Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition)
ISSN: 1671-5497
E-Publication: Online Open Access
Vol: 41 Issue: 12-2022
DOI 10.17605/OSF.IO/GMNDU

DESIGN AND ANALYZE A GRAPHICAL MODEL OF A SMART FLOOD MONITORING SYSTEM (SFMS)

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Abstract:

A flood is one of the world's biggest issues. Millions of individuals are impacted by floods every year. In this work, a smart flood monitoring system architecture has been designed to keep track of the water level, weather, and rainfall. This system's primary objective is to transmit real-time flood information to the public and rescue teams. Two key components were suggested by this system architecture. A smart autonomous system makes up the second component, while weather and water level monitoring makes up the first. Information is gathered from the wireless sensors, which are dispersed over various areas, by weather and water level monitoring systems. The smart autonomous system uses satellite communication to gather data from the weather and water level monitoring unit and provides flood warning information to the public, the rescue team, and the alarm system. Space state analysis and time automata Petri nets are used to evaluate the architecture.

Keywords: Software Engineering, System of Systems, Flood Monitoring, Evaluation of Architecture, Smart Flood Monitoring Systems.

1. INTRODUCTION

Flood is a significant issue for nations with moon-driven rain systems. These nations lack effective procedures for forecasting, measuring water levels, and managing disasters. That results in significant losses to both infrastructure and human life. More than 2000 people lost their lives and 10,000 more were affected by the 2013 flood in India. Every year, Bangladesh experiences flooding that destroys 7 million homes,

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claims 5000 lives and inundates an area of about 2000 km2. Around 361 individuals were killed in Pakistan in 2011, while 1.2 million dwellings and 5.3 million people were also impacted. 100 individual lost their life in 2013, and the massive rainfall devastated Punjab, Azad Jammu Kashmir, and Jammu and Kashmir in 2014. Thousands of acres of irrigated land are destroyed by uncontrolled floods. Many forecasting agencies have worked in those nations in the past using various technologies and management techniques, but the overall outcome has not been beneficial for managing floods. A remote site for web-based forecasting systems was built in 2011 [1]. However, because no one has access to the internet when a disaster strikes, web-based solutions are ineffective. Due to issues with hosting and server load, it is also inefficient. In 2010, the development of flood monitoring systems convey information to the authorities after receiving data from equipment installed on rivers or bridges [2].

However, that system is dependent on the government; it is not an autonomous system in which all parts were under its authority. The autonomous systems-based Smart Flood Monitoring System, which operates autonomously, avoids the aforementioned issues. (SFMS) is made up of two main parts, the first of which is a central autonomous system that assesses the values before sending them to the citizens via cellular technologies. (SFMS) is also linked to emergency response teams and city alarm systems, which aid inhabitants in the event of a crisis. Cell phones, the rescue service, and the alarm system are connected to the city tower via radio signals in all three components. The second element is an autonomous system for monitoring and forecasting floods that is linked to a wireless network and placed on bridges, canals, rivers, and urban areas. This system also includes wireless water level sensors. Both components connect through satellite, which enables quick and effective data transfer. In that project, we make use of the wireless router-equipped Wireless Balloon Network Technique 2. If city towers are damaged, we employ a wireless Balloon network. A wireless balloon network assembling into an Adhoc network in the air recovers the communication cable. Forecasting and a (GPRS) modem connection (SFMS). Modems and satellites along with radio communication use TCP/IP protocols.

2. BACKGROUND AND RELATED WORK

Every year, disasters have ruined infrastructure and human lives. Spending on infrastructure has cost more than US$1.5 billion and an estimated 2.5 million lives over the past 35 years. Hazards related to nature and biology cause disasters (Floods and diseases).

