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Natural Disaster and Environmental Monitoring System for Smart Cities: Design and Installation Insights

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Abstract

Climate change is mainly caused by human activities. Consequently, natural disasters such as flooding, storm, and drought are attacking people at high frequency and extreme damage. Besides, many megacities have been facing the rapid urbanization problem of carbon emission, noise, dust, and temperature that seriously impacts on the living conditions of people. In this paper, we design and implement a monitoring system for early detecting and warning the natural disasters and the environmental threats of the rapid urbanization in Quang Nam and Da Nang provinces in the Central Vietnam. The system will sense, communicate, store, process, and display the important information including precipitation, wind speed and direction, water level, and landslide/earthquake in Quang Nam and CO_2 emission, temperature, dust, and noise in Da Nang. The experimental results can help the local government and citizens with better management of natural disasters and environmental threats for smart cities.

Keywords: Climate change, natural disaster and environmental management, smart city, wireless monitoring system, wireless sensor network.

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1. Introduction

Climate change is one of the most challenges to the world. On the one hand, it has really made human life suffering from many unknown natural and environmental disasters, e.g., storm, flooding, and drought, etc. As reported by the government [1], Vietnam is one of the countries affected by climate change most seriously. About 10-12% of Vietnam population will be directly under the impact of climate change, causing a loss of 10% GDP. Efforts have been dedicated to enhancing the capacity of risk management, for instance, improving infrastructures for dyke systems, storm shelters, and flood control works. Yet, 500 people are dying of natural disasters annually, not to mention economic loss. Due to geographic conditions, the Central Vietnam provinces, e.g., Quang Nam, Quang Tri, Quang Binh, are most severely affected by natural disasters.

On the other hand, several provinces such as Da Nang and Quang Ngai, in Central Vietnam, have developed quickly. The rapid urbanization introduces high environmental threats of carbon emission, noise, dust, and temperature. Together with the problem of natural disasters, to ensure sustainable development, these provinces should have a good policy and a system to track, measure, and estimate the effect of rapid urbanization on human life so that all the problems of natural and environmental disasters are under controlled.

As communication networks play an important role in grasping dynamic changes of disasters, monitoring environment, and providing advanced applications and services, many wireless communication architectures, i.e., wireless mesh networks [2], mobile ad hoc networks [3], wireless multimedia sensor networks [4], and 5G networks [5] have been studied. Although these works are potential to be applied, the proposed architectures

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have not been developed in particular areas for practical evaluations.

In efforts to reduce the risk and strengthen the capacity for natural and environmental disaster management, the nation has deployed many monitoring stations of air (26 stations), water (56 stations), and sea water (6 stations). These stations are effectively integrated with the meteorological, hydrographic and navigational monitoring network to send data to the environmental monitoring center of the Vietnam Environment Administration [6]. In addition, some big cities, particularly Ho Chi Minh city, the traffic pollution monitoring program has been operated to grasp the environment changes [7]. Importantly, after the marine environmental disaster in Ha Tinh, Quang Binh, Quang Tri, and Thua Thien Hue provinces, the local governments have installed a seawater monitoring station and an air monitoring station around Vung Ang economic zone and its vicinity. It is expected that a whole marine environment monitoring system including automatic and continuous seawater and air monitoring stations will be developed in these provinces in the future [8].

In Da Nang, in January 2018, the Center of Integrated Circuits (CENTIC) initially deployed four solar energy-based monitoring stations for monitoring the water quality and warning the pollution level in the local rivers and lakes. These stations also monitor and evaluate the quality of industrial wastewater for the purpose of protecting the water environment and preventing the pollution incidents. They automatically send sensed data to the data center. The data is then uploaded to the Environmental Monitoring Center's website of Danang Department of Natural Resources and Environment. In Quang Nam, the authors have deployed a project entitled "Research on the dynamic changes in natural disasters (flooding and drought) in Quang Nam in the context of climate change". The objectives of the project are to evaluate the existing problems and build a decision support system with capability of calculating, updating, and warning the dynamic changes of natural disasters to minimize the damage caused by flooding and drought [9].

