CEPIS UPGRADE is the European Journal for the Informatics Professional, published bi-monthly at <http://cepis.org/upgrade>

Publisher
CEPIS UPGRADE is published by CEPIS (Council of European Professional Informatics Societies, <http://www.cepis.org/>), in cooperation with the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática,* <http://www.ati.es/>) and its journal Novática

CEPIS UPGRADE monographs are published jointly with Novática, that published them in Spanish (full version printed; summary, abstracts and some articles online

CEPIS UPGRADE was created in October 2000 by CEPIS and was first published by Novática and INFORMATIK/INFORMATIQUE, bimonthly journal of SVI/FSI (Swiss Federation of Professional Informatics Societies, <http://www.svifsi.ch/>)

CEPIS UPGRADE is the anchor point for UPENET (UPGRADE European NETwork), the network of CEPIS member societies' publications, that currently includes the following ones:

- inforewiew, magazine from the Serbian CEPIS society JISA
- Informatica, journal from the Slovenian CEPIS society SDI
- Informatik-Spektrum, journal published by Springer Verlag on behalf of the CEPIS societies GI, Germany, and SI, Switzerland
- ITNOW, magazine published by Oxford University Press on behalf of the British CEPIS society BCS
- Mondo Digitale, digital journal from the Italian CEPIS society AICA
- Novática, journal from the Spanish CEPIS society ATI
- OCG Journal, journal from the Austrian CEPIS society OCG
- Pliroforiki, journal from the Cyprus CEPIS society CCS
- Tölvumál, journal from the Icelandic CEPIS society ISIP

ISSN 1684-5285

Monograph of next issue (April 2011)
"Software Engineering for e-Learning Projects"
(The full schedule of **CEPIS UP**GRADE is available at our website)

CEPIS UPGRADE

The European Journal for the Informatics Professional
http://cepis.org/upgrade

Vol. XII, issue No. 1, February 2011

Monograph
Internet of Things
(published jointly with Novática*)
Guest Editors: *Germán Montoro-Manrique, Pablo Haya-Coll, and Dirk Schnelle-Walka*

UPENET (UPGRADE European NETwork)

CEPIS NEWS

* This monograph will be also published in Spanish (full version printed; summary, abstracts, and some articles online) by **Novática**, journal of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática*) at <http://www.ati.es/novatica/>.

Presentation

Internet of Things: From RFID Systems to Smart Applications

Pablo A. Haya-Coll, Germán Montoro-Manrique, and Dirk Schnelle-Walka

1 Foreword

"*The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it*" [1].

This sentence, written by Mark Weiser in 1991, can describe the current idea of the Internet of Things (IoT). The technology has to disappear but, as if it was a contradiction, it has to do so by becoming an essential and indistinguishable part of the everyday objects that surround us. Thus, the Internet jumps from traditional devices to real objects, thanks to the use of technologies such as wireless sensing or radio-frequency identification (RFID). The number of users surfing the web will be overtaken by the number of objects that will communicate with each other. And they will do it with one main objective: to offer users advanced computational services in a subtle and efficient way. People will not need to be aware that they are assisted by technology and, as far as possible, will interact with these objects in the most natural way. That is how the Internet of things will make technology disappear, by disappearing from the eyes and the "feeling" of the people.

As we can see from the vision of Mark Weiser, although the idea of the Internet of Things is relatively new, it is supported by concepts and technologies that have been around for decades. The ability to integrate these technologies, the advances of the miniaturization required to incorporate them into everyday objects, and the capacity of communication of these objects with the network and with each other make it possible to talk now about the realization of those concepts. This vision has already become a reality. For instance, DHL offers the DHL Paketbox where customers can frank parcels on the Internet and take them to the Parcelbox [2]. The customers open a door, place the franked parcel inside and close the door. Here, the franking code is automatically read and used for further processing steps. Right after the customer closed the door, he or she will be able to monitor the delivery status on a special web site.

The term Internet of Things, IoT, was originally coined within the RFID development community around 2000. They referred to the possibility of querying information about a tagged object by browsing an Internet address or a database entry. Today, this approach has merged with the concepts of Ubiquitous Computing (UC) or Ambient Intelligence (AmI), centred on shifting the information and interaction from screens and traditional devices to the physical environment. In this new approach, everyday objects can be discovered, located and controlled via the Internet. This does not only refer to the smart devices that we carry or that surround us in a specific moment, but also to the things that we discover while we are on the move. It is not restricted to things that have any intelligence integrated, but can be extended to ordinary things of our daily life, such as food or clothing. Hence, the basic idea is an Internet of connected everyday objects, creating the ground for two major research fields:

- Machine-to-machine communication.

