Paraimpu: a Platform for a Social Web of Things

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ABSTRACT

The Web of Things is a scenario where potentially billions of connected smart objects communicate using the Web protocols, HTTP in primis. A Web of Things envisioning and design has raised several research issues, from protocols adoption and communication models to architectural styles and social aspects facing. In this demo we present the prototype of a scalable architecture for a large scale social Web of Things for smart objects and services, named Paraimpu. It is a Web-based platform which allows to add, use, share and inter-connect real HTTP-enabled smart objects and "virtual" things like services on the Web and social networks. Paraimpu defines and uses few strong abstractions, in order to allow mash-ups of heterogeneous things introducing powerful rules for data adaptation. Adding and inter-connecting objects is supported through user friendly models and features.

Categories and Subject Descriptors

H.3.5 [**Information Storage and Retrieval**]: Online Information Services—*Web-based services, Data sharing*; C.2.4 [**Computer-Communication Systems**]: Distributed Systems—*client-server*; H.5.3 [**Information Systems and Presentation**]: Group and Organization Interfaces—*Web-based interaction*

General Terms

Information Systems, Computer Systems Organization

Keywords

Web of Things, REST, Social Networks

1. INTRODUCTION

In the last years, the evolution of the Internet of Things (IoT) toward the so called Web of Things (WoT) has created the opportunity for new scenarios and applications where Internet-enabled objects (like Karotz[1], Chumby[2], Arduino[3]) become active actors and peers in the Web. Its protocols represent the "lingua franca" in a real world made of very heterogeneous things. Several efforts have focused on the definition of architectural models and solutions (e.g., the REST vs. SOAP-based Web services debate [3]). Another aspect worth to be explored is the *social* concept applied to the WoT, where it should be possible to share the objects with other people and share data and functionalities toward a participative and collaborative use of friend's things.

This demo presents a new online social Web of Things tool for managing at once Web-enabled objects. With the term *things* or *objects* we mean not only physical concrete objects (hardware) but also already existing virtual things on the Web, like social networks, APIs, services or other software applications.

The developed prototype, called Paraimpu[4], allows people to connect, use, share and compose physical and virtual things, services and devices in order to create personalized and pervasive applications. The demonstration shows the Paraimpu on-line tool, its main functionalities and how to use them to socially connect heterogeneous things to the system.

2. PARAIMPU

Realizing the platform, things and connections are represented as RESTful resources and JSON is used as internal representational format. To define them, we make abstractions on modelling things and connections. Scalability and social features are other two key aspects.

2.1 Sensors and Actuators

In order to represent things in a more abstract way, allowing to include all types of physical and virtual things, we generally distinguish them by function:

- *Sensors*: whatever thing capable to produce data of a related type (text, numeric, JSON, XML and so on);
- *Actuators*: any thing able to perform actions by consuming data items produced by a Sensor.

For example, in the first category fall concrete things like environmental sensors (most likely connected to Arduino or equivalent boards) and virtual things producing geo-referenced data, like Foursquare and APRS.fi[5], or text

[1]http://www.karotz.com/
[2]http://www.chumby.com/
[3]http://www.arduino.cc/

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[4]http://paraimpu.crs4.it
[5]http://aprs.fi

messages, like RSS Feed and Twitter. Falling to the Actuators category are, not only objects like lighting systems, OpenPicus[6] boards, Karotz rabbits, Chumby but also Facebook and Google Calendar thanks to their capability to consume a text message posting it to their wall or agenda.
Sensors and Actuators communicate with Paraimpu using HTTP protocol. Thanks to these abstractions, it is generally possible to connect a *Sensor* to an *Actuator*, independently by their nature, realizing a kind of mixed hybrid mash-ups.