The aforementioned monitoring systems, especially in Quang Nam and Da Nang, can provide the natural and environmental disaster management agents and policy makers with useful information. This way, it is possible to set a better disaster management and more reasonable urbanization roadmap for sustainable development and thus provide a higher quality of citizens' life. However, there is a lack of monitoring storm and landside/earthquake in Quang Nam and temperature, noise, dust, and CO_2 concentration in Da Nang. In this paper, we therefore design and implement an integrated wireless system (IWS) for sensing, monitoring, detecting, and warning the natural and environmental disasters. Particularly, the IWS will sense, communicate, store, process, and display important information including precipitation, wind speed and direction, water level, landslide/earthquake in Quang Nam and temperature, noise, dust, and CO_2 concentration in Da Nang.

The rest of this paper is organized as follows. In Section II, we present the requirements of the system and the proper device vendor. We design the IWS in Section III. The designed system is tested and installed in Section IV. Section V is dedicated to experimental results and system performance evaluation. Finally, we conclude the paper in Section VI.

2. System Requirements and Vendors Selection

2.1. System Requirements

Feasibly, the IWS is designed by integrating wireless sensor networks (WSNs) and mobile cellular networks (MCN). The WSNs are equipped with sensor nodes including weather, horizontal and vertical liquid level, vibration, CO_2, temperature, dust, and microphone sensors. The WSN in Quang Nam grasps the natural disasters, i.e., storm, flooding, and landslide/earthquake by using weather, liquid level, and vibration sensors. The weather sensors are in charge of tracking the precipitation and direction and speed of wind. The horizontal and vertical liquid level sensors are used to observe the flooding. And, the vibration sensors are to measure the ground vibration for detecting landslide/earthquake. In Da Nang, the CO_2, temperature, dust, and microphone (noise) sensors in WSN grasps the environmental threats caused by rapid urbanization.

All the sensors are connected to their corresponding sinks integrated with general packet radio service (GPRS) modules. The sensed data from the sinks is sent to a server via the GPRS of the MCN. The server stores, analyze, and process the sensed data and timely warn the local governments or the citizens (if needed) about the natural disasters and environmental threats in Quang Nam and Da Nang. Furthermore, a web portal is designed at the server for explicitly monitoring the sensed data in chart form.

2.2. Vendors Selection

Based on the aforementioned requirements of the IWS, we take into account three sensor device vendors that are Libelium (http://www.libelium.com), Device Modern (http://moderndevice.com), and Seeed (http://www.seeedstudio.com). In particular, Libelium provides full requirements of weather, horizontal and vertical liquid level, vibration, CO_2, temperature, dust, and microphone sensors, integrated boards (i.e., smart city, event, gas, and agriculture), GPRS modules, and Li-Ion rechargeable batteries. Meanwhile, Modern Device

Table 1. Vendors Evaluation

Functions/Devices	Vendors		
	Libelium	Modern Device	Seeed
Sensors	*****	**	***
Integration	*****		****
GPRS communications	*****		*****
Power supply	*****	*****	*****
Catalogs and technical support	*****	**	**

offers only wind and temperature sensors and there is no information about integrated wireless communication solutions. Seeed supports more sensors than Modern Device including temperature, dust, CO_2, water flow, wind, and integrated wireless communication solutions, but not good enough compared to Libelium. Furthermore, with regard to technical support, deployment, and troubleshooting, Libelium is superior to both Device Modern and Seeed. Obviously, the IWS is at higher cost of using Libelium devices than Device Modern and Seeed. In this paper, Libelium is the best choice thanks to its full solution and technical support. The detailed evaluation of the three vendors is summarized in Table 1.

3. System Design

3.1. Installation Locations

Choosing the installation locations of the sensors plays an important role in deploying the IWS. A selected location must satisfy the following three factors: 1) highly vulnerable to natural disasters and environmental threats, 2) high signal-to-noise ratio for communicating between the sinks in WSN and the base stations in MCN, and 3) the support of citizens, e.g., in using their power supply, notifying when having problems, etc. To do so, we have considered some survey sites given as follows:

- In Quang Nam, we investigated Song Tranh Hydropower, Phu Ninh District, Dai Dong Commune - Dai Loc District, Hoi An, Ha Lam - Thang Binh, and Dien Hoa Commune - Dien Ban District.
- In Da Nang, we investigated Hoa Tien Commune - Cam Le District, Khue Trung Ward - Cam Le District, Man Thai Ward - Son Tra District, Hoa Khe Ward - Thanh Khe District, and Hoa Khanh Nam Ward - Lien Chieu District.

