A Platform to Collect, Manage and Share Heterogeneous Sensor Data

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***Abstract*—The scientific and technological advances generate an exponentially growth of the number of sensors and the parallel decrease of their cost. The result is a huge number of heterogeneous sensor surrounding us. In this demo we present Paraimpu, a prototype of a scalable platform able to collect, manage and share heterogeneous kinds of sensor data.**

***Index Terms*—Web and internet services, Sensor systems and applications**

I. Introduction

In the last years, the scientific and technological advances on physics, chemistry, engineering and medicine generate an exponentially growth of the number of sensors and the parallel decrease of their cost. Sensors and their peers dedicated to consume data, the actuators, are integrated in more and more everyday objects like the ones used in the kitchen [1]. Lots of them are Internet-enabled, becoming potential active items on the Web. Like Arduino (http://www.arduino.cc), openPICUS (http://www.openpicus.com), Karotz (http://www.karotz.com), or bicycles. While other of them are purely virtual ones. They exist only on the digital world and some examples are social networks, APIs, services and software applications. Anyway, all of them concur to increase the need to collect, manage and share a huge mass of heterogeneous data.

The demonstration presents Paraimpu (http://paraimpu.crs4.it/), a platform able to satisfy such a need. The prototype allows users to use those heterogeneous data, to share with friends and to connect a sensor with an actuator independently by they are real or virtual in order to create personalized and pervasive applications. It shows the Web-available tools of Paraimpu, its main functionalities and how to connect different kinds of sensors and actuators.

II. The Platform: Paraimpu

In this section, we describe the main concepts adopted for the platform development and its main technical features.

A. Things

We assume a *sensor* is whatever thing capable to produce data in the format of text, number, JSON or XML, while an *actuator* is any thing able to perform actions by consuming data items. Generally, we call them *things*, independently by they are real or virtual and they communicate with Paraimpu by HTTP protocol.

To support users, Paraimpu provides a set of predefined classes of things. At the moment, they are available for 10 sensors and 13 actuators. Predefined sensors includes real things like Arduino or openPICUS boards and virtual ones like Foursquare, Pachube and Twitter. Actuators include the tangible Karotz and Chumby and the virtual Twitter, Google-Cal, GoogleMap and Facebook. Predefined things let users to create their instances with a null or minimal configuration requirements. For example, creating an Arduino Ethernet Sensor, the user sets MAC and IP addresses and Paraimpu automatically creates the right sketch to upload to the board. After few seconds to complete the upload, the board starts to communicate with the platform.

For more exigent users or other categories of things, Paraimpu provides classes for generic sensor and generic actuator with the indications to submit or get data.

The things can be placed anywhere in the world. Paraimpu does not care of their position.

B. Connections

The *connection* is a real-time data flow established between two things, independently by their nature, realizing a sort of mixed hybrid mash-ups. It always involves one sensor as the data source and one actuator as the data recipient. So we can have a sensors-equipped Arduino board connected to a Karotz, to Facebook or Twitter with the same simple steps.

Obviously, the heterogeneity of the data raises the need to introduce a data adaptation mechanism. Paraimpu manages string, numeric, JSON and XML data types. Each connection can be properly configured specifying rules for data filtering and data adapting. For each established data flow, the platform

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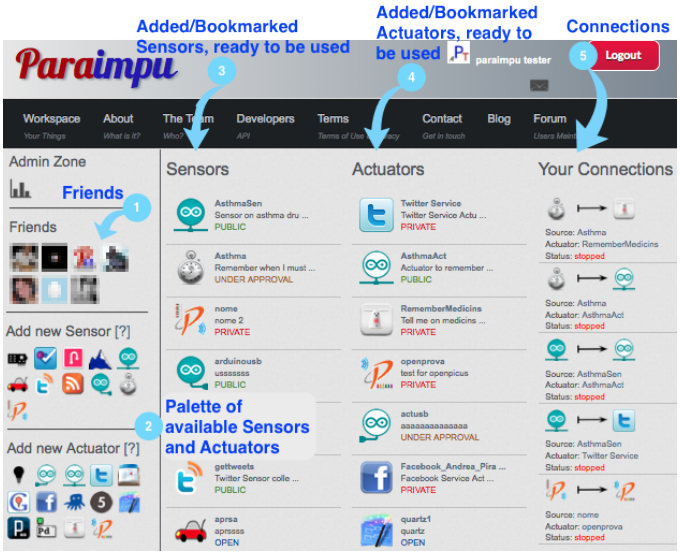

