WoT 2013: Fourth International Workshop on the Web of Things

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Abstract

We propose a workshop on the topic of the *Web of Things*, which is about extending the *Internet of Things* concept beyond the connection of things and considering issues like heterogeneity, scalability, and usability with respect to pervasive computing. The goal of this initiative is to reuse the architectural principles that made the Web successful and apply them to smart devices, thereby making real-world objects first-class citizens of the Web. The approach taken by the Web of Things initiative is to look at the problems and research issues that emerge when considering the interaction of heterogeneous devices within composite applications. Continuing the successful Web of Things workshop series, this workshop aims at further exploring the use of technologies and principles at the core of the Web to provide methods for a seamless integration of physical devices. In particular, our goal is to foster discussion on systems towards a real-time Web of Things and the discovery, search, and composition of services provided by Web-enabled devices.

Background and Workshop Objectives

phones, embedded computers, etc.) and the Internet provides new design opportunities and challenges, as digital communication networks will soon not only contain information resources (images, text, etc.), but also real objects.

The *Internet of Things* has become a well-known brand for a set of research issues in the pervasive and ubiquitous computing communities. The focus of this research theme has mostly been on establishing connectivity in a variety of challenging and constrained networking environments. Our hypothesis is that the *Web of Things* is the next logical step in the ongoing evolution of how pervasive and ubiquitous computing have enabled new applications and provided new opportunities. The Web of Things takes the next step from establishing connectivity and thus the ability to communicate with Things, to a vision where Things become seamlessly integrated into the Web – not just through Web-based user interfaces of specific applications, but by blending into the hypermedia information space created by the Web and its architectural principles [2].

Continuing the successful Web of Things workshop series at PerCom 2010 (Mannheim, Germany) and Pervasive 2011 and 2012 (San Francisco, US / Newcastle, UK), as well as the Urban-IoT 2010 workshop at the Internet of Things 2010 conference (Tokyo, Japan), this workshop aims at exploring the use of principles and technologies at the core of the Web such as *Representational State Transfer* (REST), *syndication* (e.g., Atom), and *real-time* Web technologies (e.g., HTML5 WebSockets) for providing access to pervasive and ubiquitous computing services. It aims at exploring and tackling the challenges to achieve a seamless "Web of Things" where the Web's architectural principles are applied in a way that makes Web-enabled things usable across the largest possible set of application scenarios. The general scope of the workshop is described as follows:

- Concrete integration of embedded computers, wireless sensor networks, every-day appliances, and tagged objects (RFID, barcodes) using a RESTful approach.
- Systems towards a real-time Web of Things (e.g., by using syndication or Web push mechanisms).
- Discovery, search, composition, and physical mashups in a Web of Things.
- Use of semantic technologies (e.g. ontologies, embedded metadata, context) to facilitate the interaction with and between things on the Web.
- Concrete applications, use-cases, deployments, and evaluations of Web-enabled Things in contexts such as smart homes, connected cities, and Web 2.0 enterprises.

The primary goal of the workshop is to take the wealth of research and applications already available in the the pervasive and ubiquitous computing communities, and to identify the issues that need to be addressed to make them available as part of the Web. Specifically, our goal is to highlight and focus on the difference between Web-based user interfaces ("having Web UIs for things"), and Web services ("immersing things into the Web"). In such a service-oriented view, interactions with things work in the very same way as interactions with other resources on the Web, allowing developers to mix and remix resources in ways similar to the popular Web 2.0 mashups [2, 3]. One of the key goals of the workshop is to foster collaboration among researchers in pervasive and ubiquitous computing, and to encourage them to build loosely coupled architectures to allow the various systems and architectures devised by researchers and engineers around the world to cooperate seamlessly.