Mr. Zia Shyong Kwah [6] proposed an Alerter GSM-based system in 2010. The GSM system is used by the alert to send the values it receives from distant devices to the user. That project operates in GSM systems using a MOBITECK modem. For communication, the System requires a strong, dependable band and a large number of ports. It requires constant operator supervision and machine-to-machine communication. Every time we want to connect two devices, we must manually configure them, which adds time and requires human interaction. Values are provided

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by this kind of project, but not in real-time circumstances. Arunachal University of Studies in India's [2] Saurabh Shukla published a paper in 2014 proposing a system that only benefits drivers. The system consists of four parts: water level sensors, a transmission component, a third component for receiving data, and a fourth part for processing data at the remote site. The third module includes a database that keeps the flood values and compares them before sending the results to the appropriate flood authorities. The flood monitoring system was proposed by Jirapon Sunkpho [1] in 2011. Three modules make up those systems. One of them is the database server, which functions online and stores data that users can access online. The sensor in the second module gathers data from the surrounding environment and sends it to the analysis unit. The data transmission unit that processes the data between the first two modules is the third module. Here is the breakdown of the system's parts [3] [4] [5] [6] [7].

The study demonstrates a working prototype of the UrbanFlood FP7 project's flood early warning system (EWS). The system keeps track of sensor networks placed in flood defenses (dikes, dams, embankments, etc.), looks for anomalies in sensor signals, determines the likelihood that a dike would fail, and models potential scenarios for dike breaching and flood propagation [8]. An interactive decision support system that assists dike managers and city officials in making informed decisions in case of emergency and during routine dike quality assessment is provided with all the pertinent data and simulation results [9]. Additionally, a computational module called the Virtual Dike has been built to conduct cutting-edge research on the principles underlying dike stability and failure as well as to train an artificial intelligence module using signal characteristics brought on by dike instabilities. The UrbanFlood EWS is described in this publication [10] [11] [12].

2.1 What is SoS (System of System)?

1. The ability of the system of systems (SoS) to "produce a total force effect, which transcends the sum of the individual systems" while cooperating to carry out SoS capabilities is its most advantageous quality [3].
2. The term "system of systems" (SoS) is frequently used to refer to the internet, a defense communications network, a smart electricity grid, or another intricate arrangement of distributed, independent components that functions as an integrated whole [4].
3. The term "system of systems" (SoS) refers to the context-based analysis of several, dispersed, separate systems as a component of a larger, more complicated system [5].

2.2 Conclusion of System of System

- A system of systems is made up of several separate, independent systems that work together to finish a certain task.
- A system is a framework that allows various hardware and software to operate consistently [6].

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2.3 Applications of SoS

Following are the applications of SoS: Defense sector, air craft system, auto transport systems, production / monitoring systems, health care, space exploration, software integration and energy management systems [4] [8].

3. WHAT IS THE FLOOD-MONITORING SYSTEM?

Flood poses a serious threat to a nation's infrastructure and population. Numerous nations experienced these issues every year because of the full moon and the overflow of rivers and canals. Systems that track rainfall and water levels and continuously warn the authorities are known as monitoring systems. Areas around rivers and canals are also monitored to predict disasters. Every nation employs technology to track rainfall and water levels, but due to outdated methods and metrics; it was unable to give its residents early warnings. Citizens in the UK receive flood warnings and alerts from the environment department [3]. The Central Water Commission (CWC) of India keeps track of the daily water levels in the ocean, rivers, and canals. The (FFD) Flood Forecasting Division, (NDMA) National Disaster Management, and (PDMA) Punjab Disaster Management Authority monitor the water levels of the Chenab, Jhelum, and Ravi in Pakistan. (SUPARCO) keeps a close eye on the rivers and offers pictures of the various areas. Together, these various authorities can offer better solutions and alerts. Due to communication system damage, several web-based and (GSM)-based monitoring systems are unable to continuously send out notifications [2] [7].

3.1 Water Level Monitoring:

- Measure the river depth
- Monitor the water pressure at the bottom of dams
- Calculate flow quantities
- The sensor measures the water level up to 10-15 meters in depth using ultrasonic waves
- Water-level sensors and wireless routers work on TCP/IP protocols for communication [1] [6].

