ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijircce.com

Vol. 7, Issue 5, May 2019

IOT Based Rainfall Monitoring System Using WSN Enabled Architecture

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ABSTRACT: The effect of climate change and human activities ends in a chain of risky phenomena, inclusive of landslides and flood. Environmental problems are also a critical part of human's quality of life and the improvement of civilization. Traditional methods of monitoring some environmental parameters such as physically collecting rainfall data from stations can be burdensome and inhibiting the monitoring required for careful assessment. This paper makes specialty of a flexible and efficient WSN for detecting rainfall-induced landslides. Wireless Sensor Networks (WSN) offer high quality monitoring at a very low unit cost in terms of capital and labor invested. This paper describes a WSN-enabled architecture for a tipping bucket rain gauge system to collect and transmit real time data using General Pocket Radio Service (GPRS) via a cellular network. The data is sent from remote Rain Gauge (RG) stations to a public web server known as the Weather Underground (WU). Contribution work is an approach for doubling the number of connected devices through using bandwidth compressed signal waveforms Performance analysis using SVM machine learning classifier for prediction of rainfall.

KEYWORDS: Wireless Sensor Networks, Rainfall Monitoring, Tipping Bucket Rain Gauge, Narrowband IoT (NB-IoT), Nonorthogonal, Spectral Efficiency, Testbed, Waveform, SVM.

I. INTRODUCTION

Water managed from rainfall aims to reduce economic impact and risk of lives. Most developing countries depend on rainfall for their water needs. However with poor management of rainfall water, it is difficult for example to determine water losses to evaporation or ground water recharge, how much is still available etc. Therefore rainfall measurement and monitoring is an important factor when it comes to water management as this determines the current rainfall and future prediction of rainfall hence leading to better management of water. Rainfall measurement devices like rain gauges have been a useful tool in the weather monitoring systems for a very long time. Since a rain gauge was one of the devices that were proven to be beneficial, particularly to agriculture, the rain gauge system has been improved as technology advanced. In the water control and management systems for example, these sensors can be used to help obtain and process information such as rainfall, soil moisture, and soil temperature over large geographical areas. The network uses a tipping bucket rain gauge (TBRG), temperatures and humidity sensors, GPRS module and a micro-controller to relay rainfall data to a remote server, while a solar panel is used to convene energy to critical components of the wireless sensor network.

MOTIVATION

- WSN has enabled a greater convenient early warning system and
- WSN provides a device able to study about the phenomena of natural disasters.

II. RELATED WORK

The paper [1] presents a cheap and efficient tipping bucket rain gauge with an internet enabled data logger. The data logger posts the rainfall data to a SQL database located on the server through a microcontroller which has been interfaced with a GSM/GPRS module. Advantages are: It provides efficient tipping bucket rain gauge with an

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internet enabled data logger. It provides cheap internet enabled data logger. Disadvantages are: Need to reduce power consumption. Need to optimize algorithm. In [2] paper, provides the optimal length for hops that make energy consumption optimal. For this need to use the model, of the energy consumption, defined for the wireless sensor networks. Advantages are: Shows more energy efficiency, and help to extend the network's life. Minimum energy consumption. Disadvantages are: Data routing path need for less costly path.

Rain gauge's products which are manual, semi-automatic or employ logger data that still unable to measure rainfall precisely will also reviewed in [3] paper. By the result of equipment checking out, it is able to be concluded that the rain gauge can work properly and able to be examine speedy. Advantages are: Rain gauge that easily and promptly read using Bluetooth and modem RF-FSK. Measure rain automatically and the result can be view instantly, so the flood will be easily predict. Disadvantages are: Need to create rain gauge based on IP. The GPRS (General Packet Radio Service) technology [4] to access environmental information in real time, provided by sensors strategically placed in a metropolitan area. To find out rainfall volume and phreatic ranges in times of emergency. This permits the technical services to make an appropriate decisions in the management of a huge network of pump stations, flood gates, and so on. Advantages are: This is a reliable system with an acceptable response time. The modem implements a simple Stop & Wait protocol to communicate with the logger, easy to program, and which does not need much resources.