After carefully investigating, the final installation locations selected that meet the three requirements above are Hoi An, Ha Lam - Thang Binh, and Dien Hoa Commune - Dien Ban District in Quang Nam and Khue Trung Ward - Cam Le District, Man Thai Ward - Son Tra District, and Hoa Khe Ward - Thanh Khe District in Da Nang.

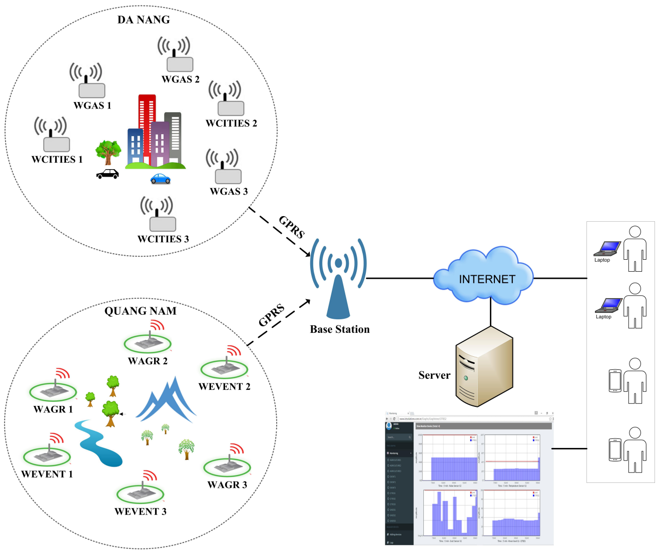

Figure 1. IWS model

Table 2. Libelium devices

Device Code	Device Description	Quantity
WA-GPRS	Waspmote GPRS/GSM (GPRS module)	3
6041	6600mA-h Rechargeable Battery (6600mA-h)	3
WEVENTS	Waspmote Events Sensor Board (collect sensed data from 9242, 9240, and 9222)	3
9242	Vertical Liquid Level Sensor	3
9240	Horizontal Liquid Level Sensor	3
9222	Vibration Film Sensor for thread	3
WA-GPRS	Waspmote GPRS module	3
6041	6600mA-h Rechargeable Battery (6600mA-h)	3
WCITIES	Waspmote Smart Cities sensor board (collect sensed data from 9203, 9259 and 9320)	3
9203	Temperature Sensor	3
9259	Noise Sensor	3
9320	Dust Sensor	3
WA-GPRS	Waspmote GPRS module	3
6041	6600mA-h Rechargeable Battery (6600mA-h)	3
WGAS	Waspmote Gases Sensor Board (collect sensed data from sensor 9230)	3
9230	CO_2 Gas Sensor	3
WA-GPRS	Waspmote GPRS module	3
6041	6600mA-h Rechargeable Battery (6600mA-h)	3
WAGRS	Waspmote Agriculture Sensor Board (collect sensed data from sensor 9256)	3
9256	Weather Station WS-3000 (precipitation, direction and speed of wind)	3

3.2. Integrated Wireless System

System model. The proposed IWS is shown in Fig. 1. It consists of the sensors and main boards (WEVENT, WCITIES, WGAS, and WAGR) with integrated GPRS modules in WSNs, the base station in MCN, and the server that allows web portal deployment. The detailed Libelium devices used for the IWS are listed in Table 2.

System functions. In Quang Nam, the WEVENT 1, WEVENT 2, and WEVENT 3 collect the sensed data from horizontal and vertical liquid levels and vibration sensors. The WAGR 1, WAGR 2, and WAGR 3 collect the sensed data from precipitation and direction and speed of wind sensors of the Weather Station WS-3000. Similarly, in Da Nang, the WCITIES 1, WCITIES

