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Special Issue on RFID - Towards Ubiquitous Computing and the Web of Things: Guest Editors' Introduction

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Introduction: The Emerging Research Field of Internet of Things

The Internet of Things (IoT) is emerging as the next technological revolution and with it opens up a new research field. In particular, this new field needs to be studied in conjunction with adequate theories, design principles, and user acceptance. As such, a number of technologies become relevant and intertwined with this new trend. In particular, IoT is an effort to reach out into the real world of physical objects. In this regard, technologies like Radio Frequency Identification (RFID), short-range wireless communications, Real Time Location Systems (RTLS), and sensor networks ubiquity contribute to make IoT vision, a reality [13].

Continuous improvements in technological performance, combined with maturing applications and decreasing prices have contributed to the pervasive adoption of Automated Identification Technology (AIT) such as bar codes and RFID technology. Following its incubation period, today RFID technology adoption can be seen in various domains making its diffusion global across industries and national borders. Over the last 10 years, RFID application is witnessing a significant growth in almost each sector. RFID Item-Level Tagging (ILT) initiatives are extensively deployed in sectors such as apparel and footwear - with companies such as Gerry Weber International, American Apparel, Macy, JC Penney, and Wal-Mart leading the movement.

Adoption of RFID is closely related to various concepts such as Ubiquitous computing (Ubi-comp), the Internet of Things (IoT), and Web of Things (WoT) [14], or the Web of Things and People (WoTaP) [26], or even as the Social Internet of Things (SIoT) [3]. All these concepts have in common the idea that a tagged object (non-living thing and living thing) can communicate electronically, in real time, with its environment through the global infrastructure of wireless Internet.

As RFID enabled sensors and *intelligence* are added to physical objects, this opens up way to innovative business models in electronic commerce and transformation of modern enterprises and their relationship with their constituencies. Not only it brings about changes to the way commerce takes place, but also to the way people interact with their environment and with each other's, and thus opening new perspectives to connect the physical world and the digital world [32].

On the other hand, effective application and adoption of these new models and technologies pose a host of research questions requiring scientific intervention. To this end, this article is expected to serve as an inspiration to raise awareness of researchers and attract their attention.

IoT & Ubicomp: A Historical Overview

The next section presents some early key events and concepts underlying the advent of the IoT.

Some Early Key Events and Concepts

Back in the early 1990's, Mark Weiser, head of the computer laboratory at the Xerox Palo Alto Research Center suggested: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" [33]. He was in fact envisioning what he would later call Ubiquitous computing [34], in which everyday objects (and persons) become computing devices that are given the ability to communicate and interact autonomously with hundreds of nearby interconnected microcomputers without explicitly attending to them. Computing becomes an "integral, invisible part of people's lives […] that takes into account the human world and allows the computers themselves to vanish into the background" [33]. Few years later, Internet entered in our everyday life and Ubi-comp was seen as the evolution of e-commerce and described as a new paradigm where "computation and (wireless) communication capability is embedded into objects, location and even people, making it possible to interact freely with digital resources at any time, and everywhere" [28].

In the same trend, back in mid-1999, Kevin Ashton met David Brock and Sanjay Sarma at the MIT's department of architecture in Cambridge, Mass., a meeting at the homes of the future that led to the founding of the MIT Auto-ID Center (now Auto-ID Labs). This was followed a few months later by a proposal by Alan Haberman of the Uniform Code Council (UCC) to set up a research center. Early sponsor such as P&G and Gillette joined the project and the Auto-ID Center opened officially in October of that year, and research initiatives were launched [4]. Since then, multiple models of university-based RFID laboratories have emerged, which contributed to build synergy between research, education and solution development in the field [6], [15].

Indeed, in October 2001, almost 25 years after the first Universal Product Code (UPC) of a Wrigley's Juicy Fruit chewing gum was scanned with a bar code reader at Marsh's supermarket in Troy, Ohio, the first Electronic Product Code (EPC) tagged products/pallets of Bounty paper towels were scanned and received at a Sam's Club in Tulsa, Oklahoma. Following this initiative, the building of a network of academic research laboratories in the field of networked RFID was launched, known as the Auto-ID Labs [4]. During this period of time, researchers from the MIT Auto ID Center started to explore how RFID technologies could contribute to the networked physical world [30], but it would take another decade before the concept could be refined to a point where analysts could predict IoT applications.