After laying the foundation of the Web of Things approach over the last three years, we observe that this approach and its underlying concepts are gaining substantial momentum. The fast growing webofthings.org community, and the recent calls for Web/Internet of Things projects launched by the European Community clearly demonstrate the growing interest in the concept. The increasing number of Web of Things related scientific publications in the field of *Pervasive Computing* (e.g., [1, 5, 6]) also confirms this fact. Furthermore, the recent developments in *Embedded Computing* and *Wireless Sensor Networks* [4], along with the successful *IP for Smart Object (IPSO) Alliance*, clearly illustrate the need and benefits to be gained from making embedded devices part of the Internet. However, these trends illustrate only connectivity at the TCP/IP level without actually considering what goes on top, at the application level, where a standard protocol is lacking. The proposed workshop targets exactly this gap. Unfortunately, the field lacks a scientific forum to discuss these issues and present solutions and prototypes. Indeed, the Web of Things workshop will enable such necessary discussions on the important issues and technical challenges of a global and scalable application for embedded devices, and also to demonstrate innovative applications and uses for such a *Web of Things*, in particular to tackle today's essential challenges such as transportation, health care, elderly care, sustainability, and energy awareness. With both application and technical backgrounds in both pervasive computing and communications, we believe that Pervasive, especially in the new joint format with Ubicomp, is an ideal venue for organizing such a forum.

Past Workshops

The first edition of the Web of Things workshop was organized at PerCom 2010.[1] With a total of 32 submitted papers (out of which 12 were selected and published in the IEEE Digital Library) from 15 countries, the workshop was identified by the PerCom 2010 workshop chairs as one of the most successful workshops, showing a trend towards the use of Web architectures in Pervasive computing. The workshop was attended by 40 very motivated researchers (maximum room capacity), including a number of people from industrial research. It featured plenum sessions, an open demonstration session, and an informal workshop dinner to create connections between the participants. On the downside, participants mentioned the fact that PerCom was perhaps not the best venue for the workshop as it was slightly too much focused on the technical/theoretical side of wireless sensor networks.

For this reason, we proposed the second edition of the Web of Things workshop[2] to be held at Pervasive 2011 in San Francisco in June 2011. It was a great success and proved that Pervasive was a very good choice of a venue to discuss topics in the Web of Things domain. In this edition, 12 out of 25 submissions were accepted to be presented in the workshop's three sessions. Additionally, the workshop featured two invited business talks (by Thingspeak and ThingWorx, respectively), a demonstration and poster session, a one-day hackathon, and an informal workshop dinner. By placing the emphasis on discussion rather than presentation of the papers and prototypes, the workshop provided an interactive forum for WoT researchers and practitioners.

[1] www.webofthings.org/wot/2010/
[2] www.webofthings.org/wot/2011/

The conference proceedings have been published to the ACM digital library[3] and listed on DBLP.

In the third iteration of the Web of Things workshop, held at Pervasive in Newcastle in June 2012, we were thus already able to build on a solid community of participants and reviewers who contribute in core domains of the WoT (e.g., deployments, Web of Things toolkits and frameworks, Web of Things architectures) but were still able to extend to new fields around the context-aware WoT, e.g., to semantics and artificial intelligence. From the seven papers that we chose to accept, the best paper award was given to Michael Blackstock and Rodger Lea for their paper "WoTKit: A Lightweight Toolkit for the Web of Things", an appreciation of their continuous work to create a toolkit that fosters the creativity of WoT researchers and allows them to focus on the actual use-cases. The third iteration of the workshop again featured multiple invited keynotes (by openPICUS, Koubachi, and EVRYTHNG) as well as a successful one-day hackathon, demonstration session, and informal workshop dinner. The conference proceedings have been published to the ACM digital library[4] and listed on DBLP.

Based on the feedback we received by presenting the Web of Things at major academic and industrial conferences, the activity on our own blog, and especially the latest developments in the industry, we are confident that the years to come will be the years of the Web of Things. As major companies start to embrace this trend, we can ascertain that the Web of Things field has become a research area in its own right.

[3] dl.acm.org/citation.cfm?id=1993966
[4] http://dl.acm.org/citation.cfm?id=2379756.2379757

Workshop Format

Due to the lack of a common venue for interaction between researchers in the Web of Things, we decided to adopt a workshop format that encourages open discussions and the sharing of ideas, thus laying the foundation for future cooperation. Unlike the classical mini-conference format with presentations and short Q&A sessions afterwards, we have been inspired by the format proposed for CHI's workshops where the mini-conference format is specifically discouraged. The presentation session of the workshop will be organized around these important points:

- Timely solicitation, preparation, and distribution of all papers to allow presentations to be shorter, as prior knowledge can be expected.
- For each paper, all participants are invited to prepare two or three questions. Prior reading allows the attendance to think about the interesting issues of each presentation, and to make connections to their own research work.
- Focused sessions around theme clusters that are derived from the accepted submissions. For these sessions, we specifically ask presenters to address the similarities and differences with the other presentations in that session, so that presentations are not isolated, but instead highlight connections, overlaps, and differences.