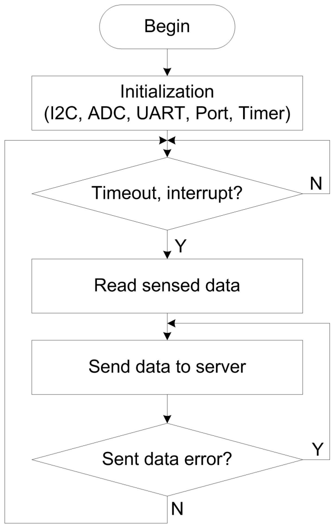

Figure 2. Operation flow chart of main board

Table 3. Data Values Sent by Sensors

Main board	Sensor	Unit	Value
WEVENTS	Vertical liquid level		2 levels: 0/1
	Horizontal liquid level		2 levels: 0/1
	Vibration film sensor for thread	v/g	0~1(v/g)
WCITIES	Temperature	^{0}C	0~100
	Noise	dB	50~100)
	Dust	mg/m^3	0~0.60
WGAS	CO_2 gas	ppm	300~450
WAGRS	Anemometer (speed)	km/h	0~240
	Wind vane (direction)	degree	0~360)
	Pluviometer (precipitation)	mm/h	any

2, and WCITIES 3 gather the sensed data from dust, temperature, and noise sensors, while the WGAS 1, WGAS 2, and WGAS 3 gather the sensed data from CO_2 sensors. The main boards, i.e., WEVENT, WCITIES, WGAS, and WAGR, are equipped with GPRS modules and rechargeable batteries to send the sensed data to the server via the base station in MCN. All the main boards, GPRS modules, and sensors can work in the power saving mode when not transmitting and thus they are able to work in months. In some convenient cases, the main power is supplied by suitable adapters.

System operation. In WSN, the general operation of a main board is described in Fig. 2. In the beginning, the main board initiates some system parameters such as I2C, ADC, UART, Timer, and Ports. The active frequencies, i.e., the timeouts, of different sensors are set properly to collect the ambient data. Interrupt mode is applied to some special sensors such as liquid level and vibration so that the data is sensed and sent immediately whenever an event happens. The main board is in idle mode if there is no interrupt by the timer and the event to save energy. If interrupted, it is active to collects the data from the sensors and send to the server via GSM/GPRS module using POST protocol. The data sensed by sensors is described in Table 3. This data is resent until it is received correctly. The main board returns to sleep mode again and wait for the next interrupt and timeout.

At the server, the received data is compared to the pre-defined thresholds for making decision and warning if needed. The received data is also displayed on the web portal. The web portal designed meets the following requirements.

- Account management to authorize the administrators and the users of the web portal;
- Display interface to show the continuous sensed data on the graph by date, week, month, and year;
- Excel export to convert the sensed data to excel format for the ease of processing and reporting;
- Adding and removing sensor/device function;
- Warning function to send warnings to the designated email list if the sensed values exceed the pre-defined thresholds. The warnings are also displayed on the web portal;
- And regular data backup.

4. System Testing and Installation

4.1. Data Format with POST http

The data format sent by the main boards to the server is given in the form of [Url][KeyDevice =ID]&[Sensor1=Value]&[Sensor2=Value]&...&[Sensorn =Value]. The detailed data format of the main boards are presented in the sequel.

Data format sent by WEVENT boards. The data format sent by WEVENT boards to the server is http://www.ictsolutions.com.vn/UpdateDate/Create?KeyDevice=EVENT &Sensor1=0&Sensor2=0&Sensor3=1&Sensor4=95, here, the Url is http://www.ictsolutions.com.vn/UpdateDate/Create? and the Sensor1, Sensor2, Sensor3, and Sensor4 are vertical liquid level sensor, horizontal liquid level sensor, vibration film sensor for thread, and power level, respectively.

Data format sent by WCITIES boards. The data format sent by WCITIES boards to the server is http://www.ictsolutions.com.vn/UpdateDate/Create?KeyDevice= CITIES&Sensor1=75&Sensor2=35&Sensor3=0.3&Sensor4=95, here, the Sensor1, Sensor2, Sensor3, and Sensor4 are noise sensor, temperature sensor, dust sensor, and power level, respectively.

Data format sent by WGAS boards. The data format sent by WGAS boards to the server is http://www.ictsolutions.com.vn/UpdateDate/Create?KeyDevice= GASES&Sensor1=400&Sensor2=95, here, the Sensor1 and Sensor2 are CO2 gas sensor and power level, respectively.

