A Concept Schema of a Portable IoT-Sensor System for Smartphones

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***Abstract*— Many new buildings have already a system in which user can adjust the temperature. Some of them have even a temperature sensor or wireless monitoring and control system via Internet of Things. These systems are typically fixed and cannot be moved. For older buildings, adding this kind of system can be expensive because this often requires remolling in addition of the cost of the system itself. Moreover, renters typically prefer to invest in systems which they can take with them. In addition, users may need other kind of sensor data and for different applications. There is therefore a need for a portable, relatively inexpensive system which should be easy to use with a smartphone. In this paper, a concept schema is presented for a such system with a case example.**

Keywords*— *Internet of Thing, IoT, temperature, energy, smartphone

I. Introduction

Internet of Thing (IoT) based systems and devices have become more available recent years. They are applied, for example, to smart homes and buildings to provide additional services and safety [1-6]. This enables building managers and inhabitants to increase the control over use of the building. For example, IoT can be used for energy modelling and energy monitoring of the building ([2-3]) or energy consumption and thermal comfort ([4-6]). These approaches offer opportunities for monetary saving and reducing greenhouse emission.

In many new buildings, such systems have already been installed during the contruction phase. However, installing such systems would require repair work on older buildings and homes. This, of course, would bring extra costs, especially in the case of an individual apartment or home. In addition, apartment renters may not want or are not allowed to install fixed systems. Thus, there is a need for a portable, low cost system, which can be used at different indoor spaces.

Many types of cheap systems have already been proposed for home automation, e.g. Yuen et al. 2019 suggested such a system for elderly, disabled and pet owners using Arduino board and different sensors including RFID [7]. Vikram et al. 2017 used a smart phone based control system utilizing multiple sensors [8]. Studies have been also made for IoT usage in energy efficiency and management e.g. [9-10] and for community level [11]. Different aspects of CO_2 have been researched like reducing the emission by using solar power and IoT [12].

This paper looks at the situation from the point of view of an end user who wants a relatively cheap IoT system in their apartment. The end user may not be familiar with much technology, but he or she has access to a smartphone. In addition, the system is desired to be easy-to-use, flexible, adaptable, cheap and easily modifiable. He or she wants information on, for example, the relationship between the temperature of the apartment and energy consumption. Thus, a concept schema for a standalone, portable system is proposed.

II. CONCEPT SCHEMA FOR A PORTABLE SYSTEM

A. *Requirements for the system*

The proposed system is indented to be used by end users who may not have very much knowledge about the IoT or other technical issues. The list of requirements is:

- Easy-to-use
- No programming or expertise required
- A portable and flexible system
- Usable by a smart phone
- Adaptable to different places
- Relatively cheap sensors available

The system must be portable and flexible. The user must also be able to select the sensors they want from different manufacturers and use them together. He or she can also add more or new sensors, decrease the number of sensors, or change to different or new sensors. The sensors should be standalone. The position of the sensors must be changeable as needed. For example, a renter can take the entire system with him to a new flat.

Many manufacturers offer apps for their IoT sensors, so sensors of this kind are suitable for the system. These apps can be downloaded to a smart phone. The apps should be easy-to-use and preferably free. It is possible to select sensors and apps for different manufacturers, so this makes possible a wide variety of sensor combinations. On the internet, one can find many calculators e.g. for evaluating CO_2 emissions.

The system should be such that it can be used in different places. Therefore, it cannot contain specific models or assumptions about the space. The user should not be required to put any additional information as this may reduce the usability at the user's point of view. The sensors should be relatively cheap and easily to be bought or ordered via internet.

B. *Concept schema*

The proposed concept schema is shown in Fig. 1. The schema shows only two sensor data sources, but users can add as many as needed for their application. Data in this case include typical indoor parameters (e.g. temperature) and electricity consumption. A sensor can be placed on the location where measurements are needed. For example, the users can monitor the temperature of living room at different positions and make necessary control adjustments. The electricity consumption data can be obtained e.g. via energy monitoring plug or some cases from an energy company. The users can, of course, select different parameters for their specific applications.

