Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 109C (2017) 1104–1109

Procedia Computer Science

www.elsevier.com/locate/procedia

The International Workshop on Smart Cities Systems Engineering (SCE 2017)

A flood warning system to critical region

Alisson Silva Souza[a], André Márcio de Lima Curvello[b], Flavio Luiz dos Santos de Souza[a], Henrique José da Silva[a]

[a]*Universidade de Franca, Av. Dr. Armando Salles Oliveira, 201 - Parque Universitário, Franca - SP and 14404-600, Brazil*
[b]*Centro Universitário Salesiano de São Paulo, Av. Almeida Garret, 267 - Jd. Nossa Senhora Auxiliadora, Campinas - SP and 13087-290, Brazil*

Abstract

Based on the *E-noe*[6] project, this paper developed with the purpose to reduce damages and losses caused by flood in urban centers, through the cheap flood warning system to authorities and population. The system monitors the water level of a runway or river and according to the risk with the level, triggers emergency alerts to the authorities through telephone calls and SMS messages. For the population, there are light beacons that define the situation of the river. The data is collected in cloud storage through the Ubidots server, turning possible to visualize them in real time.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: flood; warning; cloud; telephone; sms; notification;

1. Introduction

Nowadays, the dependence of the internet on people's routine activities is increasing, and staying connected is a fundamental prerequisite for sustaining activities. In this context paradgmas like Internet of Things (IoT) has gained space and adhesion. Studies[1] indicate that by 2020 all the equipment that surrounds us are somehow connected to the internet.

The use of IoT in urban environments allows the emergence of Smart Cities, where urban information, transit, climate and time, water and waste, health, government services, energy and transportation are interconnected with the population and authorities in general (public servants, Police, firefighters, etc). The purpose of these cities is to adapt the organization and coexistence of the population through the variations and availability of information transmitted by the urban environment in real time[2].

* Corresponding author. Tel.: +55-16-3711-8717 ; fax: +0-000-000-0000.
E-mail address: souzaalissonsilva@gmail.com

Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.05.453

With these definitions of IoT and Smart Cities applying this project is based on facts caused by natural disasters, which occurs when natural phenomena hit inhabited places causing civil damage and social and economic damage. The most common natural disaster in Brazil, occurs due to intense and prolonged hydrological events in the rainy season, being characterized as flood[4], another factor that causes this type of disaster in Brazil and the accumulation of waste in the bottom of Causing the pollution, thus increasing the risk of flooding[6].

According to the UN (United Nations), in the 21st century, about 2.8 billion people suffered from natural disasters, the damages exceeded US$ 1.7 trillion. Between 1995 and 2015, the flood affected about 26% of the deaths from natural disasters. In the same period around the world, the flood hit 56% of people affected by some kind of natural disasters[10]. According to data from the IBGE (Instituto Brasileiro de Geografia e Estatisca), more than 45% of the municipalities in the Southeast Region of Brazil have already suffered floods[4].

In large urban centers, where is crowded and a chaos on mobility, the flooding of these regions can contribute to the increase in mortality rates due to natural disasters. Since the evacuation of normally flooded regions makes it difficult for the people who are there to move[5]. However, smart city has adopted monitoring methodologies in flood regions, with the purpose of increasing the safety of the population, projects such as that of Pechoto et. Al.[6] E-no: Network of wireless sensors to monitor urban rivers, implemented in the city of S£o Carlos-SP (Brazil), try to solve such disorders. For this, the project has three monitoring sensors:

- Pressure - used to obtain the water level,
- Accelerometer - used to contain vandalism and theft
- Fluvial plution detector;

The transmission of information and between the nodes of the networks is done by ZigBee, which has the advantages of having a larger transmission range and a low power consumption[6].