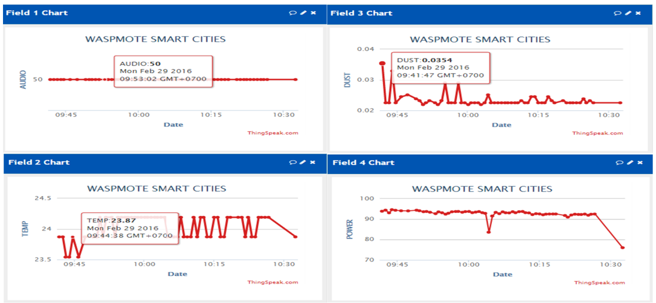

Figure 3. Testing results from the WCITIES boards displayed at https://thingspeak.com.

Data format sent by WAGRS boards. The data format sent by WAGRS boards to the server is http://www.ictsolutions.com.vn/UpdateDate/Create?KeyDevice=AGRICULTURE&Sensor1=100&Sensor2=200&Sensor3=180&Sensor4=95, here, the Sensor1, Sensor2, Sensor3, and Sensor4 are anemometer (speed), pluviometer (precipitation), vane (direction), and power level, respectively.

4.2. Sensed Data Display Testing

Tested at https://thingspeak.com. The web portal https://thingspeak.com is a free host, which is used to test the POST http messages sent from a user/device. We therefore utilize the https://thingspeak.com to test the sensed data to ensure that the data is correctly sent from the main boards. This web portal also enables us to adjust, normalize, and standardize the sensed data before launching the official web portal at http://www.ictsolutions.com.vn. Some testing results obtained from the WCITIES boards, i.e., noise (Field 1 Chart), temperature (Field 2 Chart), dust (Field 3 Chart), and power level (Field 3 Chart) are shown in Fig. 3.

Tested at http://www.ictsolutions.com.vn. The web portal launched at http://www.ictsolutions.com.vn is to monitor the sensed data received from the sensors for the purpose of analyzing and making decision. This web portal provides the following functions.

- Add new sensor devices to the display system;
- Change the display templates corresponding to each kind of sensor;
- Manage all the data collected from all sensors;
- Manage and configure the sensors;
- Provide the instruction and troubleshooting;
- Send email to inform that a sensed value exceeds the pre-defined threshold;

Figure 4. Testing results from the WCITIES boards displayed at http://www.ictsolutions.com.vn.

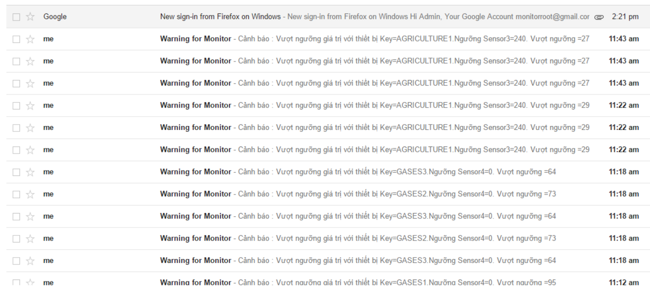

Figure 5. Emails received about the exceeding sensed values.

- Review all sensed data from every sensor versus time.

Fig. 4 shows the testing results from the WCITIES boards displayed at the http://www.ictsolutions.com.vn. The sensed data includes noise, temperature, dust, and power level. Many sensed values that exceed the pre-defined thresholds are sent to a particular email for early alarms as represented in Fig. 5. The content of an email includes: "Warning: Exceeding threshold of device [Key=ID].[Threshold of Sensor No.=Value].[Exceeded=Value]", for example, which is shown in Vietnamese, is "Canh bao: Vuot nguong gia tri voi thiet bi Key=AGRICULTURE1.Nguong Sensor3=240.Vuot nguong=27".

4.3. Installation

After having the proper installation locations investigated and the testing system completed, we install the WSNs in 6 places, i.e., 3 in Quang Nam and 3 in Da Nang. In particular, in Quang Nam, we deloy the WSNs in Hoi An, Thang Binh, and Dien Ban, while in Da Nang, we deploy the WSNs in Cam Le, Son Tra, and Thanh Khe. Some samples of installed devices are illustrated in Fig. 6. All devices are prevented from ambient effects by metal boxes.

Figure 6. Some samples of installed devices.