Some events sent a strong signal to the market about the potential and importance of this initiative. Firstly, Gillette's announcement to buy half a billion RFID tags at the end of 2002. Secondly, in June 2003, Walmart announced its plans to mandate suppliers to adopt the technology. Thirdly, at the end of the year, the U.S. Department of Defense (DoD) RFID initiatives, contributed to the creation of a critical mass of adopters. Since then, multiple vertical initiatives emerged such as the ones in the retail (led by Metro in Germany) or in the aerospace (led by Airbus).

In 2003, as the phenomenon was gaining a strong momentum, EPCglobal, a subsidiary of GS1 (a global not-for-profit standards organization), was founded to establish industry-driven technical standards to foster the adoption of RFID and design the EPCglobal Network.

Within the same year, *RFID Journal live Conference & Exhibition* and *RFID World conference* and trade show (Rebranded as RF Edge Expo in 2009) were held for the first time. These events, followed in 2004 with the *EPC Global conference* allowed players from the RFID ecosystem to meet and share on technological and business advances. Since then, other similar conferences took places until a “combination of technology maturity on one hand and the fact that the adoption level […] has failed to fully meet expectations” [20], forced the industry to cancel some of these major events and to restructure themselves in order to broaden the scope of technologies and solutions beyond RFID or to focus on specific markets such as Asia (e.g. *RFID World Asia* is today the largest RFID industry event in the region).

In terms of scientific forums of peers, in the first years following the techno hype, RFID and IoT were mainly addressed in mini tracks, but the recognized importance of these topics were quickly recognized and the field has grown considerably to attract more researchers. Today, numerous specialized conferences, workshops and symposiums are dedicated to the future of IoT in various sectors - e.g. (Site 1-12).

RFID and the IoT in the Hype Cycle

In 2003, the excitement around the potential of RFID technology and the IoT has generated huge investments from firms expecting to gain competitive advantage through these technology and concepts. In the same time, Gartner, an IT research and advisory company, started applying its Gartner's Hype Cycle methodology to RFID in order assess the maturity, adoption and business application of the technology across various industries. In fact, the Gartner's Hype Cycle methodology allows the assessment of bold promises from any new technology, thus facilitating the discernment of the hype around the new technology and the real potential of the said technology as well as the time period of the payoff of any given application related to the technology [18]. In the fuzziness surrounding this period, venture capital, private equity and corporate money was massively invested in burgeoning RFID companies; some of which survived, other were acquired or partnered, and many disappeared! Early initiatives conducted through pilots projects between 2003 and 2006 pointed to numerous issues such as technological and standards uncertainties, weak technological performance (for the first generation of Gen 1 RFID technology), lack of software/RFID middleware applications, lack of consulting and project management professionals, back end integration issues with established Enterprise Information Systems (EIS), data management challenges, unclear ROI, and strong dominant design (e.g. bar code).

The adoption hence followed a typical progression of an emerging technology, from a strong earlier enthusiasm of the RFID community through a period of disillusionment that started around 2006, when it was obvious that the technology and derived concepts (i.e. IoT, Ambient Intelligence, Smart products, etc.) were not as easy to operationalize. Early adopters including Walmart and other Consumer Product Goods (CPG) companies started to push back from unsuccessful initiatives. After reaching a *pick of inflated expectations* around 2004-2005, the market entered in a period of *disillusionment* until 2008, before to stabilize and get back on the *slope of Enlightenment* with a more realistic understanding of the technology's relevance and role in a market [7].

Fortunately, following years of developmental work to improve RFID technology performance (e.g., reduced costs, increased read range, higher data rate, multi-channels communications, reduced sensitivity to interference, etc) and deployment of applications, most of the technical problems are now resolved. Hence, enabling most of the foreseen applications to be implemented, the challenge is now to implement the technology and to learn how to leverage on its potential by translating basic data capture into key information to support real time decision making.

In April 2007, EPCglobal ratified the EPC Information Services (EPCIS) standards necessary for enabling disparate applications to leverage EPC data via EPC-related data sharing, both within and across enterprises – i.e., so that EPCglobal Network participants could "gain a shared view of the disposition of EPC-bearing objects within a relevant business context" [12]. Since then, other standards have been developed for ensuring data *Identification*, *capture* and *exchange* of information. More specifically the only standard still in development is the one related to the Discovery Services Standard (DSS). Basically, *Discovery* is defined as "finding and obtaining all relevant visibility data, of which a party is authorized, when some of that data is under the control of other parties with whom no prior business relationship exists" (Site 13).

