Journal of Industrial Information Technology and Application Vol.1 No.1 (2017)

ISSN(Online) : 2586-0852

IoT and Ontology-Based Modeling for Real-Time Rainfall and Water Level Monitoring and Warning System

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Abstract. The premise of this study is to create a disaster risk reduction framework based on the application of Internet-of-Things (IoT) and ontology modeling for the province of Iloilo, Philippines, to efficiently reduce impact of damage and loss in the community amid a disastrous event. The proposed framework is composed of rain gauges, depth and water flow sensors to detect information. It gathers and records the measurements of rainfall and water level and allows to be connected to the web through TCP/IP WiFi network. Through this, the system is able to provide real-time information to individuals who monitor the weather condition. Moreover, a data threshold is set for the warning system to distinguish variations from the norm and automatically warn the community of a possible danger. Our general approach is to develop a real-time rain condition monitoring and warning system and suggest necessary warning responses and advisories based on developing an ontology architecture.

Keywords; rainfall monitoring system; warning system; IoT; ontology-based modeling

1. Introduction

There are considerable measures of risks a catastrophic event brings. Most particularly in the Philippines which is fourth most prone disaster in the world, wherein climate related disasters are becoming increasingly frequent as indicated by a UN

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Received: 2017.3.21; Accepted: 2017.4.7; Published: 2017.6.5

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report. Furthermore, due to the increasing phenomenal incidences on flash flooding and drought in the world caused by climate change, the demand for undertaking real-time rainfall and water level measurements is increasing. This is one method of managing the water resource, irrigation system, agrarian industry and overall risk. Hence, automated rain gauges are a necessity for a more effective way of doing control measures, planning and development, and water security.

At present, Iloilo region has a few programmed rain gauges installed in some areas. But, these rain gauges are not fully equipped with warning system and are using a conventional method for gathering rainfall information estimations. Accordingly, in this study, we present a design of real-time rainfall and water level monitoring and warning system based on IoT and ontology modeling. Connecting the devices and enable them to communicate with each other in real-time is the thought gotten through the use of internet-of-things (IoT) [1] and therefore, the application of the IoT concept in environment monitoring has a great potential [2]. Moreover, proper management of the proposed system should be observed and effective communication with different people involved is also necessary for better monitoring and ontologies are a tool that can be used to handle such issues because they specify a conceptual framework [3]. There are several ontology-based architecture related works such as in [3], they applied ontology for smart transportation system same with [4] which suggested to apply ontology with knowledge deployment for environmental impact assessment and [5] that proposed on developing an ontology model for drought management related issue in Thailand. In [6], a water and rainfall monitoring and warning system was developed as a decision support system for accurate and real-time support for flood prevention, however, a different technology is applied which is Flex and ArcGIS technology. In any case, limited work has been done to create advanced IoT with ontology application innovations for smart rainfall and water level monitoring system, in spite of the fact that there are as of now a great deal of existing tools and systems everywhere throughout the world that attempt to oversee risk reduction, issues on interoperability and openness in a heterogeneous domain are still issues that need to manage. Through developing the proposed framework, we want to achieve effective responses to warnings and disaster risk, improve the accuracy of rain and water level monitoring, reduce risk possibilities of mischief and misfortune and to caution people in the community of a possible danger.

2. System Development

2.1. Context Model

A context model characterizes the data that can be utilized to describe the situation of an entity. An entity could be a person, place, or object that is viewed as significant to the association between a client and an application, including the client and applications themselves [7].