The Guest Editors

Pablo A. Haya-Coll is a full-time Lecturer at the School of Engineering of the *Universidad Autónoma de Madrid* (UAM), Spain, and has been a researcher and member founder of AmILab (Ambient Intelligence Laboratory at UAM) since 2000. He received his doctorate in Computer Science Engineering and Telecommunications from the same university in 2006. His research interests currently focus on Human Computer Interaction applied to Ubiquitous Computing. More details and publications can be found at <http://amilab.ii.uam.es> or <http://www.eps.uam.es/~phaya>. <pablo.haya@uam.es>

Germán Montoro-Manrique is an Associate Professor in the Dept. of Computer Engineering of the *Universidad Autónoma de Madrid* (UAM), Spain. He received his PhD in 2005 in the area of spoken dialogue systems for smart environments. Since then he has researched in the field of advanced user interfaces related to ambient intelligence environments. Further information and publications can be found at <http://amilab.ii.uam.es> and <http://www.eps.uam.es/~montoro>. <german.montoro@uam.es>

Dirk Schnelle-Walka received his PhD in 2007 in the area of voice user interface design at the Technical University of Darmstadt, Germany. He transferred the idea of design patterns to the design of voice user interfaces. His research focus is on voice-based interaction in pervasive environments. He currently leads the Talk&Touch group at the Telecooperation Lab at the Technical University of Darmstadt. He is also the head of several open source projects on speech technology, for example the open source voice browser JVoiceXML. More details and publications can be found at <http://www.tk.informatik.tu-darmstadt.de/de/people/dr-dirk-schnelle-walka/>. <dirk@tk.informatik.tu-darmstadt.de>

■ Machine-to-human and human-to-machine communication.

2 Characteristics of the IoT Systems: Overview

A good overview of the technologies needed to make the IoT concept a reality can be found in [3]. It specifies the kind of applications that can be obtained and the open issues that are still to be addressed. Below we will summarize some of their ideas as a review of these research fields.

2.1 Technologies and Interaction

These systems can be built thanks to the integration of identification, sensing and communication technologies, as well as the presence of a middleware layer. Interaction is also an important issue, and many systems have to deal with the development of new ways of interaction.

RFID systems are one of the key parts for the development of the IoT. In these environments objects can be identified by a unique ID corresponding to a RFID tag. Readers monitor these tagged objects to map the real world into a virtual world. In [4] authors show that building applications with RFID data in the IoT is challenging because tag-read events provide only low-level information and the metadata associated with tags, antennas, and events must be personalized and carefully controlled to create a safe, meaningful user experience. This implies some problems that must be overcome, like achieving a sufficient density of tags and users or finding techniques that improve or compensate for low tag-read rates. As for privacy, a major concern in the IoT, They conclude that context-aware access control seems to be a useful, easily understood abstraction for managing location privacy. Nevertheless in this case more evaluation is needed to determine whether it meets users' needs when privacy concerns are magnified.

On the other hand, wireless sensor networks can help RFID technology to better track the status of objects by augmenting the awareness of the environment. They consist of distributed sensor nodes that monitor the environment and pass low level information (temperature, luminosity, pressure, etc.) to an interpreter which provides high level information about the state of the environment. For the successful development of the system it is necessary to choose the appropriate kind of sensors for the tasks that are to be measured. It is also important to employ some kind of technique for processing sequential sensor data, so that it can reduce noise and infer context beyond what the sensors actually measure. John Krumm proposes in [5] some well-accepted approaches:

■ Mean and median filters: a simple technique that averages together multiple samples.

■ The Kalman filter: a more sophisticated method that explicitly accounts for sensor noise and employs a dynamic model of the system to keep up with changes over time.

■ The particle filter: a less restrictive method that does not require a liner model for the process in question.

■ The hidden Markov model (HMM): which works only for discrete state variables but which can be useful for reducing the frequency of transitions between states.

The next necessary element is a middleware. By middleware we mean a software layer that connects the software and physical components hiding the unnecessary details for their communication. The middleware simplifies the development of new services and their integration with existing ones and helps to network sensors and augmented objects to talk to each other. The presence of a middleware is necessary since devices employ very diverse standards and ways of interaction. [6] describes some basic requirements for these specific middlewares:

■ Communication: Synchronous and asynchronous (event-based) communication.

■ Resilience: Replication, isolation and graceful handling of failures.

■ Security: Secure communication among distributed services.

■ Ease of use: Natural and intuitive usage for each target language.

One of the most common approaches is the use of a service-oriented middleware. For instance, the Hydra project is a major European effort to develop a middleware based on a Service-oriented Architecture for networked embedded systems. Its objective is to allow users to create AmI applications utilizing device and sensor networks [7].