The Global recession that started in 2008-2009 slowed most of the RFID initiatives, forcing to a restructuring of the market, but despite these economic difficulties, the RFID industry has witnessed growth in almost every sector Recent estimates from [1] suggested that the market for RFID transponders, readers, software, and services would generate US$70.5 billion for the 2012-2017 period with government, retail, and transportation and logistics identified as the most valuable sectors, accounting for 60% of accumulated revenue. Today, the U.S. apparel and footwear sectors is driving the growth with various RFID Item Level Tagging (ITL) initiatives and most of major retailers planning to adopt ILT within some part of their business over the next three to five years [21].

In its 2012 Gartner's Hype Cycle for Emerging Technologies [17], Gartner analysts identified some technologies that have moved noticeably along the Hype Cycle, suggesting that among others, new *hypes* include the IoT, along with big data, complex-event processing, machine-to-machine (M2M) communication services, mesh networks sensor, and home health monitoring (Figure 1). As the analysts suggest accurately, "Once connected and made smart, things will help people in every facet of their consumer, citizen and employee lives (…but) there are many enabling technologies and trends required to make this scenario a reality".

Again, in its annual special report about the top 10 strategic technology trends that have the potential to affect individuals, businesses and IT organizations during the next three years, [19] identified the IoT, suggesting that enterprises should seriously start to investigate this area of opportunities and position themselves accordingly. Similarly the IEEE Computer Society which aims to be at the forefront of current technology trends, positioned the IoT as the top 1 topic to focus on for the next year; suggesting that "the IoT promises to be the most disruptive technological revolution since the advent of the World Wide Web [… creating] a fundamental challenge to researchers, with enormous technical, socioeconomic, political, and even spiritual consequences*"* (Site 14).

While RFID technologies (for case and pallet) was present in the 2009 model [16], It is interesting to realize that it hasn't been mentioned in the 2012 version. This may be explained by the fact that the technology has been improved with continuous series of incremental innovations and has reached a point of maturity (especially for passive Ultra High Frequency-UHF technology) where it has proved its potential in a diversity of applications, facilitating the adoption process as RFID based solutions are now spanning in different industries on different continents. For instance, UHF passive RFID is now well used to support warehousing management, methodologies and best practices are available, integrated solutions are being offered, and the adoption rate is rising! Similarly semi passive RFID technology with embedded sensors has made a great leap of improvement in the last five years allowing reliable track and trace applications in various sectors such as in logistics, pharmaceutical or agricultural.

Additionally, another key technology supporting the IOT is passive HF RFID, widely used in contactless Identification, and to support Near Field Communication-NFC applications; especially in Europe and Asia. Although NFC payment is more difficult to deploy, according to the important amount of stakeholders involved in the business model, the trend towards the adoption is evident. Moreover, combining NFC tags with mobile devices opens the way to new types of transactions and provides another mean for people to interact with their environment and between them, opening the way to new social networking models.

It is however important to note that not all RFID technologies have reached a *plateau of productivity* meaning a certain level of technological maturity and acceptance. In fact, while passive HF and UHF technologies have well defined standards and that the performance of the technology is proven, active RFIDs supporting RTLS are still competing and no dominant standard has really emerged yet. After years of market restructuring, few players are now occupying specific niches offering solutions based on WiFi, Zigbee, Ultra Wide Band (UWB), proprietary 433 MHz. technologies, hybrid technology such as RFID-Infra Red or competing technologies such as Ultra sound Identification (USID) or eventually mobile location using smart phones and indoor mapping

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Figure 1: RFID and the IOT in the Gartner hype cycle (adapted from Gartner, [16]-[17])

The Wider Concept of IoT

In their extensive review of the IoT concept [23] mention that the definition of the IoT is still rather fuzzy, especially since an increasing amount of terms are added to complement or replace the concept such as ambient technology, ubiquitous technology, sensor web, sensor network, wireless sensor networks, etc. Similarly, [5] think that the multiple definitions of the IoT are an indication of debate on the subject. They suggest that any definition should be derived from the convergence of the various visions and perspective (*Internet oriented*- e.g., 6LoWPAN/IPV6, WWW or a *Things oriented*- e.g., RFID, EPC, sensors).