An ontology approach is applied to enable the sharing of knowledge. This gives a formal meaning of the semantics of context data, enabling numerous elements and distributed environment to trade data. In this study, we apply ontology to enhance disaster management to enable to respond quickly amid a disastrous event and to mitigate disaster risks [8]. Figure 1 shows the ontology model. This reflects the IoT knowledge-based model on paradigms. Here, we exhibit the behavior of the context. The model is composed of several components such as the following:

- Devices refer to the sensors and systems used to interact with the context.
- Person refers to the local authorities concerned for rainfall data analysis and monitoring of the system.
- Location. This entity refers to the location of the automatic rainfall and water gauge sensors. The system can recognize the location-based data through GPS coordinates since the setting will be taken in an outdoor environment.
- Time refers to the continuous monitoring of the measurements of rainfall and water level. A specific time, date or a particular period, for example, breaching the threshold for rainfall and water level estimations.
- Warning System. This is an entity that refers to the integrated warning system. It sends notices by means of SMS and email to the local authorities and other individuals concern during an emergency occasion, to inform them in a timely manner about an upcoming disastrous event and activates the signal warning light to warn the people in the community
- Warning_Services component refers to the services offered by the system such as sending notifications of warning responses and risk factors to local authorities and organizations concern as well as the activation of the signal light during a particular event.
- Warning_Threshold refers to the specific measurements of rainfall and water level to breach during monitoring.

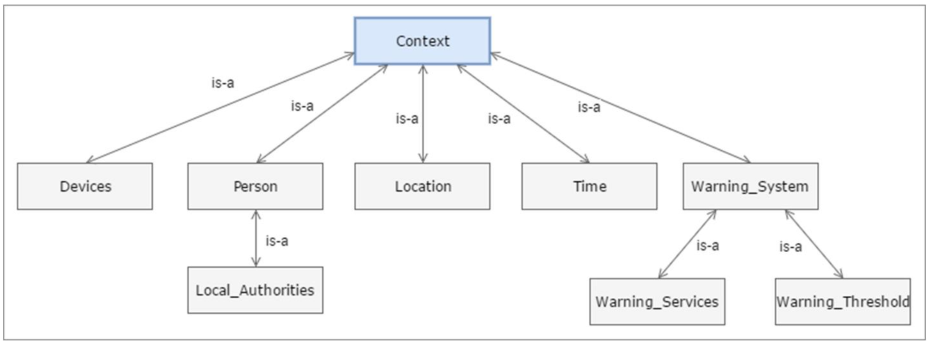

Figure 1. Context Model

2.2. System Architecture

Conventional method of implementing the rainfall and water level monitoring system is through connecting the network to GSM/GPRS especially in data transfer, however, in this study the implementation of the proposed framework will be more focused around the execution of the standard Internet Protocol (TCP/IP) to realize IoT that will interface sensors and systems or any device on the LAN, corporate WAN, or on the internet with VPN access, in transferring and sensing information for better monitoring [9]. The framework design is composed of two sections the Central station which is shown in Figure 2 and the remote station illustrated in Figure 3.

2.3. Remote Station

The rainfall and water level estimations are obtained utilizing the rain and water gauges (with device server) in remote stations connected to the Ethernet network using a modem and TCP/IP WiFi network that would enable the sensors to connect to the internet and enable to send sensed information to the central station in real-time. WiFi device is installed in every device where we can't utilize cable for installation. For data transfer, the information could be requested from a central station or initiated by the remote station.