2.2 Things Connection

The ability to connect "things" together is another central aspect. The *Connection* abstraction represents a real-time data flow established between two things which always envolves a *Sensor* as the data source and an *Actuator* as the data recipient. In this way a sensors-equipped Arduino board can be connected to a PWM motor controller, to Facebook or Twitter with the same simple steps. Obviously, it raises a data heterogeneity problem and a data adaptation mechanism is mandatory in order to let the communication between very different connected objects placed anywhere. Paraimpu manages string, numeric, JSON and XML data types, thus Sensors and Actuators produce or consume these types of data. Every single created connection can be properly configured specifying rules for data filtering and data adapting. For each established data flow, the system is responsible to enforce rules applying through an integrated JavaScript-based rule engine. Thanks to this language we can write simple but also very complex rules either for filters and data mappings. In case of actuators consuming complex data structures, Paraimpu guides the user with ad-hoc widgets and GUIs to facilitate the definition of filters and mappings. E.g., given a *Sensor A*, that produces JSON data in the form `{"value":12, "tag":"temperature"}` and a *Facebook Actuator*, accepting text, a simple data mapping could be: Condition = `A.value > 25`, Replace = `Summer is coming, we have <% A.value %> Celsius`; which means: *when field "value" on data coming from Sensor A is > 25, then post to Facebook wall the text "Summer is coming, we have X Celsius*; X will be the real temperature value coming from the Sensor.

2.3 A Scalable Architecture

Like the Internet of Things, The WoT vision includes not only Internet-enabled electronic objects but also any everyday objects: clothes and foods, commodities, utensils, furniture, buildings, streets, monuments, boxes, books and many others. Today, they are estimated in about 50000 billion [4]. Thus, in a WoT platform the workload is put at the extreme level and scalability is a compulsory requirement. Thousands of concurrent HTTP requests must be managed ensuring availability and performances. Thus, the Web server is required to efficiently face the C10K problem [2]. For the same reason, the supporting database server must provide scalability being able to partition data over multiple nodes. We have chosen:

- Tornado Web Server[7], a scalable, non-blocking Web server and tools

[6]http://www.openpicus.com/
[7]http://www.tornadoweb.org/

Figure 1: The Paraimpu general vision of a Social Web of Things. Physical and virtual objects on the Web can be added, inter-connected and shared

- NGINX[8], the load balancer used in conjunction with Tornado
- and MongoDB[9] which natively stores schema-free, JSON-like documents, manages replication, fail-over failure and supports sharding.

2.4 Things Sharing and Social Aspects

As also remarked in other works [1], it is interesting to explore social aspects and *things sharing* between users. Paraimpu enables users to discover and *bookmark* objects shared by other users/friends. In fact for each instanced thing, the user can select a visibility policy between private, public or moderated. The last two kinds of things can be used by contacts/friends included in a personal list. *Bookmarking* action corresponds to import shared things to the user workspace, allowing to use them in a *Connection*, like the owned ones. Moreover, existing social networks profiles can be used as *Sensors* or as *Actuators*, like any other object. For example, Twitter and Facebook are currently seen in Paraimpu as Actuators to post text messages, Foursquare as a Sensor producing geo-located data. Figure 1 illustrates a general overview of the Paraimpu social Web of Things vision.

3. DEMONSTRATION

The Paraimpu demonstration is focused on the usage of the user *workspace* (Figure 2), which is mainly composed of five areas.

- **Friends** (area 1): a list of connected friends. Selecting a friend, it is possible to discover his/her profile, his/her shared things and to *bookmark* them in order to import the friend's objects in own workspace.

