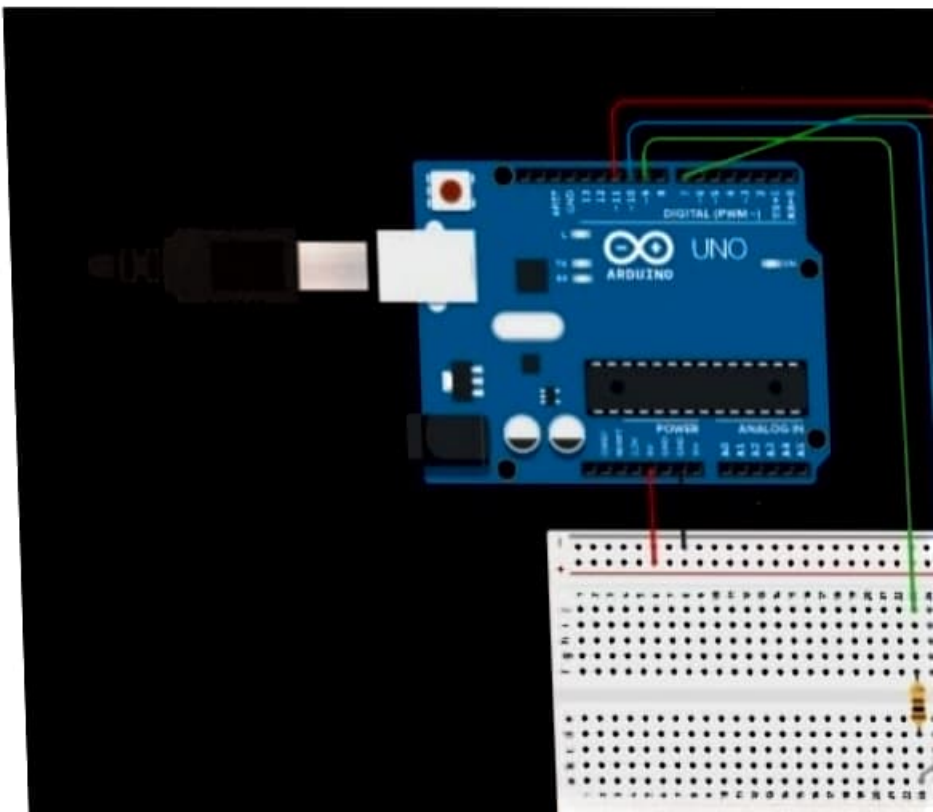
PAPER • **OPEN ACCESS**

IoT Based Noise Monitoring System (NOMOS)

To cite this article: M B Badruddin *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **884** 012080

Ajishlin P.S
ECE - III



IoT Based Noise Monitoring System (NOMOS)

M B Badruddin[1], S Z A Hamid[2], R A Rashid[3] and S N M Hamsani[4]
[1,2,3,4]Communication Engineering Department, School of Electrical Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, MALAYSIA

E-mail: baihaqibadruddin@gmail.com

Abstract. Presently, noise pollution has become a very big issue around the world. The adverse effects of this pollution include hearing impairment, negative social behavior, annoyance, sleep disturbance and intelligibility to understand people's speech. In learning context, noise can affect understanding and behavior of people and places with high noise level are not suitable for learning and teaching process. Internet of Things (IoT) technology is one of the best choices to monitor the noise or sound intensity in the environment for the safety of human being. The aim of this paper is to deliver a development of an IoT based noise monitoring system comprises of a sound sensor, an IoT platform called NodeMCU, LCD and LEDs. The system will provide a real-time alert if the noise exceeds the threshold noise limit set by Environmental Department of Health standard. Equipped with an Android application, the data from the sound sensor will be transferred into the cloud server and subsequently transferred into the app for display and to enable remote monitoring. A case study is carried out using the developed prototype to ascertain the noise comfort for Universiti Teknologi Malaysia (UTM) students for studying or learning purpose. The sound level is measured for two different days during weekend and weekday. Based on Charted Institution of Building Service Engineers (CIBSE), 60dBA is the permissible ambient level and any readings that above 60dBA can interrupt speech intelligibility. From the research, the suitable time for students to study for weekend is all day starting from morning until midnight. As for weekday, the most suitable time to study is during midnight. These justifications are made based on the readings of the sound level.