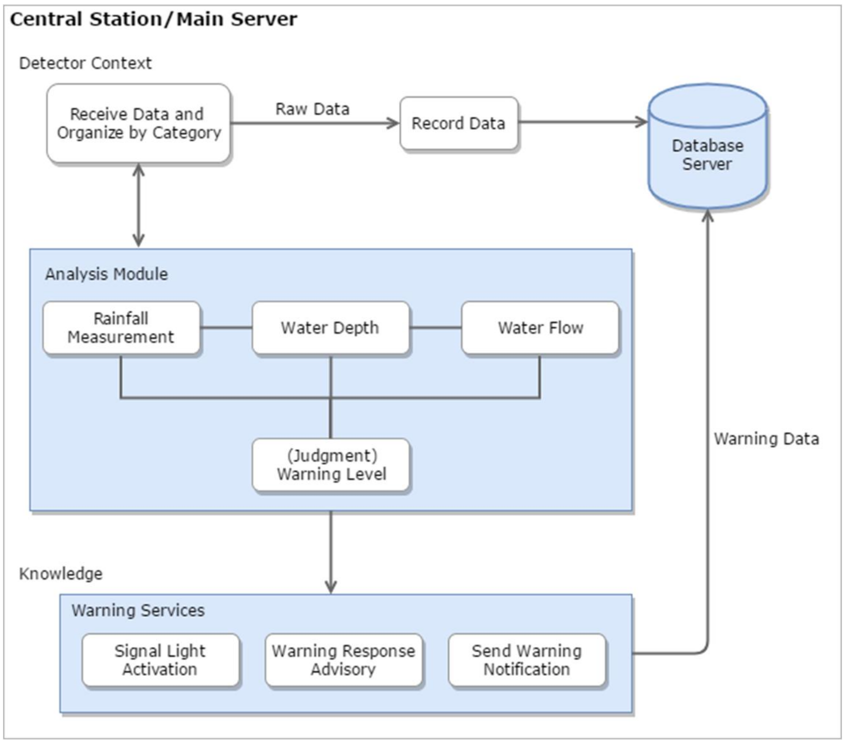

Figure 2. Central Station

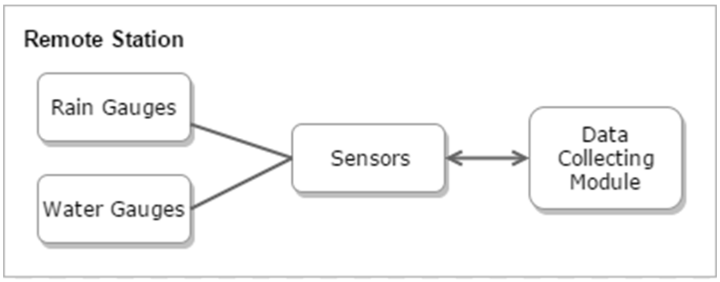

Figure 3. Remote Station

2.4. Central Station

The central server is composed of several components based on the context model. First layer is the detector context which is in charge of acquiring the context information. The context information is sensed data to be received, sorted and categorized by the central server. Data available can be accessed by means of web interface for further analysis and decision making support. Next, an analysis module is responsible for analyzing the sensed data and making judgment based on the warning threshold set in the warning system. In conclusion, lastly, the knowledge layer is accountable for making inferences based on the contextual information provided by the detector context. Ontology is applied for notice warning sort of responses and advisories to local authorities and people in the community. This kind of reading is at the knowledge layer after the threshold is set in the warning system.

2.5. Warning System

The system allows the user to set the threshold or based it on the previous data acquired for automatic warnings. The sensors will sense the data then if it breaches the threshold, the system will activate the warning light based on the emergency levels set in the system. It will automatically update and recommend warning responses based on the set thresholds. At that point, it automatically sends warning notification by means of SMS and e-mail to the local authorities and other individuals involved in monitoring and directly store warning data to the database. However, if the sensed data does not breach the set threshold it automatically records the sensed data in real-time.

2.6. Rainfall and Water Level Data Access

Iloilo Province has as of now rain and water gauges installed in some particular areas of the province. The devices are maintained and overseen by the Department of Science and Technology (DOST) - Region 6 which is a government institution. We will utilize the data accessible through its API documentation for rainfall, water level and other feature information extraction for further review and analysis.

3. Conclusion

The development of the real-time monitoring and warning system for rainfall and water level with IoT and ontology-based modeling applications is a way of reducing disaster risk that provides an efficient environment monitoring and a timely manner of giving people in the community full awareness of an upcoming danger. Moreover, the context model developed based on ontology ought to contribute to the improvement, not just to the monitoring aspect but also to the improvement of programs and emergency responses on Disaster Risk Management in the province of Iloilo. However, we still need to deal with the occurrence of information loss in attempting to model comparisons based on inexact relationships of elements which are problems on scalability [10]. For future work, the performance and efficiency of the architecture developed based on IoT technology and ontology approaches will be assessed and analyzed through conducting a case study.

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