Indoor Personal Comfort Levels Monitoring using IoT

Ashwini S Patil
Department Of CSE,
T. John Institute of Technology
Bangalore, India

Bhavya N Javagal
Department Of CSE,
T. John Institute of Technology
Bangalore, India

***Abstract*— We display a minimal effort IoT based framework ready to screen acoustic, olfactory, visual and warm solace levels. The framework is given diverse surrounding sensors, registering, control and availability highlights. The combination of the gadget with a smartwatch makes it conceivable the investigation of the individual solace parameters.**

INTRODUCTION

During last years there has been an increasing demand by buildings occupants for the continuous monitoring of all indoor comfort related parameters. In this setting the Internet of Things (IoT) guarantees another period in encompassing checking since the measure of savvy gadgets and available information is always developing. Although comfort is a subjective concept composed by many factors (i.e. acoustical, visual, thermal and olfactory comfort) most of the recent works focus on thermal aspects only [1] and assess comfort condition by the use of the Predicted Mean Vote (PMV) formula [2]. Since it can be to a great degree costly to accumulate ongoing measures of a few factors required in PMV equation (i.e. metabolic and apparel individual parameters), suppositions are made keeping in mind the end goal to utilize this list [3]. Different approaches can be found in [4], where authors proposed the monitoring of temperature, humidity and light in order to control appliances. In [5] authors monitored and controlled the visual comfort by using a LED system. Finally in [6], the authors developed a Wireless Sensor Networks (WSNs) to monitor temperature, humidity and concentration of gases (i.e., CO and CO_2). The solution presented in our paper, namely ComfortBox, is an open hardware and open software IoT based platform, which allows to monitor the four personal comfort parameters. The acoustic, olfactory, visual and thermal comfort levels are evaluated according to the international ISO, American Soci-ety of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) and Environmental Protection Agency (EPA) regulations (standard EN15251 [7]). The stage is given by a Light Weight Mesh 802.15.4 correspondence module ready to deal with a work organize and connect with articles furnished with a similar module. On account of the web availability of the Comfort Box, each question associated with the work organize (e.g., disseminate sensors or actuators) can be remotely controlled. Information gotten from sensors are put away both locally and in a cloud server. One of the key discoveries of this work is the coordination of a savvy in the stage that enables us to gauge the factors required in the PMV equation, consequently making conceivable its utilization in a true situation.

I. SYSTEM ARCHITECTURE

The entire framework is created by a minimal effort genius grammable little single-board PC, to be specific Raspberry PI, an Apio Dongle [8] and distinctive natural sensors. The alleged Apio Dongle is a USB stick that incorporates an Atmel microcontroller with a Lightweight Mesh communication module. The sensors integrated in the ComfortBox are: a digital temperature and humidity sensor, an Indoor Air Qual-ity (IAQ) sensor measuring carbon dioxide (CO_2) level and the concentration of Volatile Organic Compounds (VOCs), a light sensor and a microphone. The software platform is built using Node.js for both the server side and cloud syn-chronization while the client side is based on Angular.js. The non-social database is manufactured utilizing MongoDB (the entire equipment and programming structure is portrayed in Figure 1). Because of the correspondence module, any question outfitted with a Lightweight Mesh can be associated with make a work arrange. Since the ComfortBox is associated with the web

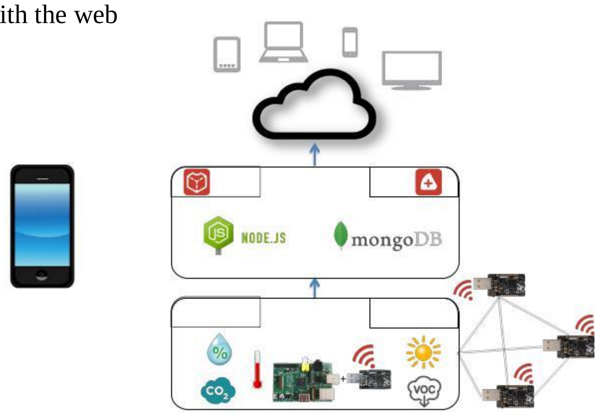

Fig. 1: Hardware and software architecture of the ComfortBox and smartwatch communication procedure.

(by means of ethernet or wi-fi) any question of the work system can be overseen by means of programming, along these lines ending up plainly remotely available, monitorable and additionally controllable consequently through its system address and the ComfortBox IP. The smartwatch has been incorporated into the framework by means of a portable application through a web attachment. The entire source code is accessible for nothing on GitHub.

III . COMFORT ANALYSIS

In this section we analyze the four different human comfort parameters (thermal, acoustic, visual and olfactory) as well as the default warning levels.

1) Thermal Comfort: The PMV/PPD model was developed by P.O Fanger in the 70's utilizing heat adjust conditions and experimental learns about skin temperature to characterize com-fortress. Fanger's PMV conditions, which can be found in [2], depend on air temperature, mean brilliant temperature, relative dampness, velocity, metabolic rate, and attire protection. Zero is the PMV ideal value and the comfort zone is defined within the recommended limits of 0:5 on a seven point scale from cold (-3) to hot (+3). According to a sensitivity analysis, the most influencing variables are the metabolic and clothing parameters. To the best of our insight nobody beforehand abused smartwatch measures to get these parameters which as a rule are viewed as just as consistent qualities. The equations used to compute metabolic rate can be found in ISO 8996 norm:

$$M = \left(\frac{HR - HR_0}{RM}\right) + M_0 \qquad (1)$$

where M is the metabolic rate, $[W{=}m^2]$, M_0 is the metabolic rate at rest $[W{=}m^2]$, RM is the increase in heart rate per unit of metabolic rate, HR_0 is the heart rate at rest, under neutral thermal conditions. The value of HR_0 and HR are measured by the smartwatch, RM formula can be found in ISO 8996 norm and

