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Design and implementation of an IoT gateway to create smart environments

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Abstract

The paper presents a proposal of a practical implementation for an IoT gateway dedicated to real-time monitoring and remote control of a swimming pool. Based on a Raspberry Pi, the gateway allows bidirectional communication and data exchange between the user and the sensor network implemented on the environment using an Arduino.

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Keywords: Internet of Things; Sensor Networks; Smart Environments

1. Introduction

Nowadays the urge to connect everything to the Internet is growing, not just to send information to servers for processing and storage but also to provide full control of physical devices over the web.

While humans will continue to connect their devices to the Web in greater numbers, by 2020 more than 200 billion smart devices are expected to be connected to the Internet [1], making Machine-to-Machine (M2M) communications up to 45% of the whole Internet traffic [1,2,3].

Examples such as Smart Homes, where users can control their thermostats or lights with a smartphone, are the basis for Internet of Things (IoT). IoT was designed to play a great role improving our quality of live and its applications are present in many of our day to day experience such as transportation, health care and industrial automation.

IoT has the ability to transform a simple physical device into a smart one, using the embedded technology and computational power. Using the sensors and actuators available to guarantee the features of the device, it is possible to share that information between devices and put them to work together to improve the user experience. This will contribute to a bigger explosion coming from things connected to the Web that were not connected before, did not exist, or now use their connection as a core feature.

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The Internet is one of the most important developments of man kind and IoT will represent the next evolution of the Internet[2,3]. With the capability of gathering, analyzing and distributing the data, IoT consists in the connection between the Internet and a range of devices and sensors.

IoT, as shown in Fig. 1, can be divided into six elements[4] that help us understand its real meaning and functionality, i.e, *identification*, *sensing*, *communication*, *computation*, *services* and *semantics*.

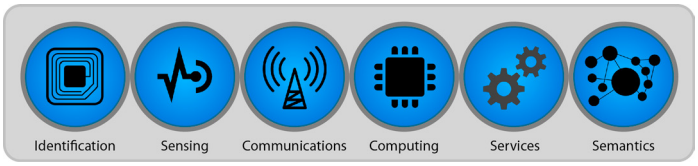

Fig. 1. IoT elements

IoT projects have the ability to do more than just connect the device to the Internet, they can be a big part of improving the efficiency or even adding new features such as Artificial Intelligence, transforming every common objects into connected one.

In this paper the authors describe the designing/developing of a system that can be applied to any object or environment with little or no modifications and easily used by any person. The system will provide full remote and secure control and monitoring of sensor networks, via an online platform, that can be applied to any non-smart object or environment allowing them to be connected to the Internet and to the user. With the possibility to add a set of rules and Artificial Intelligence it is possible to improve the efficiency leading to potential gains, such as energy or water savings. Although the main goal is to create a low cost system that is flexible in the sense that it can be easily adapted to any specification, in this paper the practical functionality will be tested and evaluated in a swimming pool, with an application capable of monitoring the water temperature and level, the environmental temperature, relative humidity, air pollution and luminosity and remotely control the water pumps and pool lights.

2. Related Work

IoT gateways[5] are dedicated hardware applications used to connect the user to the network, allowing the conversion of data between the short distance communication protocols to the traditional communication network. The gateway is supposed to support different types of sensor nodes, multiple communication protocols, both wireless or wired, and provide a set of unified information for the application or user, making these only responsible for data processing.

The main challenge on creating an IoT gateway is the lack of standards, being that each sensor node can communicate with a different protocol that is not compatible for others. This makes the development of a general purpose gateway a complicated task, which explains why it is common to find gateways developed for specific applications. Nevertheless, all have the same key requirements: low-cost hardware, easy implementation and extensibility and an application layer support.

R. Gerstendorf in his article[6] examines ten platforms for creating smart homes, from ZigBee to the Apple HomeKit. All ten are market solutions available to consumers as a ready-to-use product in order to control smart devices through a gateway. Each one has a communication protocol, proprietary characteristics and a range of pros and cons.

In the literature it is possible to find several proposals[7,8,9] for IoT gateways implemented using low-cost hardware devices, such as Arduino and Raspberry Pi. Most of them use these devices to support the web server, which difficults its access from outside the network. Other solutions were found[10,11], that use wireless communication protocols for specific applications and little to none IoT gateways were designed to use wired protocols. Only one of these[12] did it, where the authors used the gateway with the RS485 protocol to control end-devices from the Internet. This makes all of these solutions limited in flexibility and adaptation to other environments.

The literature presented a similar concept for a multi-communication protocol IoT gateway. In this[13], the authors present a heterogeneous IoT gateway capable of using the same board to communicate with multiple wireless protocols as well as support for a large amount of communication buses, in a modularity basis.