4. WHAT IS A SMART FLOOD MONITORING SYSTEM (SFMS)?

(SFMS) is an autonomous system made up of two main components. Both units use satellite dishes to interact with one another. One unit is a centrally autonomous system, and the other is a weather forecast system. Radio waves are used by satellite stations to convey data between devices [5] [6]. The Centralized Flood Monitoring System includes two interfaces, one of which is connected to a satellite dish for data transfer to

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the other end, and the other of which is connected to a city tower system and a wireless balloon network [7]. The city's emergency alarm system, rescue service unit, and citizen cellular network are additionally linked to the city tower and balloon network [8]. The citizen can get short messages from flood monitoring systems via wireless balloon networks or GSM city towers [9]. SMS alerts residents of potential flooding and instructions on how to save the area. The rescue service unit is under the direction of the Smart Flood monitoring system, which also promptly notifies the rescue unit of any flood hazards. Additionally, it directs emergency assistance to secure locations and disaster zones. The city alarm system, which is installed in various places across the city, is also controlled by the Smart Flood monitoring system. In the event of an elevated water level, it alarms. A flood-monitoring system that is part of the (SFMS) second unit has two interfaces; one is connected to the satellite dish system, and the other is to a wireless router. Radio waves and wireless routers linked to the water level sensors installed on bridges, rivers, canals, and cities are used via satellite dishes to broadcast flood values to the centralized (SFMS). Water level sensors 5 measure the water flow and rainfall intensity. The (GSM) technology these sensors use has a transmission range of about 10-15 kilometers. Sensors to estimate the depth of the water up to 10-15 meters use ultrasonic waves. Multiple routers that are situated in various parts of a city are connected to flood monitoring systems. Wireless routers and water level sensors communicate using TCP/IP protocols. That system is entirely self-contained, self-managing, and monitor able. Together, the aforementioned elements enable the smart flood monitoring system to complete its overall duty [5] [8] [13] [14].

5. SATELLITE RADIO TELEMETRY SYSTEM

Below is a block diagram of a fundamental satellite radio telemetry system. The following enhanced features make this system an improved version of the before discussed basic radio telemetry system [2] [3] [6] [7]:

a) A communication satellite, a device that rotates continuously around the globe and is outfitted with one or more transponders operating as radio-wave repeaters in the sky, facilitates communication between the transmitter and receiver.

b) The radio frequencies (RF) used, also referred to as microwave frequencies, are typically higher than 3.3 GHz.

c) As seen in the picture, the sending earth-transmitter stations include the following:

   i. Modulator: It commonly uses PSK, QPSK, or QAM for digital transmission or frequency modulation (FM) for analog communication.

   ii. IF-to-RF up-converter: This device has an RF output at the so-called uplink frequency and consists of a mixer followed by a band-pass filter.

   iii. Power amplifier.

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d) In addition to filters and a power amplifier, the transponder has a frequency translator (mixer plus band-pass filter). Its job is to receive a microwave signal from one earth station, amplify it, change the frequency from a higher-band uplink to a lower-band downlink, amp it up again, and then send it back to the other earth station.

e) The receiver in the receiving earth station at the downlink frequency picks up the radio signal. It includes an input filter, amplifier, RF-to-IF down-converter (which transforms the downlink frequency signal to an IF signal), and an IF demodulator, as indicated in the image.