1. Introduction

Internet of things or commonly called IoT refers to the network of physical devices, vehicles, electronic appliances and other items embedded with sensors, software and connectivity which enables these things to connect, collect and exchange data without requiring human-to-human or human-to-computer interaction [1]. IoT is currently growing due to some factors such as convergence of multiple technologies, real time analytics, machine learning, commodity sensor and embedded systems [2]. The term IoT was firstly coined by Kavin Ashton of Procter and Gamble and later by MITs Auto-ID centre (1999) [3]. Cisco System estimated that IoT was developed between 2008 and 2009 [4]. It is widely used in today's applications such as consumer, commercial, industrial and infrastructure spaces. There is a lot of thing that can be implemented for the consumers' daily uses. Take a smart home for instance, IoT is used in this invention to control lighting, heating, air-conditioning, media and security systems. This means it can save energy as it can automatically ensure lights and other electronics

Figure 1. Working principle of IoT

In term of learning process, noise can affect understanding and behaviour of people. Places with high noise level are prone to have unfavourable learning environment and make the teaching process exhaustive [8]. It is important to have good acoustical condition so that noise problems cannot affect the students and teachers. There are a lot of adverse effect of noise pollution toward human being such as hearing loss, increase blood pressure, headache and annoyance. Moreover, it can also deter the intellectual growth of students such as impaired learning, speaking and writing difficulties and also constraint in reading comprehension as well as vocabulary development.

1.1. Problem Statement

Noise monitoring is very crucial since 20% of the European Union (EU) population or close to 80 million people suffer from noise level that experts consider to be unacceptable [9]. IoT allows an exchange of information to and from a device or thing and due to its flexibility and low cost, IoT is getting popular day by day [10]. Thus, IoT is very suitable to be implemented in monitoring the noise level in some areas to deal with the problem. The demands of modern society lead to the creation of noise sources such as industrial sources, transport vehicles, defence equipment and construction. The most significant example is inside UTM. Noise coming from vehicles and construction sites have significantly distract the focus and the intellectual development of the students. This issue results in the needs of a system that will monitor the noise level at that specified areas. It is also an alternative for students to know the suitability to study via app.

2. Literature Review

IoT has been implemented in many noise monitoring systems nowadays including mobile phones and vehicles. These technologies were invented and developed because of the demand from society to have systematic and efficient system for monitoring purpose. With the use of cloud server, the users can access the data at anytime and anywhere [11]. It is an effective way to reduce the work for authorities and less time consuming when recording data.

2.1. Air and Sound Monitoring System

To apply air and sound monitoring system where its objective is to measure the quality of air and sound in the environment, Arduino is used as microcontroller. All sensors such as sound sensor, temperature sensor and gas sensor are connected to it. Sound sensor or mic sensor provides digital output and it detects sound from atmosphere. A WiFi module is also connected to Arduino and it is used to transfer data from the sensors to cloud server. ESP8266 WiFi module is used to store

the data to online server. The data from sensor are basically analog signal so analog to digital converter (ADC) is used to convert the data [12]. 16 x 2 Liquid crystal display (LCD) is used to display the measured value from the sensors. It can display two lines and each line has 16 characters.

2.2. Air and Noise Pollution Monitoring in the City of Zagreb by Using Mobile Crowd Sensing
The objective of this system is to create a fine-grained pollution and noise maps to pinpoint urban areas with critical negative effects on human health. Users use their smartphones and constantly collect sensor readings from wearable and built in sensors. The recorded data is transferred to cloud servers independently and periodically. Cloud servers run on Mobile Crowd Sensing (MCS) service to produce dense sensor readings and provide ways to discover new phenomena in city environments [13]. The exposure metrics and collected data are accessible for personal usage which can be viewed through a web interface. Meanwhile, the function of MCS application is to notify citizens about their surroundings like the users can change their route if there is bad air quality or traffic congestion. This system is low cost and uses non static equipment, but the drawback is the data must be calibrated to obtain accurate readings of noise level since the collected data by different phones is not directly similar.

2.3. The Noise Impact in the Learning-Teaching Process in an Elementary School
Unnecessary or emission of noise that is coming from surrounding of school environment can become a barrier that distorts the communication within community inside the school. The aim of the project is to study the effect of noise from inside and outside of the school building also whether the noise can influence or not students' performance in elementary school. World Health Organization (WHO) suggests that the maximum noise level and reverberation for school is 35dB for classrooms and 55dB for outdoor activities and the recommended reverberation time is 0.6 sec [14]. The data for the project is collected by surveys and measurement of noise level using the sound level meter. Based on the results, there are various factors that contribute to noise level. However, the noise level around the school area still complies with normal level of noise but eventually it will affect the teaching-learning process of students.