Many authors refer to the work done by the team of analysts from the ITU, who suggest that the IoT is a “technological revolution that represents the future of computing and communications, and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology” [22]. In their report, [22], they take a look at the next step in *always on* communications, where technologies like RFID and smart computing promise a world of networked and interconnected devices (through or to the internet). The reflection of [14] is interesting, as the author suggests that the IoT could be approached from two perspectives (i) from a technical perspective, where it is perceived in term of infrastructure, hence, viewed as an extension to the Internet, or (ii) from an application perspective and therefore seen as another Internet-enabled service.

The definition proposed in the final report of *Casagras* [8] is the one of a “global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object-identification, sensor and connection capability as the basis for the development of independent cooperative services and applications. These will be characterised by a high degree of autonomous data capture, event transfer, network connectivity and interoperability”. The IoT is comprised of a number of technological protocols that aim to connect things to other things, to databases and to individuals [23]. In this view, RFID is a technology for uniquely identifying objects (ID, status, location, condition), while the IoT serves as a platform for connecting these objects with further data and applications.

In a report that outlines the results of a workshop organised by the European Commission Information Society and Media and the European Technology Platform on Smart Systems Integration, experts attempted to elaborate on “what the Internet of Things might become in the future” [10]. They point at the semantic origin of the expression comprised of the two words and concepts *Internet* and *Thing* suggesting that semantically, *Internet of Things* would mean “a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols”. When considering the functionality and identity dimension, they define the IoT as “(Interconnected) things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts”. In agreement, the IoT European Research cluster

(IERC) which aims to address the potential for IoT-based capabilities in Europe (Site 15) sees the IoT as an integrated part of the future Internet and emphasis the notion of a "dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where *things* (…) are seamlessly integrated into the information network" [31]. IERC's researchers hence suggest that the IoT could allow people and things to be connected "Anytime, Anyplace, with Anything and Anyone, using Any path/network and Any service". Their vision in line with the early work done by the Strategy and Policy Unit of ITU according to which: "from anytime, anyplace connectivity for anyone, we will now have connectivity for anything" [22].

Thus, the concept of IoT represents a vision where all physical items have the ability to communicate with each other and RFID, along with ultra-low power wireless technologies, is in the core of this vision. However, this vision is not yet a reality, but rather a prospective vision for a number of technologies that, combined together, could drastically modify the way our societies function [8]. It represents a vision in which the Internet extends into the real world embracing everyday objects where physical items are no longer disconnected from the virtual world, but can be controlled remotely and can act as physical access points to Internet services [25]. In this sense, the IoT makes computing truly ubiquitous! Accordingly, ABI Research's latest data on the IoT shows that there are already more than 10 billion wirelessly connected devices in the market today; with over 30 billion devices expected by 2020 [2].

Finally, in a series of recent interviews with RFID practitioners and early adopters [11], different views of the IoT have been revealed. For instance, Paul Steinberg, Motorola's chief technology officer, sees it as a technological capability - "Simply put, the IoT implies the ability of almost anything to communicate with any other thing via the Internet". Henry Barthel, VP of system integrity and global partnerships for Brussels-based GS1, position it in an RFID continuum suggesting that the IoT is an evolution of RFID rather than something entirely new; "it is not, in itself one particular application or one particular technology […] like today's RFID systems, only more powerful and pervasive". Victor Vega, director of RFID solutions for NXP Semiconductors, emphasis on the social dimension of the IoT suggesting that "NFC is quickly becoming a social enabler and a popular technology for the public, helping end users gather additional information about objects and helping to link them to [other] objects and locations".

If analysing the above debates, one can only say that the phenomenon of IoT is only an emerging notion. Whether one refers to it as a technology, concept, field, or whatsoever, it is only an emerging phenomenon. As such, we consider it an interesting and potential emerging research field, which is organically intertwined with RFID and alike technologies.

Research Outlook

Understanding trends, implications of, and future directions for RFID (and the IoT) research can be done through various approaches such as bibliometric analysis and a historical review based on publications in indexed journals [9], [24], or by examining the published literature and classifying articles using categories for each diversity characteristic [27], [29]. Another way is by analysing internet trends. Although Google search engine is not recognized as a conventional scientific source for reference, it may be interesting to use this tool as an indicator for understanding some trends on research. *Google Trends* is a tool that allows people to see what others have been searching for in Google. For instance, which keywords and how often these keywords are used over time and where geographically most people are searching for a given keyword. It is interesting to realize the trend for *RFID* search has been decreasing since the initial hype (see Figure 2) while, the trend for *Internet of Things* search has followed the opposite pattern, demonstrating an increased interest in this concept (see Figure 3).