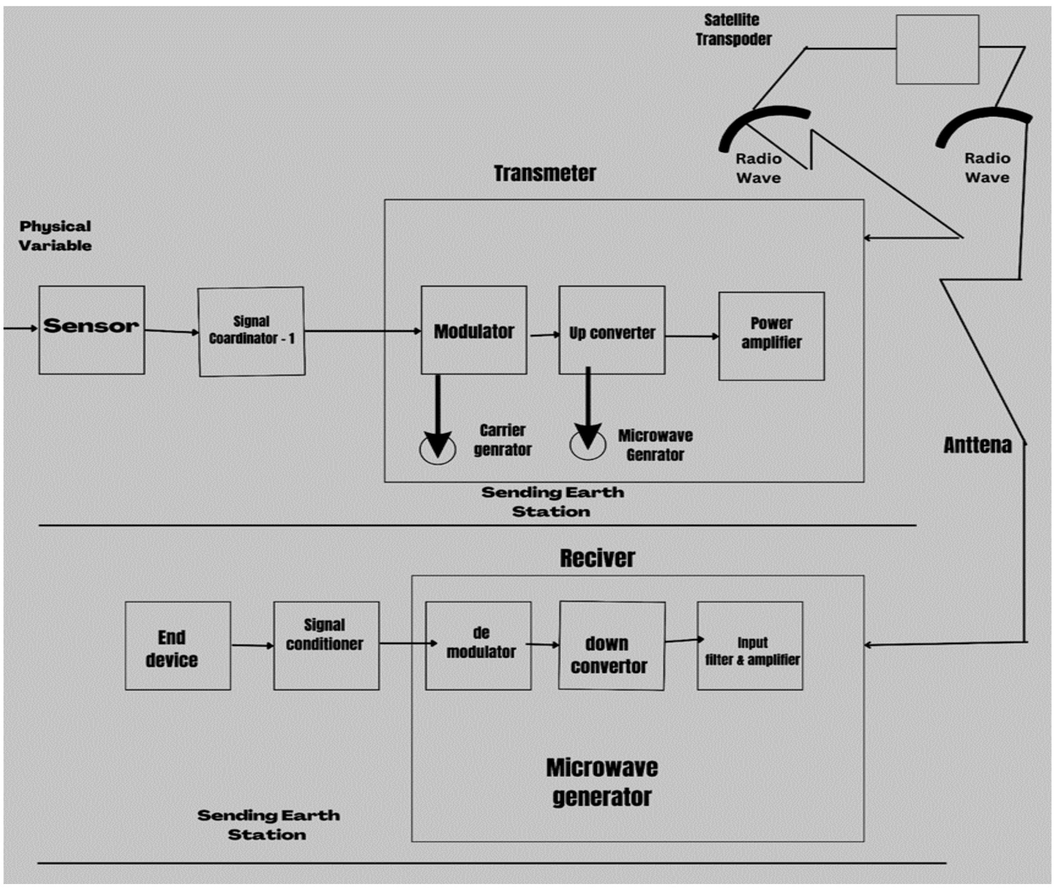

Figure 1: Satellite Radio Telemetry System

6. RESEARCH QUESTIONS

Qno1. Is it possible to analyze and design a correct graphical model of a Smart flood monitoring system?

Qno2. How is it possible to correctly show the data flow in the model?

Qno3. How to perform the state space analysis of the formal data model?

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Qno4. How to specify and evaluate the correctness properties of safety and aliveness in a Smart Flood Monitoring model? [15-22]

7. PROPOSED ARCHITECTURE

Currently, all flood-monitoring systems utilize wireless sensor networks that are web-based, as I covered in Chapter 3. However, in all of the aforementioned systems, there is human monitoring, which uses antiquated techniques to keep track of floods, rainfall, and weather predictions. This chapter covered smart flood monitoring systems, which are self-contained and have automatic control over all system elements. The suggested system continually transmits data to the weather/flood forecast system by taking values from water level sensors that employ GSM technology. The system transmits and receives values from one unit to another using satellite communication. Because of damaged GSM towers caused by floods, which prevent citizens from sending or receiving data, satellite communication is used to connect system units and emergency responders. The functional layout of smart flood monitoring system is shown in Figure 1.

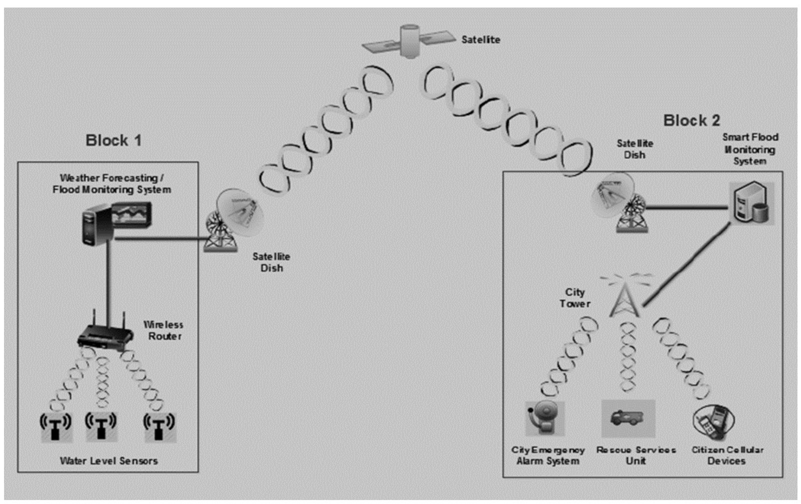

Figure 2: Smart Flood Monitoring System

7.1 System Architecture

(SFMS) based on three major components, which describe its architecture.