3. Methodology

3.1. Hardware Development
For the hardware parts, LM 393 sound sensor is used to read the readings of the sound level from the environment. The reading of sound sensor is calibrated using the real sound level meter to get the accurate readings of the sound level. The 16x2 LCD will show the values of sound level at that researched area and give the warning that says the level of sound is high when the measurement exceeds the set value. If the users could not read the readings due to poor eyesight, they can know the level of sound by using the light emitting diodes (LED) which in red, blue and green colour placed below the LCD. LED acts as an indicator to indicate when the noise is very high. It will turn to red, blue for low noise while green for intermediate level. All these components such as sound sensor, LCD, and LEDs will be connected to the ESP8266 NodeMCU.

Figure 2. Prototype of the Project and interface of the app on mobile smartphone

3.2. App Development

As the app was created by using Android Studio, the app will display the data taken from the sound sensor. Android Studio is a software to create app use JAVA language to design an Android development. The app has four features which are the reading of sound level in dBA, the level of warning based on the reading of sound intensity, the possible sound that contributes to the sound level and the suitability for students to study. The app gives different level of warning such as "low", "normal", "high" and "very high".

3.3. Working Principle of the Prototype

The sound sensor will record the readings of sound level at the researched area. Then, the data is sent over to the cloud server called Firebase. Firebase is a development platform that is specialized for web application and mobile developed by Firebase Incorporation [15]. Firebase is chosen as the cloud server for this system because it can easily be connected to Android Studio. The data is stored in Firebase real-time database which the user can also access via web browser. Then, data from Firebase is transferred to the app. The users can use the app to know the reading of sound level and they also can know which time is suitable to study and what factors contribute to the high noise based on the value of sound level.

4. Results and Observations

The prototype is calibrated using actual sound level meter to get the accurate measurement of sound level or sound intensity. The prototype is used to measure the sound level at five different times which are during morning, afternoon, evening, night and midnight at a place where UTM students are staying. The reading is taken 30 minutes per range of time. Within that time, the lowest and highest sound intensity were recorded and from the readings, the range of sound level was determined during that specific range of time. The results are tabulated in Table 1.

Table 1. Data Analysis from Prototype.

Time	Weekend (Saturday) (dBA)	Weekday (Sunday) (dBA)	Allowable Noise Level according to Environmental Department of Malaysia (dBA)	Permissible Level of Comfort according to CIBSE (dBA)
Morning 7.00am-12.00pm	47 – 60	57 – 71	55	60
Afternoon 12.01pm-14.00pm	43 – 49	54 – 69	55	60
Evening 2.01pm-7.00pm	43 – 49	62 – 69	55	60
Night 7.01pm-12.00am	42 – 59	48 – 63	55 (7.01pm–10.00pm) 45 (10.00pm– 12.00am)	60
Midnight 12.01am-6.59am	34 – 35	34 – 35	45	60

The allowable noise level that is suggested for researched area is below 55dBA for daytime and 45dBA for night. This justification is based on the researched area which is categorized as medium density residential area. Based on CIBSE, 60dBA is the maximum allowable sound level to achieve comfort in a building. Any sound that exceeds 60dBA will interrupt the speech intelligibility and the learning process. Based on Table 1, during weekend, the sound level in the morning and night are in between 47dBA to 60dBA and 42dBA to 59dBA. It shows that noise problem does occur during that time because the value of 55dBA is included in the range. As for afternoon, evening and midnight, all readings of sound level are below the allowable noise level standard which are during afternoon (43dBA – 49dBA), evening (43dBA – 49dBA) and midnight (34dBA -35dBA). Thus, during these times, noise problem does not occur. As for weekend, the suitable time for students to study is the whole day starting from morning until midnight because all readings are showing that they are within permissible level of comfort which is 60dBA.. As for weekday, the sound level during morning until night are all above the allowable noise level standard which are; morning (57dBA – 71dBA), afternoon (54dBA – 69dBA), evening (62dBA – 69dBA) and night (48dBA – 63dBA). It can be concluded that during that specific time, the noise problem does occur. As for midnight, the sound level recorded is 34dBA to 35dBA which indicates no noise problem. The reading at midnight also shows that it is less than 60dBA which makes it a comfortable study time for students.

