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Rachit Agarwal[1], David Gomez[2], Jorge Lanza[2], Luis Sanchez[2], Nikolaos Georgantas[1], Valerie Issarny[1]

[1] Inria Paris, France;
[2] University of Cantabria, Santander, Spain
{{rachit.agarwal, nikolaos.georgantas, valerie.issarny}@inria.fr,
{dgomez,jlanza,lsanchez}@tlmat.unican.es}*

Abstract. IoT applications are usually built on top of proprietary platforms that collect data from IoT devices. Further, some applications have been developed that use similar data coming from various sources. Thereby needing to deal with issues like interoperability and heterogeneity in the data. A solution is to add another layer (a platform in a middle that addresses above-mentioned issues) and then build applications that use data made available via such platforms. As a proof of concept, we present our application `EnMonitor` that is built on top of one such platform called FIESTA-IoT platform. The application provides citizens with an understanding of the environment they live in with both local and global surrounding view.

Keywords: Semantics, IoT, Citizen-Centric Application

1 Introduction

Citizen-centric applications are focused on the well-being of citizens and provide information about their environment [1, 2]. These applications get information from dedicated platforms that collect data from available sensors using various sensing mechanisms (static, mobile or participatory). The use of such platforms limits a citizen from knowing much fine-grain information about the environment, as the applications are limited to receive the data from sensors attached to the specific platform. Using data from various other platforms as well across the domain of interests provides much more comprehensive knowledge about the environment. However, an application would need to deal with data coming from heterogeneous platforms. In order to mitigate such interoperability issues, much attention has been paid recently on the creation of a unified ontology that data-sources (also called `testbeds`) must comply in order to provide a common data model [3, 4]. Moreover, to ease development effort, a platform in a middle is introduced that is responsible for aggregating data made available via testbeds.

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Thus, a developer now has to only use the APIs of middle platform to get the needed data.

`FIESTA-IoT`[3] platform [5, 6] is one such EU H2020 initiative that enables federation of testbeds to help citizen-centric application developers provide a comprehensive large-scale fine-grain view. Note that, there are other EU H2020 and research initiatives [7] that talk about federation of data or provide resources to build such applications; however, they lack interoperability, common understanding about the data and have a static snapshot of data. The data in the testbeds associated with FIESTA-IoT platform constantly evolve over time.

We utilize FIESTA-IoT platform and build an application called `EnMonitor`[4] that provides citizens near real-time comprehensive information about both their local and global environment. EnMonitor focuses on the environmental realm, displaying information about a number of different physical phenomena (e.g. temperature, noise level, relative humidity, solar radiation, concentration of harmful particles in the air, etc.) that have health related issues on citizens. As an example, using EnMonitor, a user could get information about surrounding environment before traveling or taking a certain path. Not limiting to this, EnMonitor also helps decision making bodies to make policies based on the comprehensive view.

EnMonitor has a twofold objective: *(a)* to provide near real-time information about environment all around the globe and *(b)* to display it in an intuitive manner. Through a easy-to-use web-based graphical interface, users can pinpoint to concrete regions on a map, select among different environmental phenomena, view different metrics (eg. heatmap) as shown in Fig. 1a. Once the application is configured, EnMonitor periodically sends requests to the FIESTA-IoT platform for the results.

2 System Overview

After EnMonitor is customized, it performs analysis of the acquired data and represents the information using:

- **Sensor data**. Users can click on a device to get the last measurements observed by each of its underlying sensors. Thanks to the interoperability supported by the FIESTA-IoT platform, datasets from different testbeds will have same format that is fully compliant with the FIESTA-IoT ontology.
- **Heatmap**. Not limited to the individual most recent observations, a user can also visualize the gradients perceived in a global perspective. Such visualizations enable detection of behavioral patterns that might be the consequence of strange behaviors (e.g. a fire in a forest would bring about drastic changes in temperature and relative humidity in a limited area).
- **Weather station**. Even though significant number of measurements are gathered by each sensor, aggregation of data conveys a higher level of information. Thus, EnMonitor calculates the averages values within a selected region.