The paper [5] presents NB-IoT features, i.e., connection count analysis theory, delay analysis theory, coverage enhancement mechanism, ultra-low power consumption technology and coupling relationship between signaling and data. The security requirements of NB-IoT aiming to the 3-layer architecture consisted of perception layer, transmission layer and application layer. Advantages are: Low power consumption. Enhanced coverage and low latency sensitivity. The NB-IoT adopts data retransmission system to reap time diversity gain and low-order modulation. Disadvantages are: The data transmission rate is lower than 100Kbps. In [6] paper, presents an experiment-based feasibility study on the co-existence of NB-IoT with pulsed radars when NB-IoT uses the shared channel in the uplink. The study of NB-IoT uplink channel is essentialprimarily because NB-IoT UEs are power constrained, and the coverage is determined based on the uplink performance. Advantages are: The NB-IoT system can co-exist with S-band radars. NB-IoT coverage area is lower when radar interference is existent. Disadvantages are: Need to improve the battery life of NB-IoT UEs.

In [7] paper, proposes a novel discrete-Fourier transform (DFT) based implementation for both DSB and SSB FOFDM. In particular, show that the proposed scheme enables M-ASK SSB FOFDM to avoid the use of Hilbert transform, and exhibit the same performance, complexity, and ISD as conventional $M^2 - ary$ quadrature amplitude modulation (M^2-QAM) OFDM. Advantages are: Reduced complexity. The model built in [8] paper is used to classify the rainfall datasets in identifying districts of more rainfall and of lesser rainfall in the state of Andhra Pradesh. In this paper support vector machine, random forest, K-nearest neighbor and decision tree classification methods have been used to classify rainfall data sets which is divided into training set and test set for classification and later validation of the obtained results. Advantages are: SVM gives better results for rainfall prediction. SVM is more efficient than k-nn, decision tree and random forest classifiers.

A bandwidth compressed waveform termed spectrally efficient frequency division multiplexing (SEFDM) is experimentally demonstrated in a 60 GHz millimeter-wave (mmwave) radio-over-fiber (RoF) scenario to increase transmission data rates without changing signal bandwidth and modulation format. The SEFDM system [9] principle especially the crucial digital signal processing including signal generation, channel compensation and signal detection. Advantages are: The bit rate of SEFDM signals can be substantially higher than that of OFDM signals. The SEFDM system is outperform the 8QAM OFDM with 1 dB performance gain. Disadvantages are: Increases complexity. Expensive. The paper [10] designs and implements RealRain, the first real-time wireless system of monitoring rainfall, which explicitly serves as an effective and efficient scientific instrument for domain experts to facilitate the measurement of large-scale and real-time rainfall. With the tipping bucket as the rainfall signal detecting device, RealRain employs commercial embedded wireless platforms to record and collect rainfall data automatically. Advantages are: Human-free operation. Real-time delivery.Time-synchronized observation.Data reliability.

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Disadvantages are: Need to implement RealRain with a large-scale deployment to monitor the rainfall in forest environments.

III. OPEN ISSUES

Fixed networks for example do not always cover areas where data is to be collected from. For this reason, systems that are low cost and make information readily available need to be designed. Wireless Sensor Networks are one of such networks that offer high quality monitoring at a very low unit cost in terms of capital and labor invested. In recent decades, researchers around the world have been developing environmental WSNs with the purpose of collecting data to be used in hydrometeorology and hydrology industries. WSN consists of low-cost, low-power devices called sensor nodes. They are small in size and readily communicate on wireless, cellular, or radio networks.

Disadvantages:

- Need to reduce power consumption.
- Need to optimize algorithm.
- Less accuracy.
- More time complexity.
- Expensive.

IV. SYSTEM OVERVIEW

The WSN for monitoring rainfall system is made up of two levels: 1) Rain Gauge station and 2) Data Collection (server side) as shown in Fig.1. Each level is further described in detail in the following sections. One RG station is made up of hardware and software that collectively work together to achieve the intended goal.

a) Hardware

The main hardware components that are used in the tipping bucket rain gauge station are described below.

The Tipping Bucket: The tipping bucket is calibrated in such a way that every 0.2mm of water obtained by bucket is registered as the bucket (black in color) ‘tips’. The system is calibrated to be able to wake up when rainfall is sensed and sleep when it is not raining, this will be used as an energy saving mechanism.

- DHT22 (also named as AM2302) humidity and temperature sensor
- Arduino Uno ATmega328P microcontroller board
- SIM900 GSM/GPRS Module
- Power Source
- Spectrum Analyzer

This paper studies an approach for doubling the number of connected devices through using bandwidth compressed signal waveforms. Thus, spectral assets can be stored and reserved for extra devices. In this paper, a signal waveform termed Fast-OFDM, saving 50% of bandwidth, is theoretically and practically investigated for the NB-IoT applications. Simulation shows that Fast-OFDM and SC-FDMA achieve the same performance in additive white Gaussian noise (AWGN) channel. To design the bandwidth compressed signal waveform, standard signal configuration may have to be insignificantly modified.

