GAIA: Saving Energy and Teaching Sustainability

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Abstract. A considerable part of recent research in smart cities and IoT has focused on achieving energy savings in buildings and supporting aspects related to sustainability. In this context, the educational community is one of the most important ones to consider, since school buildings constitute a large part of non-residential buildings, while also educating students on sustainability matters is an investment for the future. The Green Awareness In Action (GAIA) project has focused on educating students on energy-related matters and achieving energy savings by using IoT data generated inside school buildings.

Keywords: IoT · Education · Sustainability · Smart Cities

1 Introduction

The Internet of Things (IoT) and smart cities are two of the most popular directions the research community is pursuing very actively. But although we have made great progress in many fields, we are still trying to figure out how we can utilize our smart city and IoT infrastructures, in order to produce reliable, economically sustainable solutions that create public value, and even more so in the field of education. In this context, the EU considers environmental education one of the most prominent instruments to influence human behavior towards sustainability, while educational buildings (i.e., buildings for primary and secondary schools, high schools and universities, research laboratories, professional training activities) constitute 17% of the EU non-residential building stock (in m^2)[1]. It is thus evident that schools and the educational community could play an important role in our quest for lowering energy consumption as a society in general.

2 Project Description

GAIA [2], a Horizon2020 EC-funded project, has developed an IoT infrastructure inside a number of school buildings in Europe. Its primary aim has been to raise awareness about energy consumption and sustainability, based on real-world sensor data produced inside the school buildings where students and teachers live and work. Today's students are the citizens of tomorrow, and they should

have the skills to understand and respond to challenges like climate change. Currently, 25 educational building sites participate in GAIA, located in Sweden, Italy and Greece. An IoT infrastructure is installed in these buildings, monitoring in a real-time manner their power consumption, as well as several indoor and outdoor environmental parameters.

However, this infrastructure would not be particularly useful without having a set of tools to allow access to the data produced and provide functionality to support educational activities. The GAIA Challenge is a playful interactive platform aimed at students, designed to serve as an introduction to aspects related to power consumption and energy saving. In addition, real-time data from sensors in the buildings and participatory sensing help to visualize the real-life impact of the students behavior and enable competitive gamification elements among different schools. The GAIA building manager is a web application offering visualization of energy consumption and environmental data. A smartphone app allows end-users to access school building data from the GAIA infrastructure in a more immediate manner.

3 Current Status - Results

The project has completed its official activities on May 2019. Among its biggest achievements, is the fact that it has managed to build an operational and reliable large-scale IoT infrastructure inside 25 school buildings in Greece, Italy and Sweden. This infrastructure [7] includes over 1200 sensing endpoints, which have been based on open-source components. Also, a large number of the hardware components developed and used in the project are available as open-source designs [6]. Fig. 1 provides some examples of the actual hardware used inside the schools of project.

As part of the educational approach of the project, a set of educational hands-on activities based on IoT hardware and software have been developed. These activities are now available as the GAIA Educational Lab Kit [4]. A booklet containing structured lesson plans based on this activities will be made publicly available during Summer 2019. Evaluation by the students and teachers that participated in these activities shows some very positive results [5].

In terms of participation in the project activities and use of the project tools, one other positive result is the participation of students themselves through their registration and use of the GAIA Challenge, a playful introduction to the project. The Challenge includes a number of "missions", in which students complete certain "tasks", by answering questions, making correlations, etc. Overall, 3735 students registered to the Challenge, while it also helped to make the introduction to the project without requiring the schools and teachers to dedicate additional time for this activity.

In terms of actual energy saving results from combining the tools and project methodology with data produced inside school buildings during related activities in the schools, we have seen results in the range of 15-20% at a number of instances [8]. With respect to engagement, an important factor has been com-

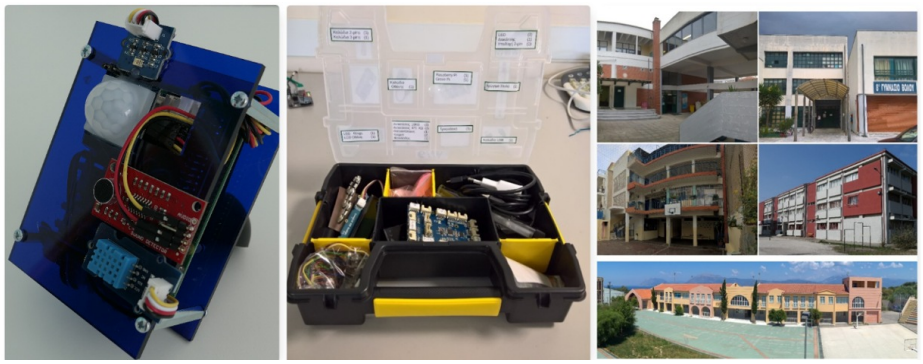

Fig. 1. Instances from hardware components used in the GAIA schools (a), hardware used in lab activities (b), and the exterior of some GAIA schools (c).

petition: students were intrigued by the prospect of competing with students from other schools and countries, and were further motivated to participate in GAIAs competitions for energy savings and related ideas. The project also held two official competitions between schools during educational years 2017-18 and 2018-19, which proved a valuable tool in motivating and engaging the schools participating in the project.

4 Conclusions - Future Work

The GAIA project has been successful in building a large IoT infrastructure inside schools in Europe to support energy-focused educational activities. Such activities have resulted in tangible energy savings in several of the schools participating in the project. GAIA has officially completed its activities on May 31, 2019. However, the network of schools built during the project, as well as the software tools developed, will continue to be active in the following school year (2019-2020). The members of the consortium will continue their efforts in monitoring the ways IoT can aid in understanding our energy footprint and how our behavior can affect it in meaningful ways.

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