Based on the *E-noé*[6] project, this project was developed with the purpose of making decisions in order to reduce damages and losses caused by natural events in urban centers. The project took into account the cost benefit of the equipment, so that the final product is accessible and easy to implement. The system monitors the water level of a runway or river and according to the risk with the level, triggers emergency alerts to the authorities through telephone calls and text message (SMS). For the population that comes or goes near this monitoring point, there are light beacons that allow us to define the situation of the runway or river[4]. Even if the theme presents global relevance, regional impacts and prevention of natural disasters is still *”little discussed in academic texts”*.

The objective of this work was to develop and construct a system capable of monitoring the variation of the water level of a river in order to alert the authorities and the population about regions and situations of risks in order to avoid great losses and prejudices.

2. The Flood Warning System

Warning systems are often entrusted with issuing warnings at risk of tragedy. These systems generally consist primarily of a hydrological model, supported by meteorological data obtained by monitoring, visual observation and weather forecasting[3].

Natural phenomena, which affect regions and negatively affect local development, causing financial losses, can be monitored using different devices, such as sensors, satellites and seismographs. To minimize such damages, researchers have developed projects based on geographic information of volunteers (VGI), where information is made available on the Internet by volunteers who play the role of ”sensors”, allowing the perception and interpretation of this information, thus, being capable to notify other people[8]. Unlike the VGI methodology, the present work is based on electronic components that monitor the rivers and weather forecasting systems. The flowchart of its functionality is represented by the Figure 1.

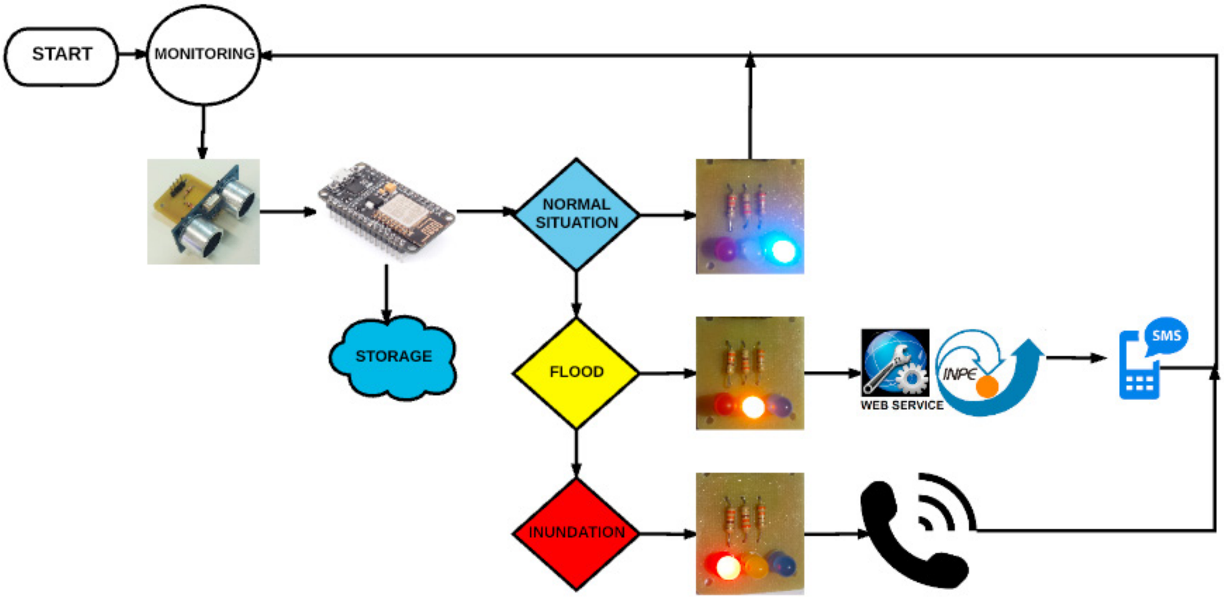

Fig. 1. System Flow

At the start, the system starts to monitor the water level of the river using a sonar (ultrasonic sensor HC-SR04). It sends the extracted data to a microcontroller (ESP8266 NODEMCU). The microcontroller processes the data, and subsequently, periodically performs an average of the monitored levels in order to minimize errors due to current disturbances. The obtained results are stored in the cloud for the purpose of being applied in research and study of the place.