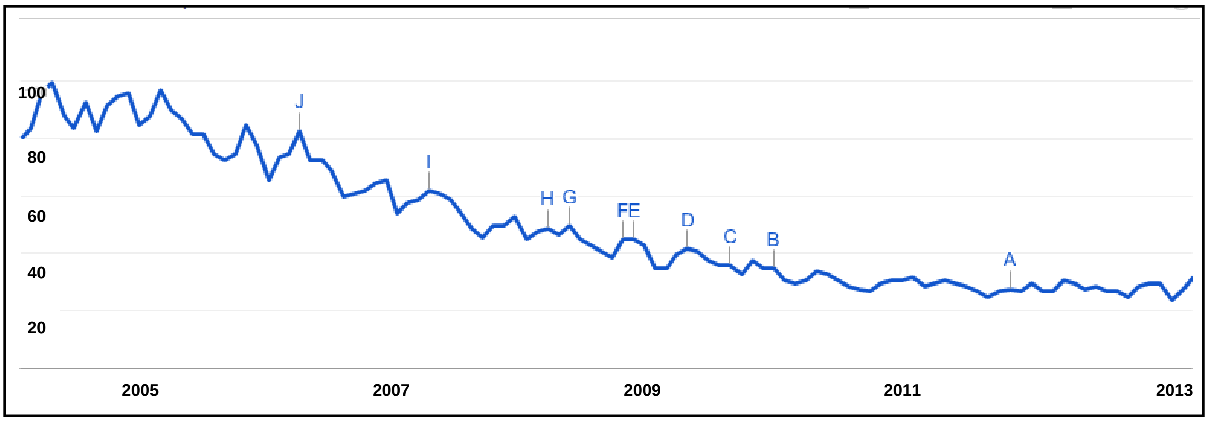

Figure 2: Google search trends for *RFID*

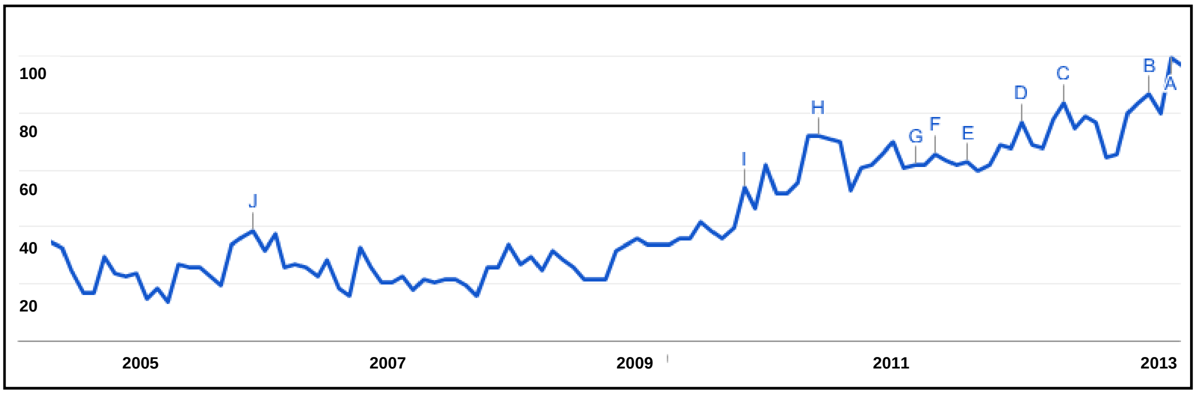

Figure 3: Google search trends for *the Internet of Things*

While Figure 2 and 3 show certain shift, the reader should be advised that this doesn't mean that either the potential of RFID is fully realized or it is not an actual research field anymore, but rather it should be interpreted as RFID is by now more understood and, as a consequence, it creates less *excitement*. It happens with any new technology after its hype is over. On the other hand, the IoT is now the fashion keyword that managers are exploring to try to understand what business potentials it opens up for them.

In order to give some insight about the potentials of this emerging field of IoT, including RFID and the WoTaP in general, it would be of interest to refer to three papers that appear in this very same issue of the journal; each discussing RFID-enabled applications in different domains.

Avrahami, Herer and Shtub conducted a research in the printing industry to analyse the effect of improving paper reel management and enhancing the available paper reel supply chain information through the use of semi passive RFID technology.

While the use of RFID for improving warehouse operations has been increasingly investigated in the recent years, very few papers have looked at the front store yet. In their paper, Al-Kassab, Thiesse and Buckel analyse a case for RFID-enabled business process intelligence in retail stores and present results from a real-world trial conducted by a large apparel retailer.