The key issues for this workshop to be successful is to have good timing, and to be very clear in communicating the requirements for attendants and presenters before the workshop date. In the middle of the day an interactive demonstration session will allow for more direct interactions amongst the participants. While we are

planning on accepting demonstration papers, the session will be open to any participants having a prototype/poster to show.

At the end of the day, the organizers will sum up the edition in an interactive panel session where participants will be asked to give their thoughts on the main research issues and challenges for a global Web of Things. Finally, an informal workshop dinner will foster longer-lasting connections between the participants.

Expected Papers and Attendees
We expect a fair number of papers to be submitted, and our goal and hope is that this workshop will be able to look beyond simply using HTML or XML as tunnel for "inside of the box" communications in pervasive computing. Instead, we will prioritize submissions that specifically look at ways in which the core principles of the Web architecture can be applied in pervasive computing. Our goal is to have a workshop with sufficiently related research themes and topics, so that active participation is easily possible. Ideally, the number of participants should be around 20, and we are confident that we will be able to attract enough submissions to get to that number.

Hackathon
Like in the last editions of the WoT workshops, we plan to organize a one-day "hackathon" the day before the workshop. The hackathon and workhsop are two separate events and participation at the hackathon is not tied to workshop participation. From our experience with the hackathon, we expect that about 15 individuals will be attending both the hackathon and workshop. The hackathon therefore also helps to do the "warm up" for the workshop, i.e., allowing participants to get to know each other in a more informal setting and to ideally already start discussing. The concrete activities and outcome of the hackathon are very much dependent on the participants' ideas and the hardware that we (and sponsors) will provide (e.g., Sensor nodes, Arduinos). In the last years, the participants created several prototypes that were then demonstrated at the workshop the day after. We are going to take care of finding a place that will provide appropriate space and equipment for the hackathon.

Soliciting Submission

Although WoT 2013 will, being only the fourth workshop in this area, be part of a sustained attempt to build a community around the Web of Things, we have access to existing channels and forums that are focused on the Web of Things. Based on our experience with past workshops, we are confident that the following mix of channels will make this workshop well-known in the relevant communities: well-known mailing lists such as SIGMM and the LocWeb list can be used to send emails with announcements, notifications, and reminders, in addition to the various internal mailing lists of the organizers' institutions, along with those of our PC members. The webofthings.org Web site as well as its associated groups on LinkedIn,[5] Facebook,[6] and Twitter[7] also have a good number of readers and followers. Last but not least, advertising can be done on conferences between the Pervasive notification date and the proposed workshop paper due date (end of May). We also plan to advertise the workshop in person at the conferences and workshops that we will attend during the next few months and leverage the various contacts we have been continuously establishing through our participation and workshops organization at various conferences and symposia.

[5] www.linkedin.com/groups?gid=1818463
[6] www.facebook.com/group.php?gid=71529085265
[7] twitter.com/webofthings

If Ubicomp 2013 has a policy of publishing workshop proceedings in a series, we will gladly make the proceedings available through that series. Otherwise, as last years, we plan to publish the proceedings in the ACM ICPS series, which also have successfully been used for the LocWeb and WS-REST workshop series (by former members of the WoT organization committee). This publication channel makes all papers available in the ACM digital library and therefore guarantees a high degree of visibility.

Selecting Participants

As for WoT 2010, WoT 2011, and WoT 2012, we will select participants based on submitted papers and reviews provided by our committee. We will propose two types of papers:

- Demonstration papers (max. 4 pages): Accepted demo papers will require the authors to setup a demo and/or prototype (and poster, if appropriate) and present their work in a more interactive way during breaks and demonstration session of the workshop.
- Regular papers (max. 8 pages): Accepted papers will be expected to be presented during the workshop in a short presentation. These may also be accompanied by a demo and/or prototype.

All submissions will be peer-reviewed and selected based on their originality, merit, and relevance to the workshop. Through the peer-reviews of our program committee, we expect to select about 8 regular papers and 4 demonstration papers. When appropriate, to reduce the number of presentations, regular papers will be invited to present a demonstrator instead of a full presentation.