7.2 System Components

1. Centralized Autonomous System
2. Weather/ Flood Forecasting System
3. GPRS Modems
4. Wild Blue Satellite Modem
5. Satellite
6. Water Level Sensors

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7. Citizen Cellular Network
8. Rescue Services
9. City Alarm System
10. City Tower

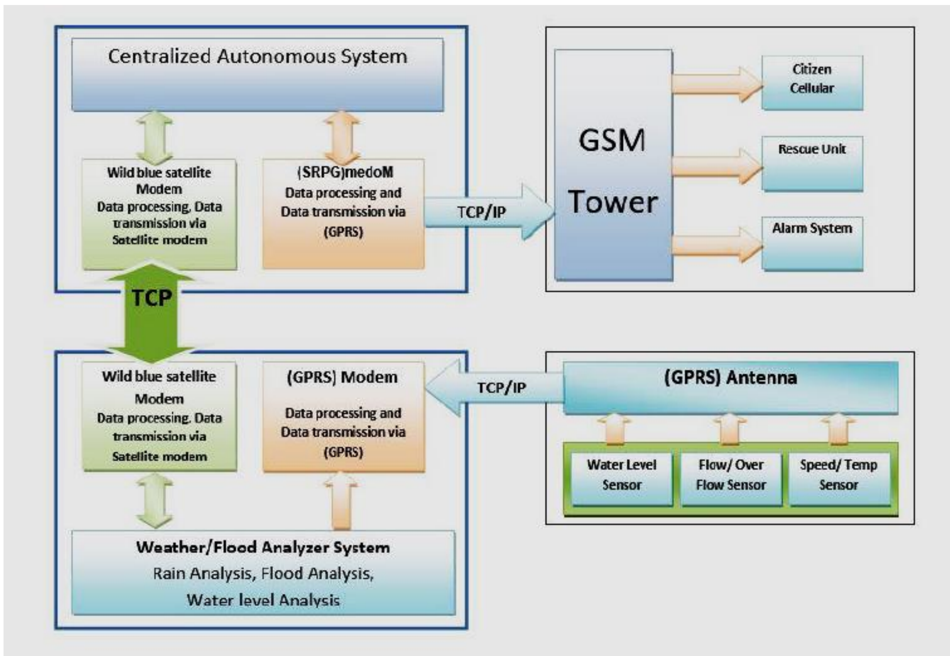

Figure 3: System architecture

8. SUMMARY AND CONCLUSION

Real-time flood monitoring is the primary goal of system development. Smart flood monitoring systems operate as autonomous systems that manage every aspect of their construction. The system is composed of two key components. A weather/flood forecasting unit makes up the initial component, and a smart flood-monitoring unit makes the final decision based on the data that is received. One of the two endpoints of the weather forecasting device is connected to the wireless router. The wireless sensors, which are positioned at various water flow sites, are connected to a wireless router. The autonomous system in the second unit has two ends as well. One portion is linked to the GSM tower, which is then linked to the three main units: the citizen cellular network, the rescue unit, and the alarm system.

The satellite dish is connected to the autonomous system's second section, which is further connected to the communication satellite. Both devices rely on satellites for communication, using a satellite dish for both uplink and downlink. I define the architecture that demonstrates the system's full capability in our research work. Utilizing colored Petri nets as a testing tool, we assess the architecture. We define each component in places and transitions in colored Petri nets, and we connect each place and transition with the aid of arcs. The model in the CPN tool is fully described in Chapter 4 as well. The state space analysis, which demonstrates how the token interacts with each node entirely, is also covered in Chapter 4. The model presented above is a logical framework that illustrates how the system functions; it is not a real implementation of the system.

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