5. Conclusion

People thought that noise pollution is merely an annoyance but it is actually very important to monitor noise level because according to research, people who are exposed to noise for a long duration of time can have hearing loss, sleep disturbance, high blood pressure and injuries [16]. Besides, it can affect the learning process of people in terms of understanding and behaviour. Thus, this research investigates and subsequently proposes the suitable time for students to study by utilising the cloud server and android application to realize an IoT based noise monitoring system. From the prototype, it also can be determined the dominant sound that increases the noise level in the researched area. The app can display the reading from the prototype successfully. Based on the results, it can be concluded that the students can study throughout the day starting from morning until midnight during weekends because the noise level is still under the allowable standard which is 60dBA according to CIBSE. As for weekdays, the suitable time to study is found out to be at midnight because the readings are below 60dBA for that time. The limitation of this study is that it is conducted within UTM campus only. In addition, the app can only show the reading from only a single prototype as well as the prototype and app can only operate when there is an internet connection. This system can be improvised in future to include measurements outside UTM such as at schools and airports.

Acknowledgement
The authors wish to thank Universiti Teknologi Malaysia for the financial support under Vot number R.J130000.7351.4J401 and Telecommunication Software & System Research Group (TeSS) for the advice on this project.

References
[1] Abu, Brown, Eric (13 September 2016). "Who Needs the Internet of Things?". Retrieved from https://www.linux.com/news/who-needs-internetthings
[2] Wigmore, I. (June 2014). "Internet of Things (IoT)". Retrieved from https://internetofthingsagenda.techtarget.com/definition/Internet-of-ThingsIoT
[3] Ashton, K. (22 June 2009). "That 'Internet of Things' Thing". Retrieved from https://www.rfidjournal.com/articles/view?4986
[4] Dave Evans (April 2011). "The Internet of Things: How the Next Evolution of the Internet Is Changing Everything". Retrieved from https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
[5] Kang, Won Min; Moon, Seo Yeon; Park, Jong Hyuk (5 March 2017). "An enhanced security framework for home appliances in smart home". Humancentric Computing and Information Sciences. 7 (6). doi:10.1186/s13673-0170087-4
[6] Demiris, G; Hensel, K (2008). "Technologies for an Aging Society: A Systematic Review of 'Smart Home' Applications" (PDF). "IMIA Yearbook of Medical Informatics 2008": 33–40. Retrieved 27 October 2017
[7] Mulvenna, Maurice; Hutton, Anton; Martin, Suzanne; Todd, Stephen; Bond, Raymond; Moorhead, Anne (14 December 2017). "Views of Caregivers on the Ethics of Assistive Technology Used for Home Surveillance of People Living with Dementia" (PDF). Neuroethics. 10 (2): 255–266. doi:10.1007/s12152017-9305-z. PMC 5486509. PMID 28725288. Retrieved 27 October 2017
[8] Hagen, M., Huber, L., & Kahlert, J. (2002). Acoustic school Sasing. In Proceedings of the international forum Acusticum (Vol. 1). Sevilha, CD-ROM, Sevilha
[9] Cirrus Research plc. (2018) "Why Environmental Noise Monitoring Is Important?". Retrieved from https://www.cirrusresearch.co.uk/applications/environmental-noisemonitoring/
[10] Ms. Sarika Deshmukh, Mr . Saurabh Surendran Prof. M.P. Sardey Air and Sound Pollution Monitoring System using IoT
[11] Niki Limkar (21 Dec 2017). How is IoT in demand? Retrieved from https://www.quora.com/How-is-IoT-In-Demand
[12] Sarika Deshmukh, Saurabh Surendran, Prof. M.P. Sardey, Vol 5, Issue 6 (June 2017). "Air and sound pollution monitoring sytem using IoT"
[13] Martina Marjanovic, Sanja Grubesa, Ivana Podnar Zarko (2017). "Air and noise pollution monitoring in the city of Zagreb by using mobile crowdsensing"
[14] Zulkepli Hj. Ibrahim, Hazel Kiddo Richard (2000). "Noise Pollution at School Environment Located in Residential Area"
[15] Tamplin, James (22 October 2014). "Firebase is Joining Google!". Retrieved from https://firebase.googleblog.com/2014/10/firebase-is-joining-google.html
[16] National Institute on Deafness and Other Communication Disorders (NIDCD), (February 7, 2017), Noise-Induced Hearing Loss. Retrieved from https://www.nidcd.nih.gov/health/noise-induced-hearing-loss