After data collection, apply the SVM machine learning classifier for prediction of rainfall using weather training dataset. Performance analysis on calculate the accuracy and detection rate.

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A. Architecture

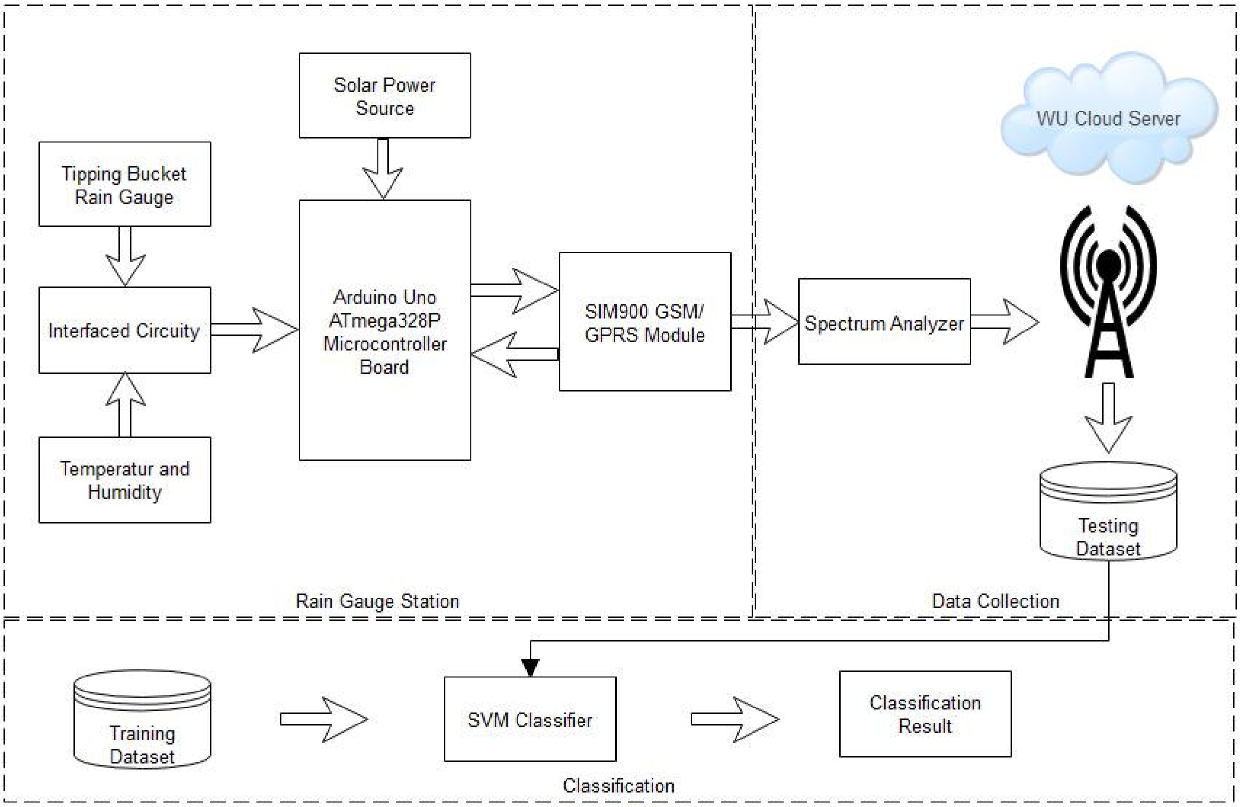

Fig.1 Proposed System Architecture

Advantages:

- It minimizes the data rate and the equipment at the user's end of the data link.
- All computation is done at the users' site which will likely be more convenient for program development and modification.
- It provide sufficient data rate for transmission of information to the web server.
- Decreases the delay in transmission of data to the server.
- Saves bandwidth due to Fast-OFDM.

B. Sensors

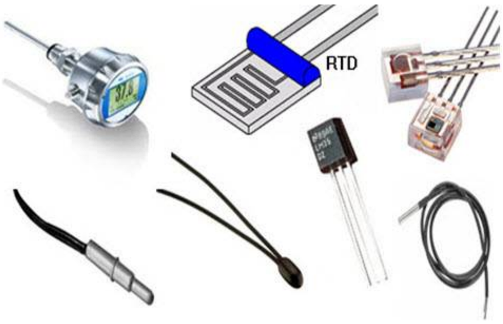

Fig. 2 Temperature Sensor-LM35

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1. Temperature Sensors

The most frequently measured environmental quantity is "Temperature" This might be expected since most of the systems are affected by temperature like physical, chemical, electronic, mechanical, and biological systems. Certain chemical effects, biological processes, and even electronic circuits execute best in limited temperature ranges. Temperature is one of the most frequently calculated variables and sensing can be made either through straight contact with the heating basis or remotely, without straight contact with the basis using radiated energy in its place. There is an ample variety of temperature sensor on the market today, including Thermocouples, Resistance Temperature Detectors (RTDs), Thermistors, Infrared, and Semiconductor Sensors.