Haan, Van Hillegersberg, De Jong and Sikkel analyse the adoption process of Wireless Sensor Networks (WSN) in the pharmaceutical supply chains for supporting cold chain management. Despite the proportion of sensitive or short life cycle products becoming subject to spoilage in the supply, and the availability of technology supporting real-time and continuous monitoring of shipments, the authors are questioning the reasons behind slow uptake and the scarce efforts to implement WSN in supply chains.

These papers are an indication on the vast potential that the emerging field of IoT and WoTaP has for research as well as for the technological improvements in terms of cost and availability and accessibility. This sets up a new vision where innovative technology is driving today's business and our every day's life.

However, making available, and at low cost, the technology to equip trillions of objects raises numerous challenges that are ahead, such as the need to integrate and ensure interoperability among multiple heterogeneous systems and data/communication standards, manage huge data volumes arriving in real time, ensure scalability of the environment, address privacy and security issues, address legal and regulatory concerns etc. [25].

With respect to the diverse range of technologies supporting the IoT, important research will still need to be conducted in aspects like (i) *sensing*, to automatically identify any thing and capture its condition, (ii) *computing and processing,* to manage the amount of data collected and exchanged and process the information, (iii) *networking and communicating,* to connect the things and communicate with their environment using established communication protocols and standards, (iv) *embedded intelligence* to ensure things' self-management, (v) *energy harvesting* for *intelligent* devices to be power efficient and reliable, and (vi) *built in security* to prevent any form of hacking.

With respect to the managerial aspects of the IoT, important research will still need to be conducted in aspects like (i) IoT based new business models, (ii) AIT-enabled enterprise and network transformation, (iii) AIT and sensing technologies-enabled e-supply chain management, (iv) real time data management and operational business intelligence, (v) Near Field Communication (NFC) technology and IoT applications to connect things and people.

With respect to the political and social aspects of the IoT, important research will still need to be conducted in aspects like (i) governance to address legal and regulatory concerns, (ii) privacy issues, or (iii) user acceptance.

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Although the above enumeration is rather a few representative issues, it is done to emphasize that in order to fully transform the IoT vision into reality, major technological innovations and development will need to take place [10] and substantial research needs to be conducted within and across various fields of knowledge addressing aspects of the IoT (see for instance [31] for an IoT research agenda with timelines and priorities). This paper only attempted to raise such awareness and draw attention to this emerging new research field of the IoT.

Websites List

Site 1: EEE iThings, The 2013 IEEE International Conference on Internet of Things, August 20-23, Beijing, China
http://www.china-iot.net/ithings2013.htm

Site 2: FiCloud, The International Workshop on the Future Internet of Things and Cloud, August 26-28, Cyprus
http://www.scim.brad.ac.uk/~iamusbah/FiCloud.php

Site 3: ICAC 2013, The 10th International Conference on Atomic Computer, Track on Self-aware Internet of Things
https://www.usenix.org/conference/icac13/self-iot-self-aware-internet-things

Site 4: Internet of Things, Big Data and Internet of People Event, June 4, 2013, Eindhoven, Netherlands
http://iotevent.eu/

Site 5: IOT 2013, The 1st IEEE ICCC International Workshop on Internet of Things, August 12-14, 2013, Xi An, China
http://www.ieee-iccc.org/

Site 6: IoTIP-13, International workshop on Internet of Things – Ideas and Perspectives, May 21-23, Boston, USA
http://www.hds.utc.fr/iotip13/

Site 7: IoT&SP 2013, The 6th Conference on IoT and Smart Spaces, August 28-29, 2013, St. Petersburg, Russia
http://rusmart.e-werest.org/cfp.html

Site 8: SoftCOM 2013, Symposium on RFID Technologies & Internet of Things, September 18-20, 2013, Split, Croatia
http://marjan.fesb.hr/SoftCOM/2013/files/cfp/CfP_SYM_RFID_Patrono_2013_v3.pdf

Site 9: FoWIC-2013, The 5th Future of Wireless International Conference, July 1-2, 2013, Cambridge, UK
http://www.cambridgewireless.co.uk/futureofwireless/default.aspx

Site 10: SIOT 2013 - International Workshop on Secure Internet of Things, May 29-31, 2013, Bucharest, Romania
https://systems.cs.pub.ro/siot2013/