[8]http://wiki.nginx.org/Main
[9]http://www.mongodb.org/

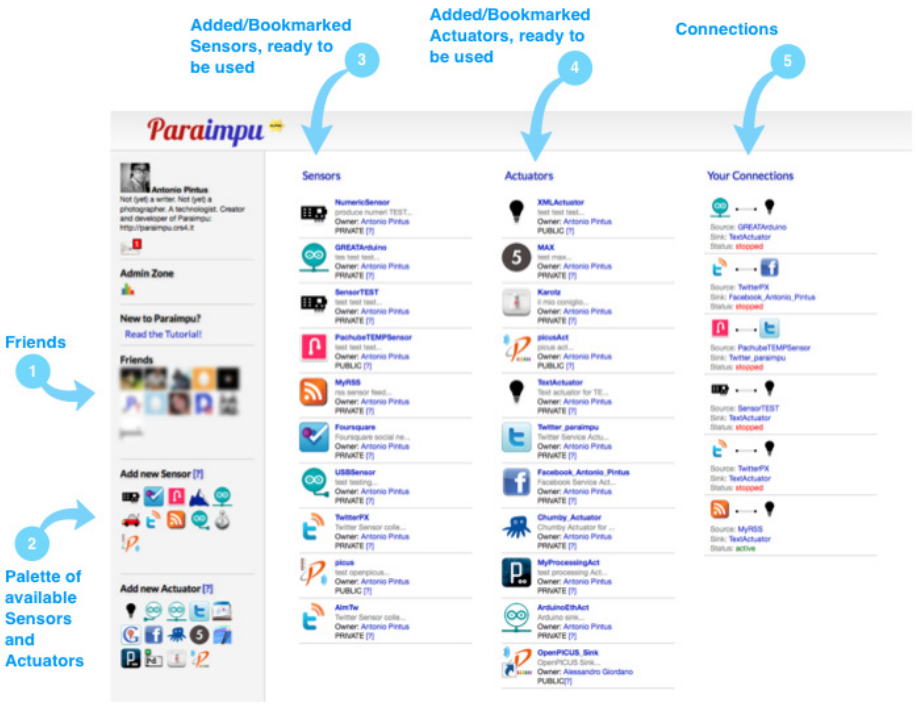

Figure 2: The Paraimpu Workspace

- **Sensors and Actuators Palette** (area 2): it shows the available *Sensors* and *Actuators* and allows users to add virtual and real things to the personal workspace. The creation of custom *Sensors*/*Actuators* is possible by the generic Sensor/Actuator palette's item. They should be used when the maximum flexibility is required but the user must develop its code to post and use data according to the APIs described in the Web page with the instance details.
  To simplify user usage, Paraimpu provides a set of predefined classes of things. At the moment, they are available for 10 *Sensors* and 13 *Actuators* different types. Predefined Sensors includes Arduino boards, Foursquare, Pachube, Twitter and timers. Among Actuators, we have GoogleCal, GoogleMap, Facebook, Karotz, Chumby and, again, Twitter and Arduino boards. The predefined things allow users to add their instances with a null or minimal configuration requirements. For example, creating an Arduino Ethernet Sensor, user must set only MAC and IP addresses of the Internet board and Paraimpu automatically creates the correct sketch to upload to the board. After a few seconds to complete the upload, the board starts to communicate with the system.

- **Added/Bookmarked Sensors and Actuators** (area 3 and 4): the list of added (using the palette) or bookmarked (shared things) Sensors and Actuators.

- **Connections** (area 5): the list of connections. Each one has the controls to configure, activate and deactivate the data flow between the Sensor and the Actuator. Paraimpu supports users in defining data adaptation rules through ad-hoc widgets. Figure 3 illustrates a data mapping definition for a connection involving a Twitter Sensor and an Arduino Ethernet Actuator.

The demonstration exploits all the facilities of Paraimpu showing how the add-connect-share process becomes simple. In few steps, things can be added or imported to workspace and, in a matter of seconds, they start to communicate with the platform through HTTP protocol. Moreover, it shows how the inter-connected objects establish real-time data flows and how writing simple but powerful data filtering/adapting rules that let very heterogeneous objects to effectively communicate.

4. SCENARIOS AND REAL USE CASES

4.1 An Ambient Assisted Living Scenario

Forgetting to take medicines is a common lack for everybody but in case of elderly and mild cognitive people, it could be a key task to perform everyday. In this scenario, of which a video is available on YouTube[10], Robert is affected by asthma and he goes to doctor for a cure relaxing the pathology.
After the visit, the doctor prescribes to take one asthma drug tablet three times per day. Like many people, Robert often forgets the right time to take the right medicine so the doctor sets a Paraimpu timer sensor with the hours to take it. That sensor is shared with Robert and it is used to activate the Paraimpu-enabled objects in patient's home.
At home, Robert places the medicine box on the table "augmented" with the Paraimpu things and its Karotz rabbit on the desk. At the time set by the doctor, the Robert attention is drawn by the Paraimpu things: Karotz LED lights

