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Domestic water consumption monitoring and behaviour intervention by employing the internet of things technologies

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Abstract

As the water resource is becoming scarce, conservation of water has a high priority around the globe, study on water management and conservation becomes an important research problem. People are increasingly becoming more individual households, which tend to be less efficient, requiring more resources per capita than larger households. In order to address these challenges, this paper presents the achievements of monitoring domestic water consumption at the appliance level and intervening people's water usage behavior which have been made in ISS-EWATUS (www.issewatus.eu), an European Commission funded FP7 project. The water amount consumed by every household appliance is wirelessly recorded with the exact consumption time and stored in a central database. People's water consumption behavior is likely affected by the real-time water consumption awareness, instant practical advices regarding water-saving activities and classification of water consumption behavior for individuals, all of which are provided by a decision support system deployed as a mobile application in a tablet or any other mobile devices. Only the enhanced water consumption awareness is presented in this paper due to the space limitation. The integrated monitoring and decision support system has been deployed and in use in Sosnowiec in Poland and Skiathos in Greece since March 2015. The domestic water consumption monitoring system at appliance level and the local DSS for affecting people's water consumption behavior are innovative and have little seen before according to the knowledge of the authors.

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1. Introduction

In the history of humanity, water plays a key role in sustaining life and building of social structures. With the climate change and population growth, it has posed potential threats towards water resources sustainability. The right access to a sufficient amount of safe drinking water for personal and domestic uses has been recognised as a fundamental human right by the United Nations in September 2010. Conservation of water has a high priority around the globe. Study on water management and conservation becomes an important research problem. To meet the growing demand of water resources, novel and interdisciplinary solutions have to be in place.

There are two main categories of water saving measures to reduce water use: technical measures include network improvement, repair leaks, developing water-efficient appliances; non-technical measures cover information, education, awareness that may change consumptive habits. This paper focuses on the non-technical measure and presents the ways of intervening people's water consumption behaviour by using the Internet of Things (IoT) technologies. The work was conducted as part of an on-going European Commission funded research collaborative project ISS-EWATUS (Integrated Support System for Efficient Water Usage and resources management). The project detail can be found from the project website www.issewatus.eu.

The rest of the paper is organised as follows. Section 2 briefly reviews the latest development in the IoT technologies and water consumption behaviour research. Section 3 introduces an IoT system for households developed in the ISS-EWATUS, giving consumer precise information on their water consumption on a single water-using appliance scale; the structure of the global IoT system and its features. Section 4 describes a practice model, an intervention model, and a data model which will be used in deriving the decision support system tailored for improving people's water consumption behaviour. Decision support system for households is presented in Section 5. The functions include providing water consumption awareness, generating practical advices regarding water-saving activities and classifying water consumption behaviour for individuals, where advices and behaviour classification were automatically generated through the analysis on the actual water consumption data. Section 6 concludes the paper.

2. Literature review

2.1. Internet of Things

The concept of the Internet of Things (IoT) is to make every single 'network enabled' object in the world network connected[1], and represents a vision in which the Internet extends into the real world embracing everyday objects and people together with software. Santucci et al pointed out "the Internet of Things is an emerging network superstructure that connects physical resources and people together with software"[2]. The term "Internet of Things" was popularized by the work of the Auto-ID Center at the Massachusetts Institute of Technology (MIT), which in 1999 started to design and propagate a cross-company RFID infrastructure. IoT is also normally described as a self-configured dynamic global network infrastructure with standards and interoperable communication protocols where physical "things" are seamlessly integrated into the information infrastructure. The purpose of the IoT is to create an environment in which the basic information from any one of the networked objects can be efficiently shared with others in real-time. With more powerful and efficient data collection and sharing ability, such envision is promising and capable of supporting sophisticated decision support systems by providing services in a more accurate, detailed and intelligent manner [3].

In our previous work[3] the fundamental characteristics of what the IoT technology does were summarized as

(i) The IoT is a global and real-time solution; The IoT technology is Internet-based or other wide-area network-based, the scope of the IoT has no any physical boundary. Any object linked with the network can be incorporated into the IoT. Furthermore, the data communication over the IoT has time constraints and could be treated as real-time or near real-time.