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. Miniaturization and increased performance of computing devices embedded in common physical objects leads naturally towards their integration with the Web – hence the Web of Things. This tutorial provides a vertical overview of the system 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 on various levels of abstraction and transform them into "first-class residents" on the web.

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

Humans are born with five senses: sight, hearing, smell, taste and touch. While we grow and develop, we use these senses to observe the surroundings, learn patterns; we learn concepts and associate these concepts with shapes and patterns. Then we are able to generalize, recognize unseen patterns and infer new ones. Now, with the ever increased number of sensors being deployed world-wide, we are developing a global sensing system. A natural next step would be to find a way to connect this system with existing technology such as data mining, machine learning and semantic technologies to develop powerful systems that can help us understand the world – a kind of Global Oracle (see Figure 1). The web infrastructure is the ideal means to connect these two worlds: the sensors and the artificial intelligence. This way, the Web will continue to change the world [1] by providing equal and instant access to information.

From the "things" point of view, there are various technologies such as RFIDs and wireless sensors (i.e. IEEE 802.15.4, Zigbee, 6LowPAN, Wireless MBus) that can be deployed worldwide, connected in networks and eventually to the Web. Some of these technologies already found useful applications [3] while with the miniaturization and increased performance of computing devices it is expected that more will be embedded in common physical objects. The "things" will generate large amount of streaming data which will need to be efficiently processed, some of it stored, and consumed by applications. In this respect, data mining, machine learning and semantic web technologies will play a key role. For instance, traffic data may be processed on the fly and fed to traffic information systems, while only a model (i.e. hourly, daily) will be stored and consumed by non-real time services and applications. Furthermore, tasks which are currently being crowd sourced[1], may be automatically observed by different flavors of smart infrastructures [3][4]. Furthermore, sources of data can be combined in a smart for building physical mash-ups [1].

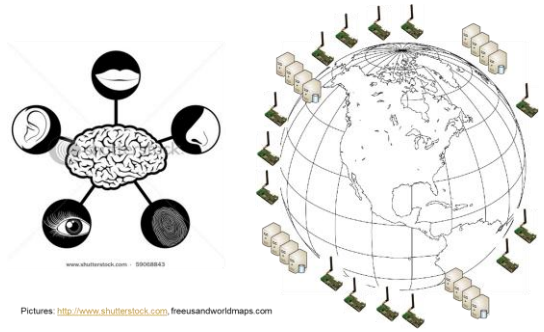

Figure 1 Analogy between human senses and brain and the Web of Things as presented in this tutorial

2. DESCRIPTION

The tutorial on Web of Things[2] will discuss the vertical of the system by identifying the relevant components, illustrating their functionality and showing existing tools and systems. First the tutorial will cover architectural aspects and discuss the levels of abstraction for integrating the "things" into the web. Then, the tutorial will focus on semantic technology and analytic methods for leveraging services and applications on top of the things. Finally, through live demos, state of the art technology and tools will be showed. Existing projects and research directions will also be provided.

Part I. Motivation & background

WWW'12, April 16-20, 2012, Lyon, France.

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

[2] The slides are available at http://carolinafortuna.com/web-of-things-tutorial/

- Web Of Things
  - …what is WoT?
  - … why do we need WoT?
  - …what problems can it solve?
- Architectural considerations
  - showing possible verticals from hardware to software
  - identify important components: “things”, the “glue”, the applications and services
- The “Things”
  - …sensors 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
  - how to start working in the area
  - steps to build a vertical

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 into stream mining
  - introduction into 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 is relevant because it shows how small devices can be connected to the web on various levels of abstraction and transform them into "first-class residents" of the web. The WoT vertical is relevant for an extensive range of application areas from ambient intelligence, agriculture and wildlife monitoring, logistics, smart cities, energy grids, etc. The tutorial is timely as global challenges such as overpopulation, intense urbanization in developing regions and climate change push for smart, large scale monitoring and optimizations.

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 1996. She is one of the leaders of the SensorLab group which consists of approximately 10 PhD students. She has actively participated in FP6 and FP7 projects and gained industry 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 major European academic institutions and industries such as Bloomberg, British Telecom, European Commission, Microsoft Research, New York Times. Marko is also co-author of several books, co-founder of four start-ups and is/was involved into over 25 EU projects.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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