The same stored data is used to control the sequence of lights that signals the current location situation. Each light color corresponds to a situation, for this project was defined:

Green light: corresponds the level of the river is stable and normalized,

Yellow light: it affirms that the level of the river is above normal, in the entente, without crossing its bed, thus being characterized a situation of flood

Red light: denotes that the location is at risk as a flood.

When the yellow light comes on, indicating a flood situation, the flood warning system sends a SMS to an emergency central with a flooded area identifier and information on a forecast of the weather conditions that may or may not occur, extracted from a web service of the INPE (National Institute of Space Research), which through CPTEC (Center for Weather Forecasting and Climate Studies) periodically executes numerical models of weather forecast[7]. When the red light is on, signaling flood, the same GSM module, makes a telephone call to an emergency center informing the flood in the place. The lights, serve as signaling the situation of the monitored river to the population, this way the population, can take measures in a timely manner in order to minimize further social damage. The notification by SMS and telephone call, serve to notify the public authorities in order to intervene in the critical region and may accentuate evacuation of the population of the region.

3. Study Case: Simulation of the Flood Warning System

Some flood-fighting projects use software platforms to validate their methods, such as the *Green Cloud Platform for Flood Early Detection Warning System in Smart City*[11] , which uses the ArcGIS platform, a Geographic Information System application.

For validation, software was developed in C-language that receives a signal from an ultrasonic sensor (HC-SR04) that measures the level of the river, a GSM module to alert authority, store the data in the cloud and later indicates the situation of the place By means of a sequence of signal lights. The ultrasonic sensor has the principle of sending and receiving a sound signal, the reading of the signal is made through the pins *Trigger* and *Echo* that makes it possible to know the distance between the sensor and the object that reflected the signal . This monitor, from a distance, is performed periodically by a microcontroller (ESP8266) whose main function is to store the cloud data (Ubidots), to store the data it is necessary to use an API and a security key to send the data. Data over the local area network (WiFi). Both features are included in the software. After performing tests in a simulated environment, a turbidity caused by the current was observed, in order to minimize these sudden changes in the water level, a moving average filter was implemented with the data collected. After acquired the average, the software analyzes some conditions that are defined as flood, flood and normal situation. In the test prototype the normal situation is defined when the average presents us a value smaller 5 centimeters, between 5 and 9 centimeters is considered flood and exceeding this level is found flood. These values are configurable and can be adapted to any other distances up to 5 meters maximum

However, the simulation environment, shown in Figure 2, created to test sofwtare is composed of:

items I : a receiver that stored all the water for the simulation, just below this reservoir was coupled a water pump,

items II : has the function of pumping water to a trough, just above

items III : the channel, where the water flows simulating a river current.

items VI : point where the ultrasonic sensor and the entire system are positioned. The variation of the water level is made by a

items V : built to support the rail and electronic system, the structure allows adjusting slope levels.

