Are you Energy-Efficient: Sense it on the Web!

Dominique Guinard[1,2], Markus Weiss[1] and Vlad Trifa[1,2]

[1] Institute for Pervasive Computing, ETH Zurich
[2] SAP Research, Zurich
Corresponding author: dguinard@ethz.ch

Abstract. Reducing their energy consumption has become an important concern for many people lately. A necessary step to save energy is to raise consumption awareness, that is: to realize how much electricity is consumed by household appliances. We propose a system that uses and extends intelligent power outlets called Plogg[3], which contain sensor nodes to wirelessly measure the energy consumption of various devices. We further describe the implementation of a web based API and a web user interface that enables users to monitor and control the consumption of their appliances using their favorite web browser.

1 Introduction

A major burden for people, who want to save energy at home, is for them to identify how much energy is consumed by different appliances. How much does my computer consume in operation, standby or powered off? Is the consumption of my energy-saving lamp significantly lower in the long run than the normal lamp I've got there? Such questions are key to understanding where energy can be saved without too much effort [4]. Currently available solutions, such as traditional LCD power monitors, are helpful, but do not fully fit the needs of individuals. They lack demonstrating power such as being able to compare consumption of individual devices on a centralized screen, in an appealing manner. Furthermore, they do not offer open APIs and developing applications on top of them is cumbersome.

In the "Energie Visible" project, we implement and deploy a system that is rather simple to setup and can be used in everyday life. As a first step each device to be monitored is coupled to a Plogg. These sensor nodes are a combination of an electricity meter plug and a data logger. Furthermore, they offer a Bluetooth interface to retrieve the current or logged consumption. These factors make them especially suited for appliance-level monitoring.

In order to automatically acquire the logged data, we extended the basic functionality of the Ploggs to feature continuous measurements on a fine, granular, time basis. In addition, to ease application developments using the Ploggs, we have built a gateway software that discovers the Ploggs and makes them available directly on the web through an easily integrable RESTful API [1]. Finally, we propose web-based user interface (UI) which allows for attractive visualization and control of the power consumption of the connected devices.

[3] http://www.plogg.co.uk/

2 Architecture

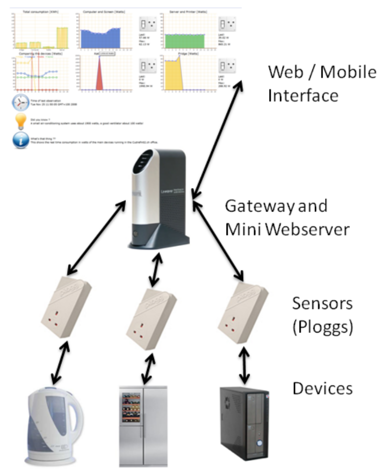

Fig. 1. Devices extended with Ploggs communicate with a gateway to offering the Ploggs functionalities through a RESTful API.

The architecture of our prototype is based on four main layers as shown on Figure 1. The first layer is composed of appliances we want to monitor and control with the system. In the second layer, each of these devices is then plugged to a Plogg sensor node. In the third, these nodes are discovered and managed by a gateway software which can be installed on any computer or embedded device with sufficient memory and Bluetooth communication capabilities. The gateway also embeds a micro webserver which offers the monitoring and control functionalities of the Ploggs as structured URLs. Finally, the last layer is the visualization interface. It uses the web-accessible functionality to dynamically draw graphs depicting the current energy consumption of all the Ploggs available in the environment.

2.1 RESTful Gateway and Webserver

The gateway is a small-footprint component written in C which manages the Ploggs by automatically discovering them on a regular basis over Bluetooth. In order to enable interoperability with other applications, the gateway embeds a small footprint web server[4] and offers access to the sensors' functionalities using URLs.

[4] `http://shttpd.sourceforge.net/`

The approach, that makes an application's functionalities accessible through a simple web API is often to referred as RESTful [1]. Traditionally, this type of approach is used to integrate several websites [3]. Consistant with the views we presented in [2], in this prototype, we apply the REST principles to real-world service to form the so-called *Web of Things*. The most interesting benefit of this approach in our case is the direct integration of the Ploggs to the web which eases the development of applications and prototypes on top of the Ploggs. Indeed, devices connected to the Ploggs can be controlled and monitored simply by calling the corresponding URLs in a standard web browser. As an example the monitoring data of all the currently available Ploggs can be retrieved by accessing the following URL:
`http://webofthings.com/energymonitor/ploggs/*`.