The users can view this data on their smartphones. After this, they can use it e.g. for evaluating greenhouse gas emissions or the price of electricity consumed. This can be done using available on-line calculators on the internet. This makes possible to user to see e.g. how much a room temperature effect on greenhouse gas emission.

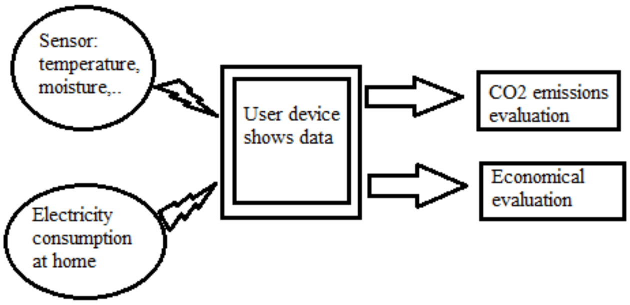

Figure 1. A concept schema for a general IoT system for indoor measurements.

III. An example of possible portable system

Two sensor devices were selected for this case example. One sensor was "RuuviTag" and another "Kasa Smart Wi-Fi Plug with Energy monitoring". Both sensors are available and can be ordered. The RuuviTag sensor can be ordered from the startup's webpage (https://ruuvi.com/) in price of 35.9 6€ for one unit + postage [13]. These sensors have been shown to be suitable for indoor measurement [14]. The Kasa plug costs 37.04 € at www.amazon.de. So, both sensors are relatively cheap and available.

Fig. 2 show an ordered RuuviTag sensor which position can be easily changed. It provides data about temperature, humidity, and pressure. It has a free app; Fig. 3 shows an example of screen shot of app screen. The sensor was placed in a study room.

Figure 2. RuuviTag sensor station

The app has possibility to set alarm if the temperature goes outside a certain range. This is important to avoid room getting cooled too low temperatures and thus waste energy. The characterization of room temperatures can be done simply by setting the sensor at different positions. In one example, a room had approximately 1 ºC difference between the floor level and a point from 2 m up from the floor. This indicates that temperature measurement should be done at the place where people are staying.

The temperature data can be combined with the evaluation of electricity or energy consumption for heating. If the heating (or cooling) is the main variable changed, then it can be assumed to be the main reason for changes in electricity or energy consumption. Some companies even provide a detailed information for certain periods of time. This will help to evaluate how much certain amount of heating or cooling effects on energy consumption. When this is known, then the costs can be evaluated.

Figure 3. An example screen shot of app user interface.

The Kasa Smart Wi-Fi smart plug is shown in Fig. 4. A Wi-Fi home network is required for it.

Figure 4. Kasa Smart Wi-Fi Plug with Energy monitoring .

It has a smartphone app which provide help for connecting. With this app, the user can monitor electricity usage. Fig. 5 shows an example of screen shot. The screen shot shows short term electricity consumption of a laptop.

Figure 5. An example screen shot of Kasa Smart Wi-Fi Plug app user interface.

The user can use this data to evaluate CO_2 emissions or price of electricity. Many CO_2 emission calculators are available on-line like United States Environmental Protection Agency´s one (web address: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). If the laptop is assumed be used 100 hours per month, the CO_2 emissions per month would be 0.314 kg. If we assume that electricity price is 0.15 € per kWh, then the use would cost less than 0.10 €.

IV. Conclusions

This paper presents a concept schema for low-cost portable IoT system which is intended for different applications. It can be applied to, for example, temperature monitoring as well as CO2 emissions evaluations. The schema is suitable for old buildings, single apartments and houses as well as for renters - also cases where fixed system would be impractical or expensive. The proposed schema requires some time and activity for the user.

Acknowledgment

This research was funded from European Union Regional Development Fund (Leverage from the EU 2014-2020, EURA, project name Technobothnia IoT Learning and Testing Hub, project code: A73108) We express our gratitude to Regional Counsil of Ostrobothnia.

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