The SDN infrastructure includes two (2) USRP devices with two (2) antennas connected on each device, and they can be programmed dynamically, by using corresponding programming languages. These devices are registered on the Orion Context Broker GE that is instantiated on PiraeusU node OpenStack infrastructure, and it is accessible from FIWARE PaaS infrastructure. Each device is described in terms of its offered capabilities and the third-party user can perform queries to the public PiraeusU Orion GE instance so as to retrieve related information with the available devices on the infrastructure. Figure 5 - Figure 7 present indicative parts of the deployed devices in the SDN infrastructure.

As further research activities, PiraeusU node technical team provide an open-source API for the interaction with the SDN infrastructure. The API currently, supports the dynamic registration and discovery of available SDN devices, while it can be used, by third-party users / developer so as to be extended. Through the extension of the API it can be possible the provision of remote access and programming of SDN devices such as the USRPs, as well as the remote control of various SDN device operations. Consequently, the node users can exploit the Java API reference implementation, which, as already introduced, is available on GitHub (PiraeusUfiwareSDNAPIClient, <https://github.com/dimitriskel/piraeusu-xifi-fiware-apis.git>), so as to provide further functionality on the open-source experimental infrastructure of PiraeusU node.



Figure 4: Indicative deployment of USRP device with two antennas

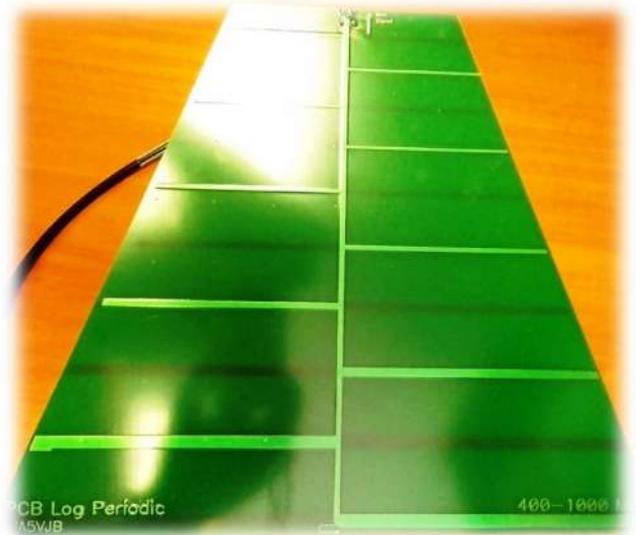


Figure 5: USRP antenna panel



Figure 6: USRP device

PiraeusU Integrated Architecture

Figure 7 presents the high level overview of the integrated architecture of PiraeusU node which actually enables the cloudification of the standalone functionality of the experimentation infrastructures that are hosted on PiraeusU node. There are five (5) different steps / interaction parts for in the integrated architecture that are described in the rest of this section.

- **Measurements collection and device level interaction:** UPRC/TNS IoT WSANs infrastructure collects measurements by available sensors. These measurements acquisition for Temperature, Humidity, Luminosity, etc. In addition, unregistered SDN devices registered to Orion GE public instance.
- **Interconnection layer:** WSAN Customized connectors get the measurements from the available WSAN boards and push the measured data to the abstraction layer where FIWARE open APIs analyze and provide them to the GEs on PiraeusU FIWARE node.
- **Abstraction layer:** Software modules that constitute the reference implementation of the PiraeusU open/public API. These modules are used so as

to support the retrieval of measurements from WSAN connectors, to serialize the measurements into relevant formats based on FIWARE context broker GE data model, while they support the store and retrieval of the data from the Orion Context Broker GE PiraeusU node public instances, through the NGSI10 REST API

- **OpenStack Node:** WSAN data from UPRC/TNS IoT infrastructure is stored into the Orion Context Broker GE. The data is available to third-party entities by using the PiraeusU open/public API so as to get them for their own purposes (e.g.: performance of experiments).
- **External experimentation testbeds / applications and services:** External users perform experimentation in the field of the IoT (e.g. smart building management). In order to perform the above interactions, the end-user connects to FIWARE Cloud and then perform request to PiraeusU Node by using the UPRC/TNS open/public APIs.

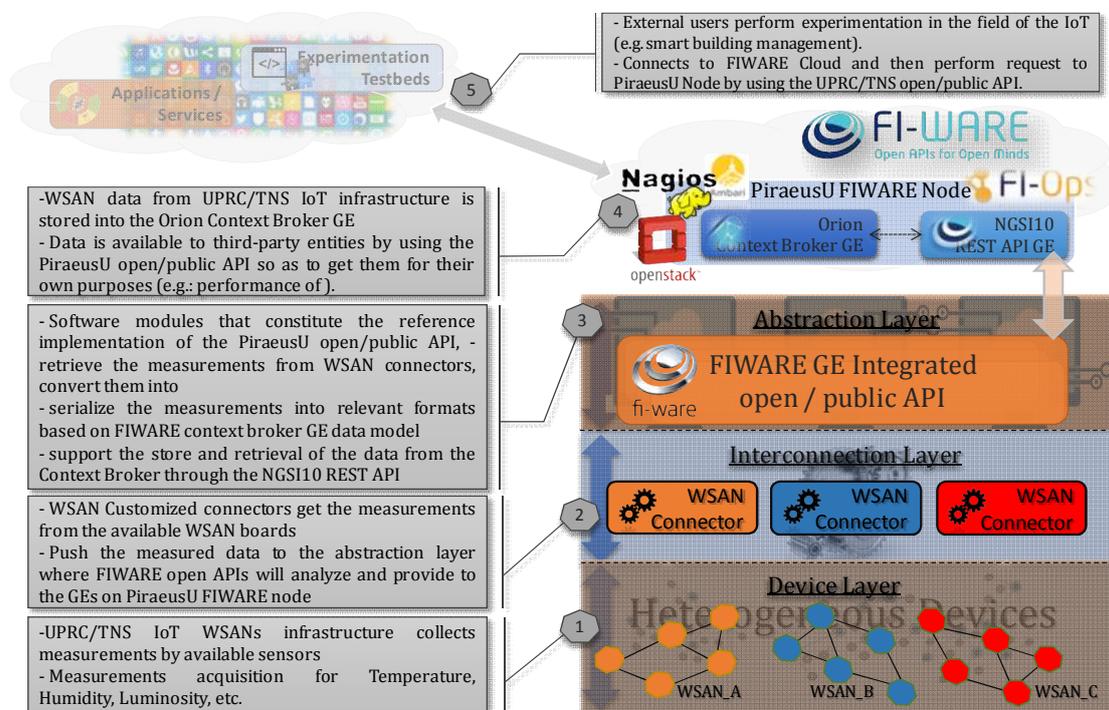


Figure 7: PiraeusU integrated architecture