As mentioned above, the IoT requires new ways of interaction, with concepts like tangible user interfaces (TUI) [8], where users interact with digital information through the physical environment or embedded interfaces [9], where the interfaces are integrated or co-located with the devices. These interfaces follow a new paradigm of design, far from the ideas of the classical user interfaces. In [5] Aaron Quigley defines ten key rules that should be followed by designers and developers of these new systems:

■ Bliss: Learning to interact with a new kind of UI should not require people to learn another skill or complex command language.

■ Distraction: Do not demand constant attention in the interface.

■ Cognitive Flow: Systems that are everywhere must allow the user to retain total focus on the task at hand.

■ Manuals: Do not require a user to read a manual to learn how to operate the interface.

■ Transparency: Do not rely on users to hold application state in the mind to operate the interface.

■ Modelessness: Avoid "modes" where the system responds differently from the same input stimulus dependent on some hidden state information.

■ Fear of Interaction: Provide easy ways to undo actions.

■ Notifications: Feedback to the user can be piggybacked and layered into interactions with their physical environment.

■ Calming: Interfaces will rely on a wide array of human inputs and human senses.

■ Defaults: Good interfaces judiciously exploit what the system knows or can deduce, reusing, for instance, user inputs.

2.2 Application Domains

Therefore, taking these considerations as a starting point we can develop a huge number of applications. One possible division would classify them into the following domains [3]: transportation and logistics, healthcare, smart environments, and personal and social.

The transportation and logistics domain includes real-time processing technology based on RFID and NFC to monitor the supply chain in a logistic environment; vehicles provided with sensors and actuators that can offer information for assisted driving; monitoring of the environmental parameters for the distribution and consumption process; or augmenting maps to provide richer contextual information.

The healthcare domain groups technologies that track and monitor objects, staff and patients in health environments; patient and staff identification; automatic data collection; or sensing to provide real-time information on patient health.

The smart environments domain includes homes and offices that become more efficient, comfortable and easy to interact by their inhabitants; industrial plants monitored by numerous RFID tags and sensors; or smart leisure environments such as museums that provide a personalized experience to the users.

The personal and social domain embraces applications that allow users to interact with other people. These can be applications to study and recognize trends in their activities; automatically update their social information; help users to locate lost objects; or warn them if they are stolen.

3 Open Issues

Finally, although many of these technologies, projects and systems are already developed, some open issues need to be addressed in the field of the IoT. They include:

- Standards for the integration of RFID or for the wireless and communication networks.
- Addressing and naming to provide mobility support and mapping between objects and references.
- Transport protocols and traffic characterization that can deal with the new traffic patterns derived from the IoT.
- Authentication and data integrity architectures adapted to the new ways of communication of the elements in the IoT.
- Privacy to ensure that only the appropriate information is shared between the different nodes of the system.
- Data integrity and privacy are two of the major concerns when we talk about the IoT. [10] presents an analysis of security and privacy challenges in the IoT. It divides the IoT into eight topics and describes the state of the art of the security and privacy for each of them:
- Communication: Mechanisms for securing communication are well-established but unfortunately seldom applied, especially in small devices with weak processing power.
- Sensors: their major problem is privacy, users should be aware that they are being sensed, be able to choose whether they are being sensed and be able to opt-out and remain anonymous.
- Storage: Mechanisms for integrity and confidentiality in storage are well-established, but unfortunately they are often complex to be employed, besides anonymization and pseudonymization mechanisms must be used to ensure that data does not contain information sensitive to privacy.
- Devices: The integrity of devices is an unresolved issue since fully Trusted Platform Computing capable operating systems are still lacking.
- Processing: Mechanisms for preserving privacy exist in data mining but are applied seldom.
- Localization, Tracking and Identification: In the three cases the user should be able to opt-out and be notified of these processes.

4 IoT in this Special Issue

Following these ideas we present in this special issue seven papers that cover some of the most relevant areas presented in the IoT. We have divided them into three categories that try to illustrate the different aspects involved in the creation of an IoT environment: system support, creating applications for IoT, and IoT applications.

4.1 System Support for IoT

In this category we present two papers that describe different approaches to create the necessary base that will allow building applications and services on top of it.

In a "*A Semantic Resource Oriented Middleware for Pervasive Environments*" the authors describe a Triple Space middleware that allows communication between heterogeneous devices through different communication links. To do this, they bring the idea of tuplespace based distributed computing to ubiquitous systems. They describe the characteristics of the implemented middleware and show their preliminary test results. As a conclusion they prove that this approach is appropriate for the integration of devices and services in the IoT paradigm.