Site 11: IoT Week 2013 - The Event on IoT Technologies and Innovation and Businesses, June 16-20, 2013, Helsinki, Finland
http://www.iot-week.eu/

Site 12: M2M & The Internet of Things, June 18-19, 2013, Thistle Marble Arch, London, UK
http://m2minternetofthings.com/

Site 13: EPCglobal Standards Overview
http://www.gs1.org/gsmp/kc/epcglobal

Site 14: IEEE Computer Society
http://www.computer.org/portal/web/membership/13-Top-Trends-for-2013

Site 15: European Research Cluster on the Internet of Things
http://www.internet-of-things-research.eu/

References

[1] ABI Research. (2012, April). The RFID market will be worth over $70 billion across the next five years. ABI Research. [Online]. Available: http://www.abiresearch.com/press/the-rfid-market-will-be-worth-over-70-billion-acro.
[2] ABI Research. (2013, May). More than 30 billion devices will wirelessly connect to the internet of everything in 2020. ABI Research. [Online]. Available: http://www.abiresearch.com/press/more-than-30-billion-devices-will-wirelessly-conne.

[3] L. Atzori, A. Iera, G. Morabito, and M. Nitti, The social internet of things (SIoT) – when social networks meet the internet of things: Concept, architecture and network characterization, Computer Networks, vol. 56, no. 16, pp. 3594-3608, 2012.
[4] K. Ashton, S. Sarma, P. Putta, C. K. Nizam, C. Ricci, D. Cantwell, B. Hardgrave, P. Peters, S. Smith, Reflection from RFID leaders, end users, researchers and providers share their insights and perspective, RFID Journal, vol. 9, no. 2, pp. 21-32, 2012.
[5] L. Atzori, A. Iera, and G. Morabito, The internet of things: A survey, Computer Networks vol. 54, no. 15, pp. 2787-2805, 2010.
[6] Y. Bendavid and L. Cassivi, A “living laboratory” environment for exploring innovative RFID enabled supply chain management models, International Journal of Product Development, vol. 17, no. 1/2, pp. 94-118, 2012.
[7] Y. Bendavid and L. Cassivi, Bridging the gap between RFID/EPC concepts, technological requirements and supply chain e-business processes, Journal of Theoretical and Applied Electronic Commerce Research, vol. 5, no. 3, pp. 1-16, 2010.
[8] CASAGRAS and EU Framework 7 Project. (2009, October). RFID and the inclusive model for the internet of things, CASAGRAS, Final Report EU Project Number 216803. [Online]. Available: http://www.grifs-project.eu/data/File/CASAGRAS%20FinalReport%20(2).pdf.
[9] C. C. Chao, J. M. Yang, and W. Y. Jen, Determining technology trends and forecasts of RFID by a historical review and bibliometric analysis from 1991 to 2005, Technovation, vol. 27, no. 5, pp. 268-279, 2007.
[10] DG INFSO and EPoSS. (2008, May) Internet of Things in 2020, a roadmap for the future. The Information Society and Media Directorate-General of the European Commission (DG INFSO) and the European Technology Platform on Smart Systems Integration (EPoSS). [Online]. Available: http://www.smart-systems-integration.org/public/documents/publications/Internet-of-Things_in_2020_EC-EPoSS_Workshop_Report_2008_v3.pdf.
[11] J. Edwards, The Internet of Things, from concept to reality: Plans for a network that connects everything and everyone everywhere are well underway, RFID Journal, vol. 9, no. 2, pp. 31-35, 2012.
[12] EPC Global. (2007, September) EPC information services (EPCIS) version 1.0.1 specification. EPC Global [Online]. Available: http://www.gs1.org/gsmp/kc/epcglobal/epcis/epcis_1_0_1-standard-20070921.pdf.
[13] M.A. Feki, F. Kawsar, M. Boussard, and L. Trappeniers, The internet of things: The next technological revolution, Computer, vol. 46, no. 2, pp. 24-25, 2013.
[14] E. Fleisch, What is the internet of things? An economic perspective, Auto-ID Labs, Zurich, Switzerland, White Paper WP-BIZAPP-053, 2010.
[15] S. Fosso Wamba and K. Michael, An information systems design theory for an RFID university-based laboratory, in Information Systems Foundations: The Role of Design Science (D. N. Hart and S. D. Gregor, Eds.). Canberra: ANU E Press, 2010, pp. 233-252.