[3] http://platform.fiesta-iot.eu
[4] http://fiesta-iot.tlmat-unican.es/icsoc-demo

– **Historical data**. The scope of EnMonitor is not limited to just spatial features, but extends to the spatio-temporal features as well. EnMonitor provides time-series based analysis for prediction of events that could be alarming and need immediate counter action.

By using these features, EnMonitor not only offers citizens a holistic view of the environment around them but also enables policy makers to take advantage of such application to complement their legacy instrumentation tools.

To have reduced computational and networking overheads, we architect EnMonitor with a client-server approach (see Fig. 1b). At the client only simple operations are carried out (basically, graphical input & output and lightweight configuration), while the server interacts with the FIESTA-IoT platform using SPARQL queries in order to extract information such as: (1) the devices that are registered (**resource discovery**); (2) the observations measured by the sensors associated to those devices (**observation harvest**). The server also caches the information obtained from the FIESTA-IoT platform. This reduces the traffic between FIESTA-IoT platform and EnMonitor in a multi user scenario.

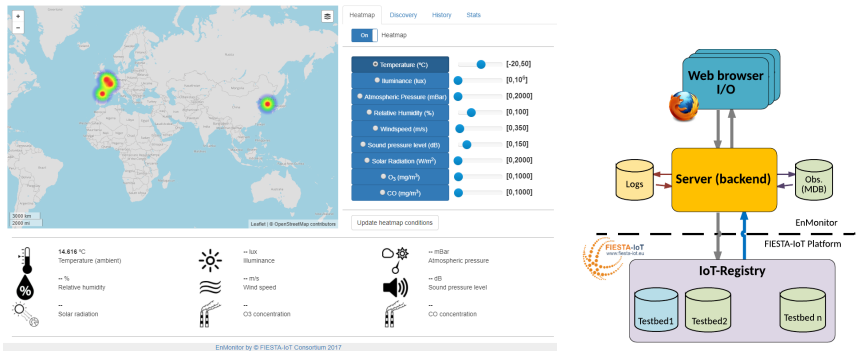
FIESTA-IoT platform is a platform that allows federation of testbeds by enforcing semantics. It is supported by various components such as Security, Data Registry, Execution Engine and Data Management service [5]. Due to space limitations, we do not focus on all the interactions happening within FIESTA-IoT platform, but focus on pointing out some aspects that are necessary for EnMonitor and on how it interacts with the FIESTA-IoT platform.

One of the most important components of the FIESTA-IoT platform is the `IoT-Registry`. It enables the interactions between FIESTA-IoT components and distributed FIESTA-IoT ontology compliant semantic testbeds. IoT-Registry contains set of clearly documented both private and public REST APIs[5] that are secured and can only be accessed if authentication and authorization step passes (in FIESTA-IoT platform, this is managed by an instance of the OpenAM platform). The APIs follow best practices and standards described in the WoT (Web of Things) literature. Out of the available set of APIs, the most useful API to us is the SPARQL interface API that enables the querying of the semantic stores. To give a glimpse of the semantic data made available by this API, we refer readers to [3]. The available semantically annotated dataset is divided into two parts: resource graph (containing description about the available sensors) and observation graph (containing observations made by the available sensors). EnMonitor exploits both these graphs depending on the chosen scenarios.

3 Conclusions

EnMonitor presents a more fine grained analysis of the environment to the citizen, thereby enabling them as well as policy makers to gain health benefits. EnMonitor, on one hand provides different visualizations and metrics to understand environment, and on another, shows the capabilities of FIESTA-IoT platform. As a future extensions, many aspects are planned to be integrated in

[5] https://platform.fiesta-iot.eu/iot-registry/docs/api.html



(a) User interface **(b)** Application overview

Fig. 1: EnMonitor

EnMonitor. These include: more near real-time statistical inferences, notifications to logged-in users and more sophisticated querying.

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