[10]http://youtu.be/LqqwyJV1iao

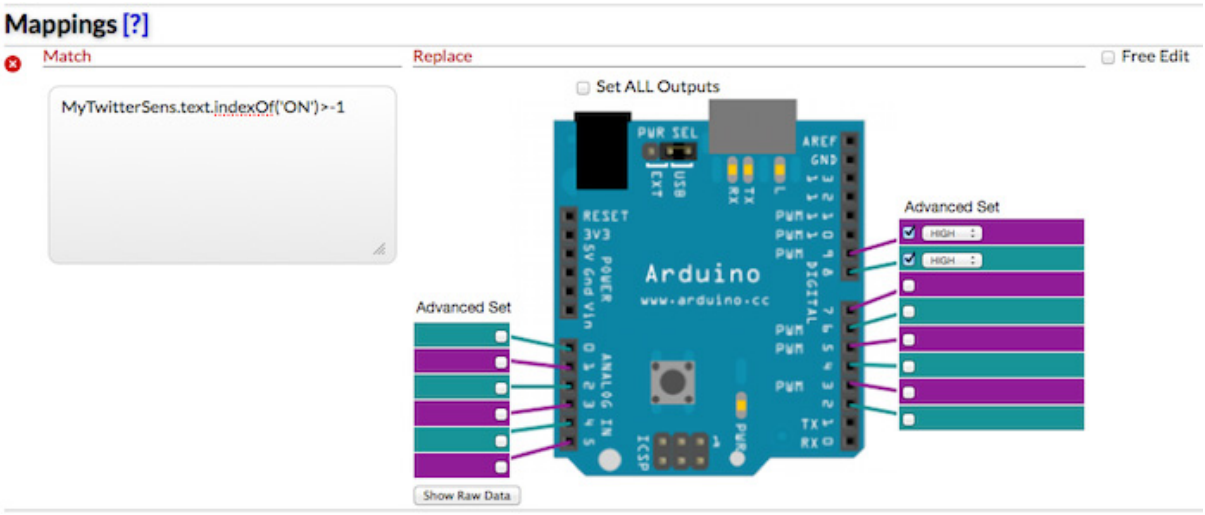

Figure 3: Data adapting rules definition: for well-known supported things, Paraimpu assists the user in creating them through ad-hoc graphical widgets

on and, rotating its ears, it tells to take the asthma drug tablets. The LED on the table lights on. Robert takes the asthma drug box, takes the tablet and replaces the box on the table. The LED switches off and a tweet with the time is automatically sent on its Twitter account. It is like "Don't worry dear! I took my asthma drug tablets!". Family and doctor read the tweet and do not worry on the asthma of their dear.

4.2 Tlight: Social Controlled Urban Lights

The T Hotel of Cagliari in Sardinia, Italy, joins the Web of Things and becomes interactive[11]. The permanent, fascinating and suggestive installation named *Tlight*, created by the Quit group[12], it is connected to the Web thanks to Paraimpu and allows everyone to change the color tones and the behaviour of the RGB lights placed on the top of the big circular glass tower of the hotel just posting a message on Twitter.
People can post a tweet containing hashtag *#thotel* and one of the following words: *red, blue, green, orange, yellow, white, cyan, wave, different, couple, full, pulse e random.* Tweets are read by an ad-hoc Twitter Paraimpu Sensor which is in turn connected to a Paraimpu Max/MSP[13] Actuator, that effectively drives the lights reacting to data coming from Twitter. The connection defines suitable data adapting rules to let Twitter and Max/MSP software successful communicate.

5. CONCLUSIONS

Envisioning and developing a social platform for the Web of Things is a challenging task, including:

- models and abstractions definitions in order to include a huge variety of objects, data connection flows management and the definition of data adapting facilities;
- platform scalability issues to enabling a social sharing of the things between people.

Paraimpu is a platform for a social WoT with facilities to add, compose, share, filter, and adapt data coming from online services, social networks and Web-enabled things.
But building the Web of Things is more than putting Things in the Web so, with the demonstration we show how Paraimpu offers a Web-based platform with tools and facilities that provide two important characterizations. First, to reduce the technology know-how required for a wider adoption of the Web of Things; second to help people on building truly personalized pervasive applications in a comfortable and user-friendly way.

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