[16] Gartner. (2009, August) Gartner's 2009 hype cycle special report evaluates maturity of 1, 650 technologies, Gartner Research, Stamford. [Online]. Available: http://www.gartner.com/it/page.jsp?id=1124212.
[17] Gartner. (2012, August) Gartner's 2012 Hype cycle for emerging technologies identifies “Tipping point” technologies that will unlock long-awaited technology scenarios, Gartner Research, Stamford. [Online]. Available: http://www.gartner.com/newsroom/id/2124315.
[18] Gartner. (2013, April) Interpreting technology hype, Gartner Research, Stamford. [Online]. Available: http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp.
[19] Gartner. (2013, February) Top 10 strategic technology trends for 2013, Gartner Research, Special Report, [Online]. Available: http://www.gartner.com/technology/research/top-10-technology-trends/.
[20] D. Gilmore. (2009, January) In inevitable move, RFID world conference expands focus to additional technologies and software, Supply Chain Digest. [Online]. Available: http://www.scdigest.com/assets/newsviews/09-01-07-3.pdf.
[21] M. Gorshe, M. Rollman, and R. Beverly. (2012, February) Item-level RFID: A competitive differentiator, Accenture consulting, the Voluntary Interindustry Commerce Solutions (VICS) and Association Item Level RFID Initiative (VILRI). [Online]. Available: http://www.vilri.org/docs/Accenture_VILRI_Item-level-RFID.PDF.
[22] ITU–International Telecommunication Union. (2005, November) The internet of things, ITU. [Online]. Available: http://www.itu.int/osg/spu/publications/internetofthings/InternetofThings_summary.pdf.
[23] R.V. Kranenburg, E. Anzelmo, A. Bassi, D. Caprio, S. Dodson, and M. Ratto, The internet of things, in Proceedings of the 1st Symposium on Internet and Society, Berlin, Germany, 2011, pp. 25-27.
[24] W. P. Liao, T. M. Y. Lin, and S. H. Liao, Contributions to RFID research: An assessment of SCI-, SSCI-indexed papers from 2004 to 2008, Decision Support Systems, vol. 50, no. 2, pp. 548-556, 2011.
[25] F. Mattern and C. Floerkemeier, From the internet of computers to the internet of things, in From Active Data Management to Event-Based Systems and More (K. Sachs, I. Petrov, and P. Guerrero, Eds.). Heidelberg: Springer-Verlag Berlin, 2010, pp. 242-259.
[26] K. Michael, G. Roussos, G. Q. Huang, A. Chattopadhyay, R. Gadh, B. S. Prabhu, and P. Chu, Planetary-scale RFID services in an age of uberveillance, Proceedings of the IEEE, vol. 98, no. 9, pp. 1663-1671, 2010.
[27] E. W. T. Ngai, C. K. M. To, K. L. Moon, L. K. Chan, P. K. W. Yeung, and C. M. Lee, RFID systems implementation: A comprehensive framework and a case study, International Journal of Production Research, vol. 48, no. 9, pp. 2583-2612, 2010.
[28] G. Roussos, Ubiquitous and Pervasive Commerce, New Frontiers for Electronic Business. London: Springer-Verlag, 2006.
[29] A. Sarac, N. Absi, and S. Dauzère-Pérès, A literature review on the impact of RFID technologies on supply chain management, International Journal of Production Economics, vol. 128, no. 1, pp. 77-95, 2010.

[30] S. Sarma, D.L. Brock, and K. Ashton, The networked physical world: Proposals for engineering the next generation of computing. IEEE Commerce & Automatic-Identification Pervasive Computing, vol. 2, no. 2, pp. 9-14, 2001.
[31] O. Vermesan, P. Friess, P. Guillemin, S. Gusmeroli, H. Sundmaeker, A. Bassi, I.S. Jubert, M. Mazura, M. Harrison, M. Eisenhauer, and P. Doody, Internet of things strategic research agenda, in Internet of Things - Global Technological and Societal Trends (O. Vermesan and P. Friess, Eds.). Aalborg, Denmark: River Publishers, 2011, pp.9-51.
[32] R. Want, K. P. Fishkin, A. Gujar, and B. L. Harrison, Bridging physical and virtual worlds with electronic tags, in Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Pittsburgh, Pennsylvania, USA, 1999, pp. 370-377.
[33] M. Weiser, The computer for the 21st century, Scientific American, vol. 265, no. 3, pp. 66-75, 1991.
[34] M. Weiser, Ubiquitous computing, IEEE Computer, vol. 26, no. 10, pp. 71-72, 1993.