items IV : the gate, able to provide a flood situation. The aluminum structure,

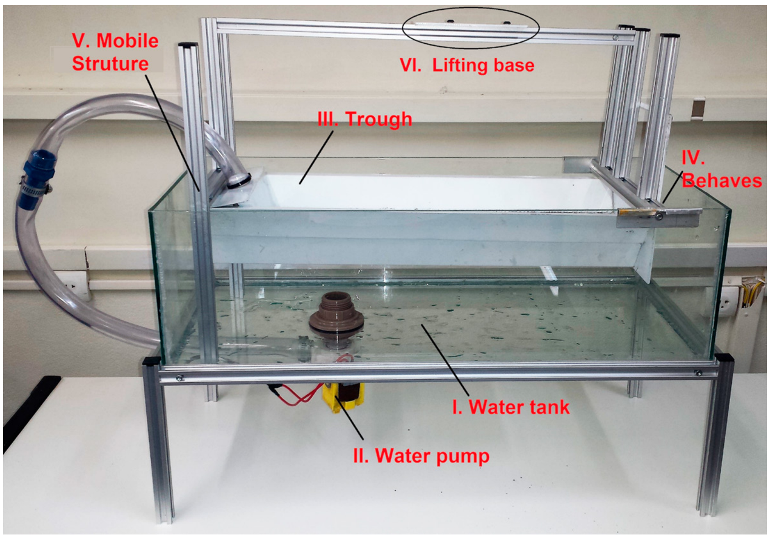

Fig. 2. Simulation environment.

4. Usage Example

With the data collected, cloud storage through the Ubidots server, it is also possible to visualize them in real time as well as events through a platform accessible to a URL. This platform allows to perform calculations of media, variance, sum, and counting of variables and also meets security requirements such as: authentication based on token and encrypted information[9], not being enough is possible to generate graphs and tables, as Illustrates the Figure 3.

Date	Value
2017 -03 -11 15:41:54 -03:00	21.87
2017 -03 -11 15:41:46 -03:00	22.08
2017 -03 -11 15:41:40 -03:00	22.23
2017 -03 -11 15:41:34 -03:00	27.8
2017 -03 -11 15:41:25 -03:00	22.66

Fig. 3. Server ubidots (modified).

The first step the system takes in a situation of risk caused by the gross increase in water level exceeding its limit of normality, but without transhipment of water, and the sending of a text message to an emergency center informing the location and the Time, as shown in Figure 4.

Fig. 4. SMS.

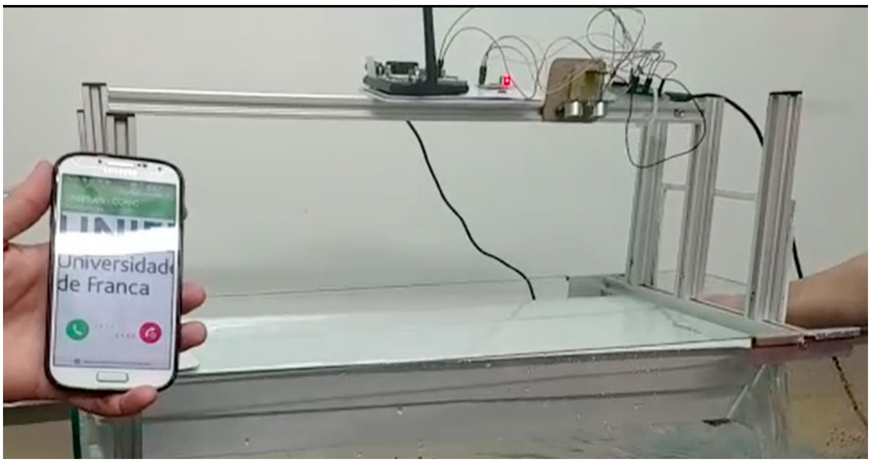

Fig. 5. Telephone call.

If the risk situation is characterized by flooding, defined as transhipment of water out of the river bed, the emergency center is notified behind an alert by a telephone call, as can be seen in Figure 5, the connection being performed together with the red light.

In Brazil, mobile telephone operators have to send an SMS to their destination within 48 hours. For this reason, the SMS alert was intended for flood situations, only to indicate that this place is likely to cause major incidents, so the plants can be prepared in advance.

Based on the above description, we can point out that the data captured in the prototype tests presented in Figure 2, were stored instantaneously in the Ubidots site, as shown in Figure 3, where the graph Generated in the ubidots itself is based on the table that constantly receives the water level.

The initial instants of the graph, according to Figure 3, observe that the level remained constant because the gate was stable and under the chute as the gate is moved manually, as shown in Figure 5, the water level increases, then the sensor detects the variation, the system performs the calculations to acquire the distance and then is sent to the ubidots, being stored in the table shown in Figure 3, and according to the variation of the table the graph restructures with the new values.

