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A Web platform for interconnecting body sensors and improving health care

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Abstract

The Internet of Things (IoT) is a paradigm in which smart objects actively collaborate among them and with other physical and virtual objects available in the Web in order to perform high-level tasks for the benefit of end-users. In the e-health scenario, these communicating smart objects can be body sensors that enable a continuous real-time monitoring of vital signs of patients. Data produced by such sensors can be used for several purposes and by different actors, such as doctors, patients, relatives, and health care centers, in order to provide remote assistance to users. However, major challenges arise mainly in terms of the interoperability among several heterogeneous devices from a variety of manufacturers. In this context, we introduce EcoHealth (*Ecosystem of Health Care Devices*), a Web middleware platform for connecting doctors and patients using attached body sensors, thus aiming to provide improved health monitoring and diagnosis for patients. This platform is able to integrate information obtained from heterogeneous sensors in order to provide mechanisms to monitor, process, visualize, store, and send notifications regarding patients' conditions and vital signs at real-time by using Internet standards. In this paper, we present blueprints of our proposal to EcoHealth and its logical architecture and implementation, as well as an e-health motivational scenario where such a platform would be useful.

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1. Introduction

Recent technological improvements in wireless communications, low power processors, and electronic devices are making the *Internet of Things* (IoT)¹ a reality. In the IoT vision, every single object on Earth can be identified, addressable, controlled, and monitored via Internet. These smart objects would be able to communicate with each other

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and with other physical and virtual resources available in the Web, thus providing information about the environment where they are deployed and value-added functionalities for end-users. The wide dissemination of IoT has shown its potential to produce a considerable impact in the daily lives of human beings. This paradigm has been increasingly employed in applications from several real-world domains, such as domotics, ambient assisted living (AAL), energy, transportation, and environmental and urban monitoring. Several everyday objects are being “computerized” and equipped with network interfaces, e.g., washing machines, TVs, lamps, exercise bikes, heating/cooling devices, etc.

One of the application domains that can benefit from IoT solutions is *e-health*, which can be defined as the health care practice supported by electronic devices and information and communications technologies and that can include electronic medical records, electronic prescriptions, remote monitoring, and health knowledge management². In the e-health context, wireless *body sensors* are small biomedical devices that are placed on the human body or are hidden under clothing³. These devices have wireless capabilities in order to allow increasing patient comfort and mobility, thus not impairing his/her normal activities while monitoring his/her health status regardless his/her location. In this perspective, such devices they can improve the quality while reducing costs of medical services by paving the way for the development of advanced, innovative health care monitoring applications⁴. Some noteworthy examples include remote monitoring of patients with chronic diseases and in AAL⁵, as well as patient-centric prevention and treatment.

As smart objects, wireless body sensors can be accessed, controlled, and monitored via Internet. This feature opens up the possibility of providing an inexpensive and continuous real-time monitoring of vital signs measurements provided by body sensors attached to patients. Therefore, it is possible to achieve faster detection of emergency situations (and hence a faster medical care) and to improve medical diagnosis elaborated by doctors. Furthermore, with capabilities of smart objects, body sensors can easily communicate with each other, so that a given body sensor can use information provided by another one, thus increasing quality of the provided information and decision-making accuracy. On the other hand, considering body sensors as smart objects introduces some challenges. The major one is regarding interoperability among such smart objects, as it is necessary to seamlessly deal with a myriad of heterogeneous devices from several manufacturers, each one providing a different interface to communicate with the devices, thus creating operational barriers to use them in a holistic way⁶. Moreover, it is necessary to handle a large amount of sensible data continuously transmitted through the network, thus arising security and privacy issues.

In order to take advantage of the benefits brought by the IoT paradigm in the e-health scenario while addressing the aforementioned challenges, we introduce EcoHealth (*Ecosystem of Health Care Devices*), a Web middleware platform for connecting doctors and patients using attached body sensors. This platform is able to integrate information obtained from heterogeneous sensors in order to provide mechanisms to monitor, process, visualize, store, and send notifications regarding patients' conditions and vital signs at real-time by using Internet standards. EcoHealth is aligned with the *Web of Things* (WoT) paradigm⁷, which envisions using existing Web technologies and protocols to enable the inclusion of physical devices in the digital world, so that their data and services can be (re)used in different applications as any Web resource⁸, thus being an enabler technology for effectively realizing the IoT vision⁹. By being aligned with WoT, EcoHealth design and implementation are based on REST (*REpresentational State Transfer*)¹⁰ principles and rely on current Web standards and protocols. In this paper, we give an overview about how middleware platforms can be an enabler technology for the e-health scenario and present blueprints of our proposal to EcoHealth.

The remainder of this paper is organized as follows. Section 2 presents an e-health scenario with some challenges that motivate the use of IoT middleware platforms. Section 3 introduces EcoHealth and describes its logical architecture and some implementation details. Section 4 presents an application scenario where EcoHealth could be used. Section 5 briefly discusses related work. Finally, Section 6 contains final remarks and directions to future works.

2. Background

2.1. A motivational e-health scenario

Nowadays, many e-health technologies are available in industry. Some of them have been simplified and embodied in daily life to assist exercise routines for athletes or to monitor health conditions of people that need continuous assistance, as the elderly and impaired people, for example. Body sensors or sensor units integrated to watches, in conjunction with mobile applications and other personal devices, allow real-time data monitoring to improve medical care of patients. Information provided by these devices can be related to measures of heartbeats per minute, temper-

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