The Web of Things

Tutorial Description

Carolina Fortuna, Marko Grobelnik
Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
+386 1 477 3114
Carolina.Fortuna@ijs.si, Marko.Grobelnik@ijs.si

ABSTRACT

The Web, similar to other successful man made systems is continuously evolving. With the miniaturization and increased performance of computing devices which are also being embedded in common physical objects, it is natural that the Web evolved to also include these – therefore the Web of Things. This tutorial provides an overview of the system vertical structure by identifying the relevant components, illustrating their functionality and showing existing tools and systems. The aim is to show how small devices can be connected to the Web at various levels of abstraction and transform them into "first-class" Web residents.

Categories and Subject Descriptors

H.3.4 **[Systems and Software]**: Information networks; H.3.5 **[Online Information Services]**: Web-based services

General Terms

Algorithms, Management, Experimentation

Keywords

Web of Things, Sensor, Sensor Network, Stream-Mining, Web-Mining, Semantic Web, Text-Mining, Machine-Learning

1. INTRODUCTION

The Web, through its evolution, proved to be one of the key factors for "flattening" the world [1] by providing equal and instant access to information. The Web of Things (WoT) may have similar scale impact on the world; however it is not yet clear how. Some seem to believe that only a smart infrastructure will be able to provide enough food, transport, electricity and water in an environmentally sustainable way for the increasing urbanized population [2].

From the "things" point of view, there are various technologies such as RFID, NFC and wireless sensor networks (i.e. IEEE 802.15.4, ZigBee, 6LoWPAN, Wireless M-Bus) that can be used to connect them in a network and eventually to the Web. Some of these technologies already found useful applications [2], while with the miniaturization and increased performance of computing devices it is expected more of them will be embedded with common physical objects. The "things" will generate large amounts of streamed data which will need to be efficiently processed, some of it stored, consumed by applications, and most importantly, used to provide useful feedback into environment. For instance, traffic data may be processed on the fly and fed into traffic information systems, while only an aggregate model (i.e. hourly, daily) will be stored and consumed by non-real time services and applications. Furthermore, observation of activities which is currently being crowdsourced[1], may be integrated into different flavors of smart infrastructures [2][3]. And various data sources can be combined in a smart way for building mash-ups [4].

2. DESCRIPTION

The tutorial on the Web of Things will discuss possible solutions to build the entire vertical system by identifying the relevant components, illustrating their functionality and integration, and showing the examples of existing tools and systems. First, the tutorial will cover architectural aspects and discuss the levels of abstraction for integrating the "things" into the Web. Next, the tutorial will focus on semantic technologies and analytic methods for leveraging services and applications on top of the "things". State of the art technology and tools will be showed through live demos. The tutorial will conclude with a brief review of existing projects and an outline of research directions and challenges.

Part I. Motivation & background

- Web Of Things
  - …what is WoT?
  - …why do we need WoT?
  - …what problems can it solve?
- Architectural considerations
  - showing possible verticals from hardware tosoftware
  - identify important components: "things", the "glue", the applications and services
- The "Things"
  - …sensors, sensor nodes and sensor networks
  - …fixed versus mobile sensors
  - …beyond common sensors
- The "Glue"
  - …the network
  - …the communication channel: wired/ wireless
  - …middleware: operating system, virtual machine, distributed/centralized storage and retrieval
  - data and meta-data
- Applications and services
  - general purpose distributed sensor platforms
  - sensor as a service
- Quick start recipes

[1] http://world.waze.com/

WWW 2011, March 28–April 1, 2011, Hyderabad, India.
ACM 978-1-4503-0637-9/11/03.

- how to start working in the area?
- steps to build a vertical solution

Part II. Technology and tools for exploiting the WoT

- Semantic aspects
  - how to organize sensor data?
  - how to describe sensor setups (mark-up languages, ontologies, etc.)?
  - how to describe sensor data (ontologies, enrichment, contextualization)?
- Analytic aspects
  - machine learning approaches to deal with sensor data
  - introduction to stream mining
  - introduction to complex event identification
- Services on the top of sensor setups
  - categorization of services
  - formalization of services and connection to standardization
  - examples of simple services

Part III. Demos, Tools & Research directions

- Applications and ongoing projects
  - small-size setups: e.g. ambient intelligence
  - mid-size setups: e.g. some indoor setups / agriculture monitoring
  - large scale setups: e.g. smart cities & smart grids
- Live demos of existing systems (can be turned into hands-on)
  - manual and automatic annotation of sensors and their data
  - services on top of sensor data-stream
- Open problems, future developments
- Literature, list of sources for further studies
- Summary

The tutorial on the "Web of Things" will show how different objects and devices can be connected to the Web on various levels of abstraction and transformed into "first-class residents" of the Web. The WoT vertical is relevant for an extensive range of application areas ranging from ambient intelligence, agriculture and wildlife monitoring to logistics, smart cities, energy grids, etc. The timing for the tutorial is very suitable and its relevance to the conference audience is indisputable given the global challenges such as overpopulation, intense urbanization in developing regions and climate change are pushing for smart, large scale monitoring and optimizations, in which the Web and its developers have an unprecedented role.

3. PRESENTERS

Carolina Fortuna

Carolina Fortuna's research interests are interdisciplinary focusing on semantic technologies with applications in modeling of communication and sensor systems, and on combining semantic technologies, statistical learning and networks for analyzing large datasets. She works at the Department of Communication Systems at the Jozef Stefan Institute, Ljubljana, Slovenia since 2006. She is one of the founders of the SensorLab group which consists of approximately 10 PhD students. She has actively participated in several FP6 and FP7 EU funded projects and gained industrial experience by interning with Bloomberg LP and Siemens PSE.

Marko Grobelnik

Marko Grobelnik is an expert in the areas of analysis of large amounts of complex data with the purpose to extract useful knowledge. In particular, the areas of expertise comprise: Machine Learning, Data/Text Mining, Link Analysis, Semantic Technologies, and Data Visualization. Marko works at Jozef Stefan Institute, the national research institute for natural sciences in Slovenia where he manages research group of approx. 30 researchers. He collaborates with leading European academic institutions, with European Commission and with corporations such as Bloomberg, British Telecom, Microsoft Research and New York Times. Marko is also co-author of several books, co-founder of five start-ups and is/was involved into over 25 EU funded projects.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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