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ScienceDirect

Energy Procedia 126 (201709) 282–288

Energy Procedia

www.elsevier.com/locate/procedia

72nd Conference of the Italian Thermal Machines Engineering Association, ATI2017, 6-8 September 2017, Lecce, Italy

Development and testing of a platform aimed at pervasive monitoring of indoor environment and building energy

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Abstract

The interest of the building energy sector is leaning towards the measurement of building actual performance, as regards both indoor environment quality and energy consumption. Sensors and central elaboration units aimed at monitoring indoor environment and HVAC system parameters can also provide the basic infrastructure for further applications such as predictive and neuro-fuzzy controls. However, the cost of such systems is high, so they are mainly used in large buildings. This paper describes the main features and expected applications for a low-budget monitoring platform currently under development and tuning. In particular, the monitoring system was developed based on electronic prototyping platform Arduino and on sensors and devices usually available in the retail market of electronics. The monitoring platform has been designed with the following characteristics in mind: replicability, full remote control, portability, versatility, reliability and affordability.

Peer-review under responsibility of the scientific committee of the 72nd Conference of the Italian Thermal Machines Engineering Association

Keywords: Monitoring devices; Pervasive monitoring; Internet of Things.

1. Introduction

The rapid development of domotics and building management systems (BMSs) in the building energy sector is stimulating interesting perspectives about the chance to record data from a large amount of buildings, besides usual indoor environment and HVAC system monitoring. Moreover, additional applications might consist in the collection of large quantities of data from which statistical figures about the indoor environment management and energy

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1876-6102
Peer-review under responsibility of the scientific committee of the 72nd Conference of the Italian Thermal Machines Engineering Association
10.1016/j.egypro.2017.08.155

consumption in buildings could be inferred. For instance, such data might be used to derive building energy evaluation models based on actual energy consumption measurements. However, such applications would require an even higher number of buildings for the achievement of reliable figures and related correlations and that would require long time because of the limited amount of (usually expensive) BMSs installed and because of the difficult synthesis of different data formats resulting from BMSs developed by different manufacturers.
In the frame of this research activity, a low-cost wireless measurement platform is being developed, together with the instructions and schemes aimed at hardware construction and software implementation, in order to aid researchers, professionals and technicians in the replication of this platform.
The hardware developed in this research consists of:

- Monitoring Hubs (MHs)
- Monitoring Units (MUs)

Each MH coordinates measurements, supplies energy to up to three MUs, logs measured values on SD cards and uploads/downloads data and settings through Wi-Fi connection. Each MU is managed by the hosting MH and contains all the circuitry needed for measuring a specific parameter. MHs are developed in order to manage many different kinds of MUs and their settings and management behaviour will be defined by the user through a web interface.

Of course, some projects aimed at the development of low cost monitoring platforms already exist. For instance, Open Energy Monitor [1] is a project aimed at the development of open-source energy monitoring tools in the field of energy use and monitoring. Furthermore, WiSensys [2] is a wireless, easy-to-install and ready-to-use sensing system with data logging capability, designed for a variety of sensors, such as temperature, humidity, CO_2 and energy sensors. Also Shah and Mishra [3] developed a customized Internet of Things (IoT) enabled sensing and monitoring platform to monitor temperature, relative humidity and light in the context of building automation. Harfield and Rattanongphisat [4] propose a monitoring platform empowering users to make intelligent decisions about energy efficiency, by sensing temperature, humidity, power and occupancy information about a room and providing services aimed at energy saving and comfort maximization. In the same field but focusing more to energy awareness, Bouhafs and Rajabi [5] present an energy monitoring system offering consumers the possibility to monitor the energy utilization of their appliances and built over a sensor network's open platform.

Another relevant context for the development of such platforms consists in the monitoring of environmental conditions. For instance, Smart Citizen Platform [6] is a platform aimed at promoting the participation of people by sharing measurements of temperature, humidity, light, sound, CO, NO_2. In the same context, AirSensEUR [7] is an open source platform developed by the Joint Research Centre and a SME specialized in IoT, for monitoring ambient air quality using low-cost sensors. Schima et al. [8] describe the development of a monitoring system covering data collection, data processing and data integration as well as data provision within one infrastructure able to acquire temperature and humidity in space (GPS) and time (real-time clock) as a built in function.

More monitoring platforms have been developed for other contexts, such as civil infrastructure, as shown in [9] and [10], and gardening, with the Open Garden platform [11], allowing the control of the state of the plants by sensing several parameters. Finally, general purpose IoT platforms [12] and health-related IoT platforms are increasingly spreading.

However, most of these sensor platforms are mainly targeted to customers as final users. For this reason, they are mainly marketed through a corresponding web shop and may include customers-oriented services. The measurement platform under development, instead, is mainly aimed at researchers, professionals and technicians in the field of building management and conservation, with the aim to provide very detailed information for the development of basic wireless and web-managed measurement platforms. For this purpose, there is no need to provide web shops or products, but the project will mainly consist in a blog containing detailed instructions and drawings for MHs and MUs development and installation. Measurement networks aimed at research activities are usually designed for the specific scope, with no further extension to other fields. Only Ali et al. [13] are working in this perspective. However, wireless capabilities are in progress in their sensor network, whereas this research activity has been planned since the very beginning with wireless networking in mind.

The measurement platform under development is the subject of this paper. In particular, Section 2 summarizes the main characteristics of the measurement platform under development and Section 3 shows an illustrative measurement taken by means of the first MH and MU developed in the frame of this research activity.