Suggested PC Members

We expect a number of PC members from WoT 2010, WoT 2011, and WoT 2012[8] to join us again for WoT 2013, and will invite a few additional members. Our PC will be composed of researchers and practitioners in the fields of pervasive computing or Web technologies that have a clear understanding of the Web of Things. A tentative list of people that we are planning to invite to the program committee of the workshop is provided here:

- Michael Blackstock, University of British Columbia, Canada
- Benoit Christophe, Alcatel Lucent Bell Labs, France
- Carolina Fortuna, Jozef Stefan Institute, Slovenia
- Aitor Gomez-Goiri, Universidad de Deusto, Spain
- Artem Katasonov, VTT Labs, Finland
- Gerd Kortuem, The Open University, UK
- Matthias Kovatsch, ETH Zürich, Switzerland
- Rodger Lea, University of British Columbia, Canada
- Olivier Liechti, University of Applied Sciences of Western Switzerland
- Marino Linaje, Universidad de Extremadura, Spain
- Diego López de Ipiña, Universidad de Deusto, Spain
- Friedemann Mattern, ETH Zürich, Switzerland
- Florian Michahelles, ETH Zürich, Switzerland
- Guido Moritz, Universität Rostock, Germany

[8] www.webofthings.org/wot/2012/committee.php

- Claro Noda, Universidade de Minho, Portugal
- Jacques Pasquier, Université de Fribourg, Switzerland
- Cesare Pautasso, Università della Svizzera Italiana, Switzerland
- David Resseguie, Oak Ridge National Laboratory, USA
- Till Riedel, Karlsruhe Institute of Technology, Germany
- Andreas Ruppen, Université de Fribourg, Switzerland
- Vlad Stirbu, Nokia Research, Finland
- Iñaki Vázquez, Symplio, Spain
- Erik Wilde, EMC Corporation, USA

Organizers' Contact Details

- **Simon Mayer**; ETH Zurich, Switzerland

  Simon Mayer is working as a PhD student and Research Assistant in the Internet of Things/Web of Things domain at the Institute for Pervasive Computing, ETH Zürich. His main research topics are aspects of integrating smart things into the Web, their semantic description, and infrastructures that support human users and machines in finding and interacting with the information and services provided by such devices. As visiting researcher at the Laboratory for Manufacturing and Productivity at MIT, he was working on bringing live data from automobiles to the Web. Simon graduated from ETH Zürich in computer science.

- **Vlad Trifa**; Evrythng Ltd, Zurich/London

  Dr. Vlad Trifa is the co-founder of WebofThings.org and also chief product officer and co-founder of EVRYTHNG, a Swiss-British company that builds the Web of Things. Widely published, Vlad is a recognized expert in networked embedded devices with higher-level applications using Web technologies. Previously, he worked as a researcher in urban and mobile computing at MIT and in Singapore, in bio-acoustics and distributed signal processing at UCLA, and in human-robot interaction and neurosciences at ATR in Kyoto (Japan). He also gained industrial experience in factory automation and enterprise computing working as a research associate at SAP Research. Vlad received a PhD in computer science from ETH Zurich and a MSc in computer science from EPFL.

- **Dave Raggett**; W3C

  Dr Raggett is the W3C Staff contact for the System Applications Working Group, Near Field Communications Working Group and the Model-Based UI Working Group. He has been closely involved with the development of Web standards since 1992, contributing to work on HTML, HTTP, MathML, XForms, voice and multimodal interaction, ubiquitous web applications, financial data, privacy and identity. Dave is currently involved in three European FP7 research projects: webinos, Serenoa and COMPOSE, and before that PrimeLife. Raggett has a special interest in the Web of Things. In addition to work on standards, he is a keen programmer as a practical way to explore new ideas. He was educated in England and obtained his doctorate from the

University of Oxford, and is a visiting professor at the University of the West of England.

- **Dominique Guinard**; Evrythng Ltd, Zurich/London

  Dr. Dominique Guinard is the CTO of an Internet of Things related startup called EVRYTHNG. He is also the co-founder of the Web of Things initiative and workshop series. During his PhD at ETH Zurich, he researched on the foundations of the Web of Things and especially focused on facilitating application development in the form of physical mashups. He was also a visiting researcher at the Auto-ID Labs of MIT, working on bringing global networks of tagged objects to the Web. Before this he worked 4 years as a research associate for SAP Research, building a service oriented architecture to enable real-world device integration into business software. Dominique had further experiences with several research institutions and companies in the Internet of Things domain such as with Lancaster University, Nokia research or Sun Microsytems. He graduated in Computer Science from the universities of Fribourg and Bern.

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