Fig. 1. The Paraimpu Workspace. It is mainly composed of five areas: a list of friends, the palette with available sensors and actuators, the list of own and bookmarked things and the connections.

is responsible to apply rules using an integrated JavaScript-based rule engine. Thanks to JavaScript, users can write (also eventually complex) rules for filtering and data mappings. In case of actuators consuming complex data structures, Paraimpu guides the user with ad-hoc widgets simplifying the mappings definition.

For example, let us to consider a Sensor called "A", that produces JSON data in the form `{"value":_number_, "kind":"temperature", "unit":"_unit_" }` connected to a Twitter actuator. We would like to set a mapping with the condition: `if A.value > 25 then send the message "Today is [_date_] and we have [_number_] [_unit_]".`

On Paraimpu, we set `Match: A.value > 25` and `Replace: "Today is <%(new Date()).toDateString()%> and we have <%A.value%> <%A.unit%>".`

Another condition could be `Match: A.value <= 25` with `Replace: "No summer .. yet"`

C. Sharing and Social Aspects

Like [2], Paraimpu lets users to discover and bookmark objects shared by other users/friends. For each thing created, the user can select a visibility policy between private, public or moderated. The last two kinds let things could be used by contacts/friends included in a personal list. Bookmarking action means importing shared things to user workspace and use them in a connection like the owned ones.

Moreover, in the same way of any other thing, social networks profiles can be used like sensors or actuators, For example, Twitter and Facebook are currently seen in Paraimpu as actuators to post text messages, Foursquare and APRS.fi (http://aprs.fi) as sensors producing geo-located data.

D. Main Technical Features

Assuming to have a system with one thousand sensors producing a data item each second and connected to a central server, it will produce 1000 * 60 * 60 * 24 = 86400000 events a day. In a realistic scenario, a system has more than one thousand sensors. Under such hypothesis, a platform supporting this system must have the requisite of high scalability.

Paraimpu must faces with thousands of concurrent HTTP requests and they must be managed ensuring availability and performances. Thus, the Web server is required to efficiently face the C10K problem [3] and the supporting database server must provide scalability being able to partition data over multiple nodes. To satisfy it, we rely on:Tornado Web Server (http://www.tornadoweb.org), a scalable, non-blocking Web server and tools; NGINX (http://wiki.nginx.org), the load balancer used with Tornado; and MongoDB (http://www.mongodb.org) which natively stores schema-free, JSON-like documents, manages replication, fail-over failure and supports sharding.

Things and connections are represented as RESTful resources and JSON is used as internal representational format. While JavaScript is used for connection rules.

III. Conclusion

With the demonstration we show how Paraimpu offers a Web-based platform with tools and facilities to add, compose, share, filter, collect and adapt data coming from heterogeneous kinds of sensors and actuators including programmable boards, on-line services, social networks and Internet-enabled things. Envisioning and developing Paraimpu required to define abstractions for things, data connection flows management and data adapting facilities. All of these keeping into consideration the scalability issues to support thousands of concurrent HTTP connections and things sharing.

At the same time, the technology know-how required to add and manage things is reduced and users are driven to realize truly personalized pervasive applications. Two examples of such applications are: an ambient assisted living scenario where a patient is supported on remembering when taking medicines (http://youtu.be/LqqwyJV1iao), and the lights of a hotel of Cagliari - Italy controlled by tweets (http://paraimpu.crs4.it/application/tlight).

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