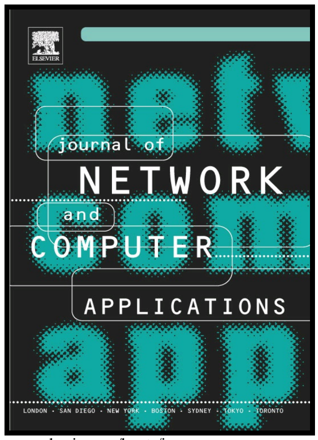
Author's Accepted Manuscript



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PII: S1084-8045(16)30292-2
DOI: http://dx.doi.org/10.1016/j.jnca.2016.11.023
Reference: YJNCA1775

To appear in: *Journal of Network and Computer Applications*

Received date: 28 June 2016
Revised date: 11 November 2016
Accepted date: 21 November 2016

Cite this article as: Miguel López-Benítez, Timothy D. Drysdale, Simo Hadfield and Mohamed Ismaeel Maricar, Prototype for Multidisciplinar Research in the context of the Internet of Things, *Journal of Network an Computer Applications,* http://dx.doi.org/10.1016/j.jnca.2016.11.023

Prototype for Multidisciplinary Research in the context of the Internet of Things

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Abstract

The Internet of Things (IoT) poses important challenges requiring multidisciplinary solutions that take into account the potential mutual effects and interactions among the different dimensions of future IoT systems. A suitable platform is required for an accurate and realistic evaluation of such solutions. This paper presents a prototype developed in the context of the EPSRC/eFutures-funded project "Internet of Surprise: Self-Organising Data". The prototype has been designed to effectively enable the joint evaluation and optimisation of multidisciplinary aspects of IoT systems, including aspects related with hardware design, communications and data processing. This paper provides a comprehensive description, discussing design and implementation details that may be helpful to other researchers and engineers in the development of similar tools. Examples illustrating the potentials and capabilities are presented as well. The developed prototype is a versatile tool that can be used for proof-of-concept, validation and cross-layer optimisation of multidisciplinary solutions for future IoT deployments.

Keywords: Internet of Things, hardware design, communications, data processing, prototyping, experimentation.

1. Introduction

Communication networks no longer connect just people, but are evolving into billions of interconnected smart devices (sensors, controllers, machines, autonomous vehicles, drones, etc.) (Atzori et al., 2014), with embedded electronics and a number of common basic functionalities (communications and networking protocols, operating systems and software) that enable automatic collection and exchange of data (possibly with little or no human intervention). This concept, known as the Internet of Things (IoT) (Atzori et al., 2010; Al-Fuqaha et al., 2015; Mattern and Floerkemeier, 2010), virtually allows any object to be sensed and controlled remotely across existing network infrastructure, creating unlimited opportunities for the integration of the physical world into automated computer-based systems.

IoT is seen as the next stage of the information revolution and, with an estimated 50 billion devices connected by 2020 (Evans, 2011), it is becoming a reality with the potential to revolutionise our lives through many new generation *smart* applications, such as smart cities, smart homes, smart e-healthcare, smart transportation, smart energy management, and smart security (Zanella et al., 2014), which will lead to improved efficiency and socio-economic benefits (Vermesan and Friess, 2013; Fleisch, 2010; Perera et al., 2014).

Future IoT systems will be multidisciplinary in nature and this will pose important challenges. Some relevant disciplines that will play a key role in future IoT systems are discussed below along with problems that still need satisfactory solutions:

1. *Hardware design.* Future IoT systems will require the ability to add IoT capability to almost any object, not only *smart* but also *dumb* objects. These interconnected devices need to be small and inexpensive. Novel hardware designs are required to enable ultra-compact wireless sensors (approximately the size of a human thumb or smaller). The size of the hardware associated to signal and data processing can be reduced with state-of-the-art nano scale technology. However, reducing the size of other components can be more challenging (this is particularly true for certain elements such as antennas, whose size can be constrained by the frequency of operation). New antenna designs that can be attached to almost any small object are required. Soft antennas and stretchable antennas are some particularly promising solutions, however they require a detailed research study in the context of IoT. Moreover, IoT devices need to be energy efficient. In industrial applications, IoT devices will often need to be able to run for at least ten years on a single battery. The battery size (and consequently its capacity) may be constrained by the size of the IoT object. Moreover, if there are to be billions or trillions of IoT devices then it

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