$$M_0 = (10{:}0\ m + 6{:}25\ h \quad 5{:}0\ a + s) \qquad (2)$$

where m is the weight [Kg], h is the height [cm], a is the age in years, s is +5 for males and -161 for females (all these parameters can be taken from the smartwatch user's profile). Clothing parameters can be found from the T_{cl} (clothes temperature) formula in [9] by substituting I_{cl} (clothes insulation) with the inverse relation of

$$R + C = \frac{T_a - T_{sk}}{I_{cl}} \qquad (3)$$

where C and R are the thermal convection and radiation coefficients (respectively considered 3:8 and 4:7) and Tsk is the skin temperature measured by the smartwatch.

2) Olfactory Comfort: Although no standards have been set for VOCs in non industrial settings, alarms are sent to people when VOCs value increases of a 50% with respect to its average value. On a similar time it is notable [10] that CO2 effectsly affects human working exhibitions. It is broadly announced by the specialized group required in indoor air assessments that the ASHRAE has a standard of 1,000 ppm CO2 for indoor spaces. A similar esteem has been set as the notice level in the Comfort Box.

3) Acoustic Comfort: The clamor examination has been conveyed out considering the levels proposed by the Environmental Assurance Agency [7] and the standard EN15251. These archives distinguish 55 decibels outside and 45 decibels inside as the levels which will allow talked discussion and other day by day exercises. An alert is sent when the indoor sound weight level compasses 55 dB (A).

4) Visual Comfort: According to EPA residential illumination standards, warnings are generated when the light level is less than 100 lux.

IV. WEB GRAPHICAL INTERFACE

In this segment we introduce the GUI and the fundamental programming functionalities of the ComfortBox web application. A screenshot of the GUI main page ("Home") is depicted in Figure 2.

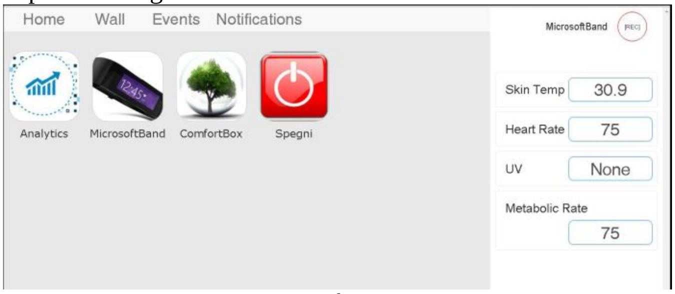

Fig. 2: ComfortBox GUI.

Buttons on the left side of the screen represent applications ("Analytics", "Band" and "ComfortBox") while in the right side sensors readings are continuously updated and formulas evaluated. The application named "ComfortBox" contains all the comfort values recorded as well as the PMV value computed thanks to the smart watch measures (depicted in the figure).

V. CONCLUSIONS

In this work we proposed an open hardware and open software platform able to turn an 802.15.4 intranet mesh network into an IoT architecture. The device is able to monitor and analyze four personal comfort parameters. Real time smart watch data, integrated to compute personal metabolic and clothing indexes, have been used to properly assess thermal comfort according to PMV index.

REFERENCES

[1] A. Pourshaghaghy and M. Omidvari, "Examination of thermal comfort in a hospital using pmv-ppd model," Applied Ergonomics, vol. 43, no. 6, pp. 1089 – 1095, 2012.

[2] ISO (International Standard Organization), "ISO-7730:2006 norm," (https://moodle.metropolia.fi/pluginfile.php/217631/mod resource/ content/1/EVS EN ISO 7730%3B2006 en.pdf), 2007, last access December 18th 2014.

[3] L. Ciabattoni, G. Cimini, F. Ferracuti, M. Grisostomi, G. Ippoliti, and M. Pirro, "Indoor thermal comfort control through fuzzy logic pmv optimization," in Neural Networks (IJCNN), 2015 International Joint Conference on, Jul 2015.

[4] S. Kelly, N. Suryadevara, and S. Mukhopadhyay, "Towards the implementation of iot for environmental condition monitoring in homes," Sensors Journal, IEEE, vol. 13, no. 10, pp. 3846–3853, Oct 2013.

[5] L. Ciabattoni, A. Freddi, G. Ippoliti, M. Marcantonio, D. Marchei, A. Monteriu, and M. Pirro, "A smart lighting system for industrial and domestic use," in Mechatronics (ICM), 2013 IEEE International Conference on, Feb 2013, pp. 126–131.

[6] A. Kumar and G. Hancke, "An energy-efficient smart comfort sensing system based on the ieee 1451 standard for green buildings," Sensors Journal, IEEE, vol. 14, no. 12, pp. 4245–4252, Dec 2014.

[7] E. P. Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," (http://www.fican.org/pdf/EPA Noise Levels Safety 1974.pdf), 1974.

[8] APIO, "APIO srl official website," (https://www.apio.cc), 2015.
[9] G. Havenith, I. Holmer, and K. Parsons, "Personal factors in thermal comfort assessment: clothing properties and metabolic heat production," Energy and Buildings, vol. 34, no. 6, pp. 581 – 591, 2002.
[10] U. Satish, M. Mendell, K. Shekhar, T. Hotchi, D. Sullivan, S. Streufert, and W. Fisk, "Is co2 an indoor pollutant? direct effects of low-to-moderate co2 concentrations on human decision-making performance," Environmental Health Perspectives, vol. 120, no. 12, pp. 1671–1677, 2012.