"*Creepy Π-on, i.e., System Support for AmI*" also tries to provide a solution to the integration of different applications and technologies in the field of ambient intelligence environments. Their proposal consists of a new kernel for machines providing IoT services, a distributed file system protocol to allow communication between the different components and a new user interface management system to let users interact with the environment. They are responsible of moving the data fast between the different components, providing a common language to exchange information and access devices and bringing distribution, replication, persistence, and interaction heterogeneity by default.

4.2 Creating Applications for IoT

Here we include two new papers that describe methods and mechanisms to deploy IoT systems.

"*The Mundo Method - An Enhanced Bottom-Up Ap-*

systems in a bottom-up way, in a different way to other bottom-up methods employed so far. To do this the authors analyse the main problems and limitations of existing approaches and propose alternatives to facilitate the design and implementation of ubiquitous computing systems.

In "*Model Driven Development for the Internet of Things*", the authors show how the Model Driven Development can be employed in the IoT to specify physical mobile workflows of business process-supporting systems. They explain how to capture the requirements to link the virtual and physical information by means of modelling techniques that can be employed by the designers. They present a development strategy and describe a framework that defines an abstract architecture and code generators that produce, from a model based in that architecture, the implementation assets required for the technological infrastructure of a specific platform.

4.3 IoT Applications

The IoT applications category is formed by the papers "*Digital Object Memories in the Internet of Things*", "*Ubiquitous Explanations*" and "*The Internet of Things: The Potential to Facilitate Health and Wellness*".

In "*Digital Object Memories in the Internet of Things*" the smart objects feature a memory that can be used to store information about the object's properties, state and usage history. Hence, objects become self representative and enable new kinds of applications in the IoT. The digital memory is realized by a layered architecture that is described in this article.

"*Ubiquitous Explanations: Anytime, Anywhere End User Support* " introduces a middleware to increase the ability of users to interact with devices that they encounter while they are on the move. Therefore, a middleware has been developed to facilitate the exchange of knowledge between centralized knowledge bases and the devices.

"*The Internet of Things: The Potential to Facilitate Health and Wellness*" investigates how home telehealth monitoring and mobile classification systems for movement activities can benefit from the IoT. The goal is to help to improve health and wellness with the help of autonomous 'things' (sensors, processing and communication devices, and displays).

The papers of this issue can cover only a part of the many faces of the IoT which are reflected by the different views on the selected categories. The creation of IoT applications combine several fields. Each of them is needed to make the vision of the disappearing computer come true.

Finally, we would like to express our gratitude to the authors for their valuable papers and to the Editorial Teams of **UP**GRADE and **Novática** for the opportunity of presenting a review of IoT concepts, applications and technologies. We hope readers enjoy them and consider them as interesting and instructive as it has been for us to help bring out this special issue.

Useful References on "Internet of Things"

The following references, along with those included in the articles this monograph consists of, will help our readers to dig deeper into this field.

[1] Mark Weiser. "The computer of the 21st century". Scientific American Special Issue on Communications, Computers, and Networks, 1991.
[2] DHL. DHL Paketbox, <http://www.dhl.de/en/paket/privatkunden/packstation/paketbox.html>.
[3] Luigi Atzori, Antonio Iera, Giacomo Morabito. "The Internet of Things: A survey". The International Journal of Computer and Telecommunications Networking, 54, 15, 2010.
[4] Evan Welbourne, Leilani Battle, Garret Cole, Kayla Gould, Kyle Rector, Samuel Raymer, Magdalena Balazinska, Gaetano Borriello. "Building the Internet of Things Using RFID: The RFID Ecosystem Experience". IEEE Internet Computing, 2009.
[5] John Krumm. Ubiquitous Computing Fundamentals. Chapman & Hall/CRC, 2009. ISBN-10: 1420093606.
[6] Yannis Georgalis, Dimitris Grammenos, Constantine Stephanidis. Middleware for Ambient Intelligence Environments: Reviewing Requirements and Communication Technologies. 5th international conference on Universal Access in Human-Computer Interaction, San Diego, EEUU. Lecture Notes in Computer Science, 5615, 2009.
[7] Markus Eisenhauer, Peter Rosengren, Pablo Antolin. "A Development Platform for Integrating Wireless Devices and Sensors into Ambient Intelligence Systems". 6th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks, Roma, Italia, 2009.
[8] Hiroshi Ishii. "The tangible user interface and its evolution". Communications of the ACM , 51,6, 2008.
[9] Matthias Kranz,Paul Holleis, Albrecht Schmidt. "Embedded Interaction: Interacting with the Internet of Things". IEEE Internet Computing, 14,2, 2010.
[10] Christoph P. Mayer. "Security and Privacy Challenges in the Internet of Things". KiVS Workshop on Global Sensor Networks, Kassel, Alemania, 2009.