As a result the gateway calls all the Ploggs and wraps the results in the form of a JSON (JavaScript Object Notation)[5] document. JSON is an alternative to XML often used as an data-interchange format for web mashups. Since JSON is a lightweight format, we believe it is more adapted to devices with limited capabilities. The JSON data resulting from the call to all the Ploggs contains consumption information for each individual device as shown below.


```
[{
  "deviceName":  "ComputerAndScreen",
  "currentWatts":  50.52,
  "KWh":  5.835,
  "maxWattage":  100.56
}, {...}]
```


2.2 Web User Interface

The second part of our software architecture presents the monitoring data to the end-user. We wanted the interface to be attractive, easily-accessible (no additional software to learn or install) and to display real-time data rather than snapshots, we decided to create a dynamic web interface which could easily be built on top of the RESTful API offered by the Ploggs gateway. The implementation is based on the Google Web Toolkit (GWT)[6]. To get real-time results, the UI calls the gateway URI every few seconds and converts the JSON Ploggs' results into graphs.

As shown on Figure 2, the resulting interface offers six real-time and interactive visualization options. The four graphs on the right side provide detailed information about the current consumption of all the appliances in the vicinity of the gateways. The two remaining graphs show the total consumption (KWh) and respectively a comparison (on the same scale) of all the running appliances. Finally, a switch icon next to the graphs enables the user to switch on and power off the devices on the web. The user interface is dynamically created depending on the number and names of the discovered Ploggs.

[5] `http://json.org/`
[6] `http://code.google.com/webtoolkit/`

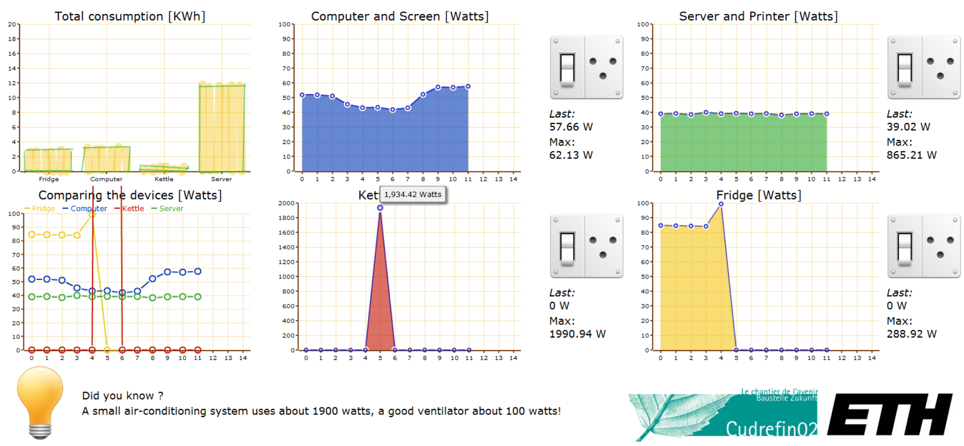

Fig. 2. The Monitoring and Control web user interface for the Ploggs shows the consumption of each connected appliance. The switch icons can be used to power off/on the devices.

2.3 Deployment

This prototype was primarily developed for Cudrefin02.ch, a private swiss foundation active in the field of sustainability. We were asked to build an easy to use an to install system that would enable both employees of the foundation and visitors to be aware of the electricity consumption of appliances in the headquarters. We successfully deployed the system on the ground-floor office of the headquarters. Currently, the Ploggs are used to monitor the energy consumption of various devices such as a fridge, a kettle, several printers, a file-server and several computers and screens. A big display in the shop-window of the office enables people passing by to experiment with the energy consumption of the devices. The office workers can also use the system by browsing to the Web UI on their desktop computer.

References

1. Roy Thomas Fielding. *Architectural styles and the design of network-based software architectures*. PhD thesis, University of California, Irvine, 2000.
2. Dominique Guinard and Vlad Trifa. Towards the web of things: Web mashups for embedded devices. In *MEM 2009 in Proceedings of WWW 2009*. ACM, 2009.
3. Cesare Pautasso, Olaf Zimmermann, and Frank Leymann. Restful web services vs. "big"' web services: making the right architectural decision. In *Proc. of WWW 2008*. ACM, 2008.
4. J. E. Petersen, V. Shunturov, K. Janda, G. Platt, and K. Weinberger. Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives. *International Journal of Sustainability in Higher Education*, pages 16—33, 2007.