Privacy, Algorithmic Discrimination, and the Internet of Things

Jenifer Sunrise Winter
University of Hawaii at Manoa, USA

INTRODUCTION

The Internet of Things (IoT) is a paradigm encompassing a wide range of developments that enable everyday objects to be tagged and uniquely identified over the Internet. Although there is no single definition for the Internet of Things, competing visions agree that it relates to the integration of the physical world with the virtual world, with any object having the potential to be connected to the Internet via short-range wireless technologies, such as radio frequency identification (RFID), near field communication (NFC), or Wireless Sensor Networks (WSNs). This merging of the physical and virtual worlds will "enable the Internet to reach out into the real world of physical objects" (Internet of Things Conference Organizing Committee, 2010). Further, it will allow increased instrumentation, tracking and measurement of the natural world, enabling analytic tools to enhance business management processes and offer citizens increased convenience and safety (Uckelmann, Harrison, & Michahelles, 2010).

The IoT is imagined as a "backbone for ubiquitous computing, enabling smart environments to recognize and identify objects, and retrieve information from the Internet to facilitate their adaptive functionality" (Weber & Weber, 2010, p. 1). In this regard, the IoT is an emerging global architecture that will enable enhanced machine intelligence to automate the exchange of goods and services. In addition to improving supply chain management, this integration of tags and sensor networks will also be employed in diverse application scenarios, including smart appliances and smart homes, disaster warning, structural engineering, farming, and in-vivo health applications (Atzori, Iera, & Morabito, 2010). This chapter will introduce the Internet of Things, address its definition and related concepts, outline anticipated application areas, highlight challenges, and discuss privacy and surveillance concerns.

BACKGROUND

Related Areas

Current research agendas focus on the IoT ecosystem – networks of physical objects embedded with the ability to sense, and sometimes act upon, their environment, as well as related communication, applications, and data analytics (Gartner, 2014). The IoT is often mentioned in relation to other, overlapping research paradigms, particularly Ubiquitous Computing, Pervasive Computing, and Ambient Intelligence, research agendas that address the integration of myriad, heterogeneous objects into the everyday environment. Weiser's (1991) vision of Ubiquitous Computing emerged in the late 1980s and emphasized the potential of multiple computers per person, in a variety of forms, to activate the physical environment and make computational intelligence an extension of human activity. Ubiquitous Computing research is distinguished by its human-centered focus and has increasingly addressed interaction contexts (Abowd, Ebling, Hunt, Lei, & Gellersen, 2002). The related concept of Pervasive Computing (Hoffnagle, 1999) emerged as a corporate vision

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at IBM during the late 1990s. This agenda has focused on the technical systems required to embed numerous, networked devices throughout the environment. Over time, the two research communities have overlapped, and the two leading conferences, ACM's Pervasive and UbiComp, merged in 2013. Ambient Intelligence research has been guided by the European Union's Fifth Framework Programme (Information Society Technologies, 1998-2002) and focuses on embedded devices, particularly those in smart homes, which are context-sensitive and tailored towards personal needs. While the IoT overlaps technical developments in these related areas, it is distinguished by several concepts. These include 1) goals for an architecture that provides billions, or trillions, of heterogeneous objects with unique identifiers that allow them to interact over a global network; and 2) an emphasis on machine-to-machine (M2M) communication. Although all of these paradigms tend to focus on near-term visions of potential future environments (Dourish & Bell, 2011), the IoT is already manifest in various ways today.

Origin and Evolution of the Concept

Kevin Ashton is credited with the first use of the phrase "Internet of Things" in 1999. He focuses on the potential of M2M intelligence to capture real-time data about the physical world and use it without direct human oversight (Ashton, 2009), stating that the goals of IoT research and development focus on endowing computers

with their own means of gathering information, so they can see, hear and smell the world for themselves, in all its random glory. RFID and sensor technology enable computers to observe, identify and understand the world—without the limitations of human-entered data. (Ashton, 2009, para. 5)

Although the concept arose in the context of supply chain management, he emphasizes that the IoT now applies to nearly any aspect of the physical world.

Since Ashton's first use of the phrase, the IoT has been associated with a wide variety of academic, government, and corporate research projects. An early and substantial influence was the Massachusetts Institute of Technology's Auto-ID Center, which was formed in 1999 to create an RFID-based IoT architecture for global supply-chain management. In 2003, the Auto-ID Center closed, and EPCglobal took over its commercial work. This effort spun off into the Auto-ID Labs, seven academic research labs that focus on building a global infrastructure using RFID or other short-range, wireless technologies. The Auto-ID Labs developed the Electronic Product Code (EPC), an RFID tag that uniquely identifies a product, and the EPCglobal stack is the de facto standard for retail and consumer goods industries.

Other large-scale efforts include IBM's Smarter Planet strategy initiated in 2008 (IBM, 2008), which has focused on the potential of instrumenting the physical world with tens of billions (perhaps trillions) of interconnected sensors. Here, the IoT is envisioned as a way to fuel economic growth, business and government efficiency, improve physical security, and enhance scientific knowledge. Similarly, HP's Central Nervous System for the Earth (CeNSE) initiative relies on billions of nanoscale sensors to detect vibration and motion (HP, n.d.)

The IoT has also figured prominently in national and international technology policy strategies. Following the International Telecommunication Union's special report on the IoT (International Telecommunication Union, 2005a), the European Union's Directorate, General Information Society and Media shifted concern to the IoT (European Commission, Community Research and Development Information Service, 2012) with its i2010 policy framework for the information society and media (2005-2010). Under its Seventh Framework Programme (FP7), the EU funded the CASAGRAS (Coordination and support action for global RFID-related activities and standardization) program, which has provided a framework for research to aid the European Commission in

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