Table 4. Performance Evaluation

Sensors	Total samples	Valid samples	Performance
Vertical liquid level	20,000	18,400	92%
Horizontal liquid level	20,000	19,000	95%
Vibration Film	20,000	17,800	89%
Temperature	20,000	18,000	90%
Noise	20,000	19,200	96%
Dust	20,000	19,400	97%
CO_2	20,000	18,400	92%
Anemometer	20,000	18,200	91%
Wind vane	20,000	19,600	98%
Pluviometer	20,000	19,600	98%
Average Performance			94%

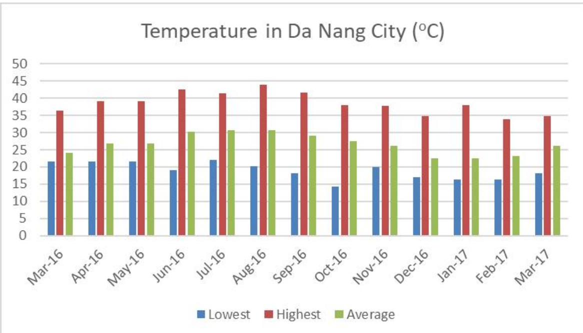

Figure 7. Temperature in Da Nang

5. Experimental Results and System Performance Evaluation

5.1. System Performance

To evaluate the system performance, it is necessary to determine the ratio of valid samples to the total number of predefined samples sent to the server. After getting the statistical data from the server, we evaluate the system performance as shown in Table 4. It can be observed that the system performance is high, i.e., 94% of the total samples are valid on average.

5.2. Experimental Results

In this paper, the experimental results are almost unchanged on weekdays, therefore, we do not discuss here. It should be noted that the results presented below are the ones exactly done during the survey period, i.e., from March 2016 to March 2017, at the selected installation locations in Da Nang and Quang Nam.

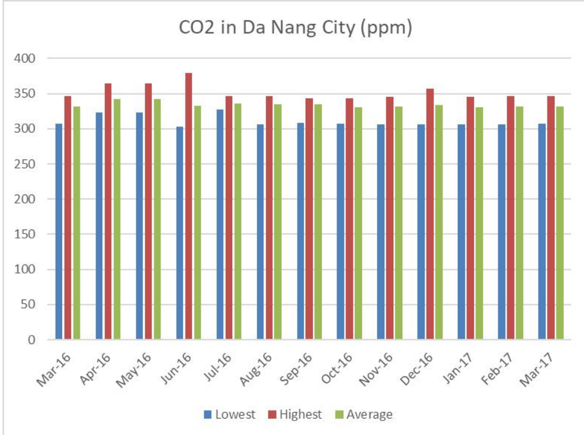

Figure 8. CO_2 in Da Nang

Results in Da Nang. In Da Nang, the sensed data includes temperature, CO_2, dust, and noise. The sensed data is shown per month and per day in a week by three values: lowest, highest, and average. However, because the sensed data per day in a week has not had any significant changes compared to that per month, we do not present it in the paper. The detailed results are presented in the sequel.

Temperature: As we can see in Fig. 7, the high-temperature points (close to and greater than 40 degrees) appeared from April to September. The average highest temperature was at 30 degrees occurring between June and September. The lowest temperature period fell from October to February at around 15 degrees. It is important to note that the hot weather frequency was relatively high and serious at 44 degrees occurring in August. The gap between the highest and lowest temperatures in each month was also very high, i.e., more than 20 degrees, especially the difference was up to 24 degrees in August, September, and October.

CO_2: Fig. 8 shows the CO_2 concentration measured in parts per million (ppm) every month. The average CO_2 concentration was below 350 ppm and the highest was 380 ppm, which is relatively low compared to the Earth's CO_2 emission threshold, i.e., 408.48 ppm reported on April 1, 2017 (https://www.co2.earth) [10]. The CO_2 emission in Da Nang was well controlled as there was no sign of getting increased in 2016 and the first quarter of 2017.

Dust: Vietnam has set a limit on the safety of dust at $300\mu g/m^3$ [11]. The results in Fig. 9 show that the average dust concentration in Da Nang increased from