Because we are in a place where the telephone network is stable, both the text message (SMS) and the call was received in a matter of seconds, after the state changes.

5. Conclusions and Future Work

The objective of the work, consisted in the development of a system capable of alerting a population and centers of emergencies of flood and flood risks has been successfully fulfilled. The final cost-benefit ratio averaged $ 110 including the prototype and electronic system. However, the ultrasonic sensor, used to measure the reference for water-level, presents a discrepancy in relation to its precision, which says 4mm, thus having to be repaired in software. In our performed tests it was possible to light the 3 flags in approximately 20 seconds, each change occurring in 10 seconds, with this we observed a response time of 7 seconds of the GSM module.

In future work is intended to develop a more robust and safe against vandalism and theft to be able to apply in the avenues of the city of Franca - SP, another work to be done will be the development of an application that will provide notification and submit alternative routes To divert from flooded places to the population.

6. Acknowledgements

We would like to thank Mister Vice-President Buranello and the staff of Telit IoT Solutions it project stayed between 10rd finalists on Telit Cup Brasil 2016 and to thank organization of CONIC 2016 for the 3rd place between engineering projects.

References

1. Jararweh Y, Al-Alyyoub M, Darabseh A, et. al. SDIoT: a software defined based internet of things framework. *J of Ambient Intelligence and Humanized Computing*. v.6, 2015. p. 453-461
2. Quwaider M, Al-Alyyoub M and Jararweh Y. Cloud Support Data Management Infrastructure for Upcoming Smart Cities. *Procedia Computer Science*. v.83, 2016. p. 1232-1237.
3. Fava CM, Mendiondo ME, Souza BCV, Albuquerque PJ and Ueyama J. Proposta metodológica para previsões de enchentes com uso de sistemas colaborativos. *XX SIMPÓSIO BRASILEIRO DE RECURSOS HÍDRICOS* 2013; **8**.
4. Souza SA, Curvello AML and Souza FLS. Sistema de alerta contra enchentes. *CONIC-SEMESP* 2016, v.4; **10**.
5. Melo SF, Silva MLJ and Macedo TH. Flood Monitoring in Smart Cities Based on Fuzzy Logic about Urban Open Data. *8th Euro American Conference on Telematics and Information Systems* 2016; **5**.
6. Pechoto MM, Ueyama J and Albuquerque PJ. E-noé: Rede de sensores sem fio para monitorar rios urbanos. *Instituto de Ciências Matemáticas e de Computação* 2013; **12**.
7. Prestes MPJ, Holbig AC, Pavan W and Fernandes CMJ. Web Service para previsão de tempo e clima através de dados georeferenciados. In: Holbig CA, Marchi BCA, editors. *Revista Brasileira de Computação Aplicada*. 2011, v.2; **117**: 2-16.
8. Rocha SR, Degrossi CL, Horita AEF and Albuquerque PJ. AGORA-PL: Uma Proposta para Desenvolvimento de Famílias de Sistemas Colaborativos baseados em VGI para a Gestão do Risco de Inundação. In: Sociedade Brasileira de computação, editors. *Simpósio Brasileiro de Sistemas Colaborativos* 2014: 118-125.
9. Souza CMA. Uma nova arquitetura para internet das coisas com análise e reconhecimento de padrões e processamento com big data. *Tese de Doutorado - Escola Politécnica da Universidade de São Paulo* 2015;**118**.
10. Tanaka LC. Sistemas de monitoramento e alerta de inundação urbana e seus efeitos no desenvolvimento local: um estudo orientado pela Design Science Research. *Curso de Mestrado em Desenvolvimento Regional, Centro Universitário Municipal de Franca-SP*, 2016;**126**
11. Yusoff A, Mustafa IS, Yussof S and Din NM. Green Cloud Platform for Flood Early Detection Warning System in Smart City. *5th National Symposium on Information Technology: Towards New Smart World*. 2015; **6**