2. Humidity Sensor

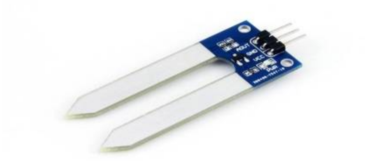

Fig. 3 Humidity Sensor

A humidity sensor (or hygrometer) senses, measures and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. Relative humidity becomes an important factor, when looking for comfort.

C. Algorithms

1. SVM algorithm: This mainly helps in data classification. The classification step is built after the training process of weather dataset. Timely collect data for rainfall detection.

Step1: SVMs maximize the margin around the separating hyperplane.

- Assume linear separability for now:
  – in 2 dimensions, can separate by a line
  – in higher dimensions, need hyperplanes
- Can find separating hyperplane by linear programming (e.g. perceptron):
  – separator can be expressed as ax + by = c

Step2: The decision function is fully specified by a subset of training samples, the support vectors.

Step3: Quadratic programming problem

Step4: Text classification method

V. RESULTS AND DISCUSSIONS

Rainfall monitoring system uses the weather dataset which has values of humidity sensor, temperature sensor values collection from different location at server side. The system administrator extracts all the data from server side and apply SVM algorithm for prediction of rainfall. For experimental set up, use Windows 7 operating system, Intel i5 processor, 4 GB RAM, 200GB Hard disk, Eclipse Luna JDK 8 tool and Tomcat server.

The fig. 2 shows the SVM classification performance of proposed Rainfall monitoring system.

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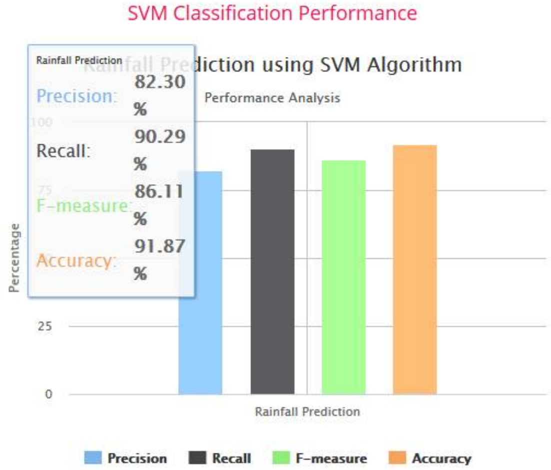

Fig. 2 Performance Analysis using SVM

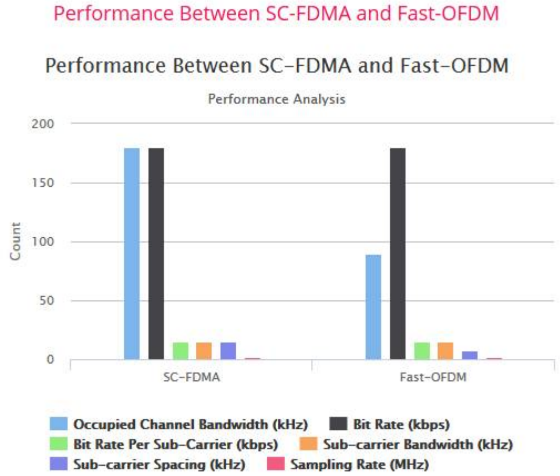

Fig. 3 Performance Analysis between SC-FDMA and Fast-OFDM

VI. CONCLUSION

This paper proposed a low cost wireless sensor network for rainfall monitoring that uses cellular towers to relay data to a remote server for storage, processing and analysis. The WSN rainfall monitoring network is made up of two major stages, the Rain Gauge station RG) and the data Collection. The RG station's main function is to measure the volume of precipitation and transmit the collected data to a remote server for further analysis. It is made up of temperature and wireless sensors, a micro-controller, a Tipping Bucket Rain Gauge (TBRG) and a GPRS shield. This paper provides an efficient solution, which could double the number of connected devices, by using a bandwidth compressed signal waveform. First, this paper introduces basic principle of NB-IoT and followed by the description of the bandwidth compressed signal waveform Fast-OFDM. In this paper support vector machine (SVM) used to classify rainfall data sets which is divided into training set and test set for classification and later validation of the obtained results.

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