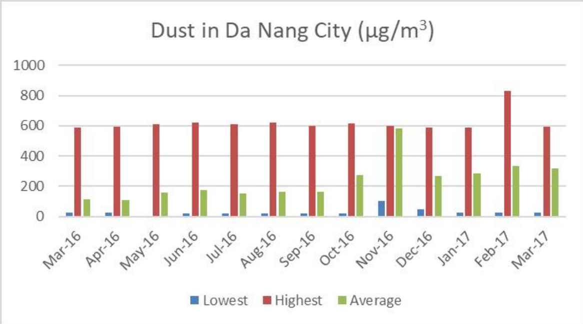

Figure 9. Dust in Da Nang

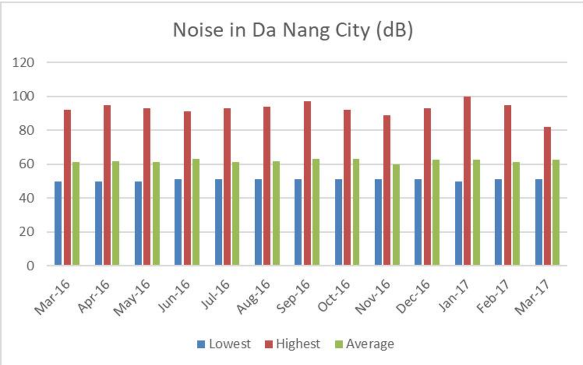

Figure 10. Noise in Da Nang

Figure 11. Sensed data of vibration sensor of WEVENT board located in Ha Lam – Thang Binh from Apr. 8, 2016 to Apr. 10, 2016

March 2016 to March 2017. There were many alarms about dust levels in most of the months, even two times higher than the limit (600μg/m^3).

Noise: While the noise limit in Vietnam is 70 dB [11], the average noise level in Da Nang was close to the limit as shown in Fig. 10. The alarms occurred at high intensity and frequency every month, i.e., from 80 dB to 100 dB. In addition, the lowest noise level of 50 dB is also an early alarm to the local government and citizens.

Results in Quang Nam. In Quang Nam, the sensed data includes vertical and horizontal liquid levels, vibration, precipitation, and direction and speed of wind. The detailed results are presented in the sequel.

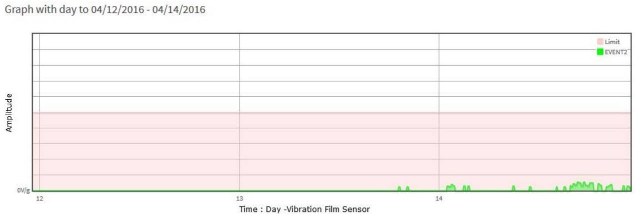

Figure 12. Sensed data of vibration sensor of WEVENT board located in Ha Lam – Thang Binh from Apr. 12, 2016 to Apr. 14, 2016

- Vertical and horizontal liquid levels: There was no important sensed data from March 2016 to March 2017. In fact, there was no flooding event and thus we do not discuss in this paper.
- Vibration: There was no significant sensed data occurred from March 2016 and March 2017, excepted that the two consecutive earthquakes were on April 9 and April 13, 2016.
- Precipitation and speed and direction of wind: They are shown per month by three values: lowest, highest, and average.

Earthquake: In 2016, two consecutive earthquakes stuck at the site of the Song Tranh 2 hydropower plant in Bac Tra My district, Quang Nam province. In particular, the Earthquake Information and Tsunami Warning Center (EITWC) of the Vietnam Global Physics Institute said the first earthquake, which was measured at magnitude 3.2 in Richter scale with its epicenter located at 7km deep, hit the Song Tranh 2 hydropower plant at 22h12’50”, on Apr. 9, 2016. Four days after that, at 14h46’21”, on Apr. 13, 2016, the second earthquake, which was measured at magnitude 3.0 in Richter scale with its epicenter located at 5km deep, recorded by the EITWC in the same area.

Most of the vibration sensors of the WEVENT boards detected these two earthquakes. For example, the vibration sensors, which located near these epicenters, i.e., located in Ha Lam - Thang Binh (55km) and Hoi An (90km), recorded the earthquake events. However, because of the relatively long distances, the detected signals were not strong enough as shown in Fig. 11, Fig. 12, Fig. 13, and Fig. 14. In addition, some of them did not detect because the detected signals were quite weak. The reason is that these earthquakes happened in the short time at a not very high in Richter scale, meanwhile, the epicenters were 100 km far from the installation locations of the vibration sensors in Dien Hoa Commune - Dien Ban District. As a result, the sensors did not detect the earthquake events from 8 to 14 Apr. 2016.

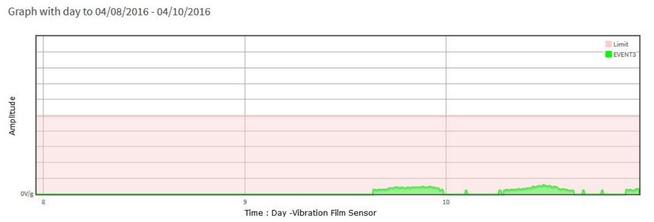

Figure 13. Sensed data of vibration sensor of WEVENT board located in Hoi An from Apr. 8, 2016 to Apr. 10, 2016

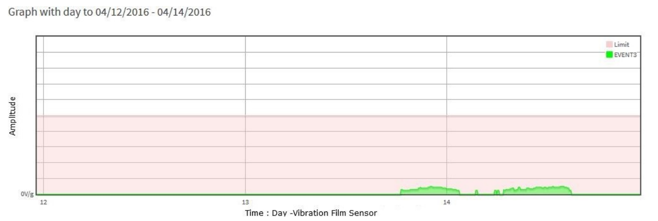

Figure 14. Sensed data of vibration sensor of WEVENT board located in Hoi An from Apr. 12, 2016 to Apr. 14, 2016

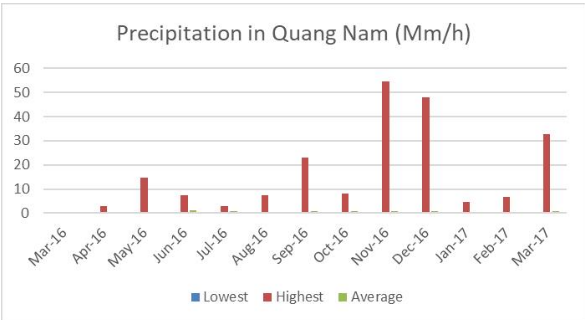

Figure 15. Precipitation in Quang Nam

There were the other earthquakes occurred on February 26 and March 1, 2017. But the distances from the epicenters were too far from the vibration sensors, the sensors were not able to detect them.

Precipitation: As shown in Fig. 15, the precipitation in Quang Nam was light, i.e., less than 1 mm/h. However, the precipitation was very diversity between the lowest and highest values, especially from September to December 2016.

Speed and direction of wind: The direction of wind in Quang Nam was mainly south-east, with average speed ranging from 1 to 5 km/h (Fig. 16). The wind speed varied from month to month, especially in September 2016, from 0.8km/h (lowest) to 30km/h (highest). But it was still harmless even at the highest speed of 30 km/h.

Summary. In summary, the sensed data in Da Nang and Quang Nam can be comprehensively evaluated in Table 5, ranked from 1 for the worst to 5 for the best. It

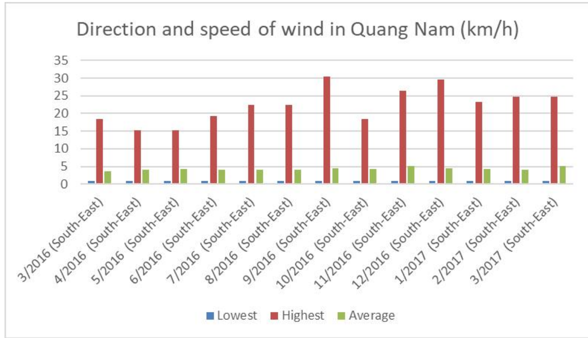

Figure 16. Wind in Quang Nam

Table 5. Sensed data evaluation in Da Nang and Quang Nam

Sensor type	Evaluation					Location
	1	2	3	4	5	
Temperature		x				Da Nang
CO_2			x			Da Nang
Dust		x				Da Nang
Noise		x				Da Nang
Precipitation					x	Quang Nam
Earthquake			x			Quang Nam
Storm				x		Quang Nam

should be noted that the experimental results will be more accurate if the duration of collecting sensed data is longer, e.g., more than two years.

6. Conclusion

In this paper, we have designed and implemented an integrated wireless system (IWS) for monitoring the natural disasters and environmental threats in Quang Nam and Da Nang provinces in the Central Vietnam. The IWS can provide many important parameters of temperature, CO_2, dust, and noise in Da Nang and vertical and horizontal liquid levels, vibration, precipitation, and direction and speed of wind in Quang Nam. The experimental results show reasonable evaluations that can help the local government and citizens manage the natural disasters and environmental threats better in the future.

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