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# IOT Based Bridge Safety Monitoring System

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**Abstract:** In this study, an IOT-based bridge safety monitoring system is developed using the WSN technology. The advent of ultra-technological devices in our day to day lives has made us smart and efficient. Advancements in sensor technology have brought the automated real-time bridge health monitoring system such system will help in disaster management and recovery. IOT-based bridge safety monitoring system is developed using the WSN Technology. By the use of wireless sensor nodes, various types of data can be collected like weather conditions, sound, and air quality and data of high priority structures. Such data would also be useful monitoring and surveillance.

The main aim of this paper is to develop a system that can prevent accidents or structural disasters of flyovers and bridges. This paper gives the survey of various techniques used to monitor the conditions of the bridges and proposed a system for monitoring continuous structures and an ultrasonic sensor for monitoring the water level in the river to avoid traffic from a bridge in flood conditions. The detected data are transmitted to the server and database for users to have real-time monitoring of the bridge conditions via mobile telecommunication devices.

**Keywords:** Bridge safety Monitoring, Flood Conditions, WSN, Structural Disasters, IOT, Data Analysis

## I. INTRODUCTION

Structural health monitoring system is one of the best popular systems [1] which is monitoring and detect the environmental condition. The bridge structure may vibrate under the action of such dynamic load as moving vehicles, crowds, wind and earthquake [2]. The analysis is an important content of bridge structure analysis. The data can be used for bridge safety management [3] and in the occurrence of disaster, for disaster rescue. For its monitoring and information communication the system uses the WSN technology. As wireless smart sensor network plays a very important role in the application of remote monitoring [4][5][6] in widespread geographical areas. Human life and property will be in a severe situation when bridge collapse. Many of these bridges are subject to decline due to external and internal factors. Under the action of dynamic load, earthquake, and ground motion it generates a huge vibration in the bridges. That's why it increases the acceleration that affects the comfort and safety of bridge structure.

We propose an integrated bridge monitoring system using IOT that can be used to prevent accidents or structural disasters of flyovers and. All sensors get the real-time value and send it to the server. If the sensor value is above then the limit then the system will play the buzzer and notify the peoples.

Like Akashi Kaikyo Bridge there are many bridges that have real time monitoring system in Korea. [7] Sensor technologies have made the monitoring process more accurate and fast.

The system developed in this study can help to reduce the accident and provide the advancement of bridge safety monitoring from different disaster like-flood, wind, earthquake, heavy load, vibration.

## II. LITERATURE REVIEW

A. R. Pawar [1] explained the Structural health monitoring system is used to measuring the key parameter of the structural and environmental conditions on a continuous base at real-time. Purposes of SHM are detect structure damage, safety, disaster mitigation etc. Wireless sensors to monitor physical or environmental condition like pressure, level of water, acceleration etc. For bridges and dams application, wireless sensor measures the acceleration, tilting angle of bridge pillar and water level. The wireless sensor network is used in industry, urban terrain tracking and civil structure monitoring, security and surveillance, smart buildings etc.

Ren-Guey Lee et al.[2] gives an efficient and reliable backup scheme for bridge monitoring system by using the wireless sensor network (WSN). By collecting the environment parameters transmitting the numerical data to the gateway through the multiple-hop relay, and then it further stores data in the back-end database for the specialized monitoring staffs to analyze and study. This system can able to improve the inconvenience to add or remove sensor nodes in an existing wired bridge monitoring network.

Jin-Linn Lee [3] explained IoT-based bridge safety monitoring system is developed using the ZigBee technology. This system is composed of: monitoring devices installed in the bridge environment; communication devices connecting the bridge monitoring devices and the cloud-based server; a dynamic database that stores bridge condition data; and a cloud-based server that calculates and analyzes data transmitted from the monitoring devices.

Shivan Haran, et al. [5] discusses the monitoring of bridges using WSN. As a testbed, a heterogeneous network of WSN and conventional P2P together with a combination of sensing devices is to be used on a bridge model. Issues related to condition assessment of the bridge for situations including faults, overloads, etc., as well as analysis of network and system performance is discussed.

Chae, M. J. Ph. D., P.E. [7] gives the Advancements in sensor technology have brought the automated real-time bridge health monitoring system. Many long span bridges in Korea and in Japan have adopted this real-time health monitoring system. However, current system uses complicated and high cost wired network amongst sensors in the bridge and high cost optical cable between IOT Based Bridge Safety Monitoring System ICEM, Department of Computer Engineering 2018-2019 4 the bridge and the management center, which increases the overall cost of installation and maintenance cost of health monitoring system.

This paper [8] presents the development of a cyber physical system that monitors the environmental conditions or the ambient conditions in indoor spaces at remote locations. The communication between the system's components is performed using the existent wireless infrastructure based on the IEEE 802.11 b/g standards.

The paper [9] presents a Cities need to constantly monitor weather to anticipate heavy storm events and reduce the impact of floods. Information describing precipitation and ground conditions at high spatial-temporal resolution is essential for taking timely action and preventing damages. Traditionally, rain gauges and weather radars are used to monitor rain events, but these sources provide low spatial resolutions and are subject to inaccuracy.

### III. SYSTEM ARCHITECTURE

The proposed system is the development of bridge monitoring system using IOT. The system continuously monitors the bridge condition. They use a different sensor to get the bridge information like ultrasonic sensor, load cell sensor, vibration sensor, and temperature sensor. The bridge load is getting through the load cell sensor and the vibration is getting using a vibration sensor. By using the ultrasonic sensor system get the water level under the bridge. All sensors get the real-time value and send it to the server and android. The analyst login the android device and analyze the data that was sent by the system. It sends the data to the user. User can see the data which are already registered in the database these data will help the user to see the details of the bridge. These data can be helpful to avoid accident and all that data will display on the lcd. If the sensor value is above then the limit then the system will play the buzzer and notify the peoples. The detail description of proposed system is as follows:

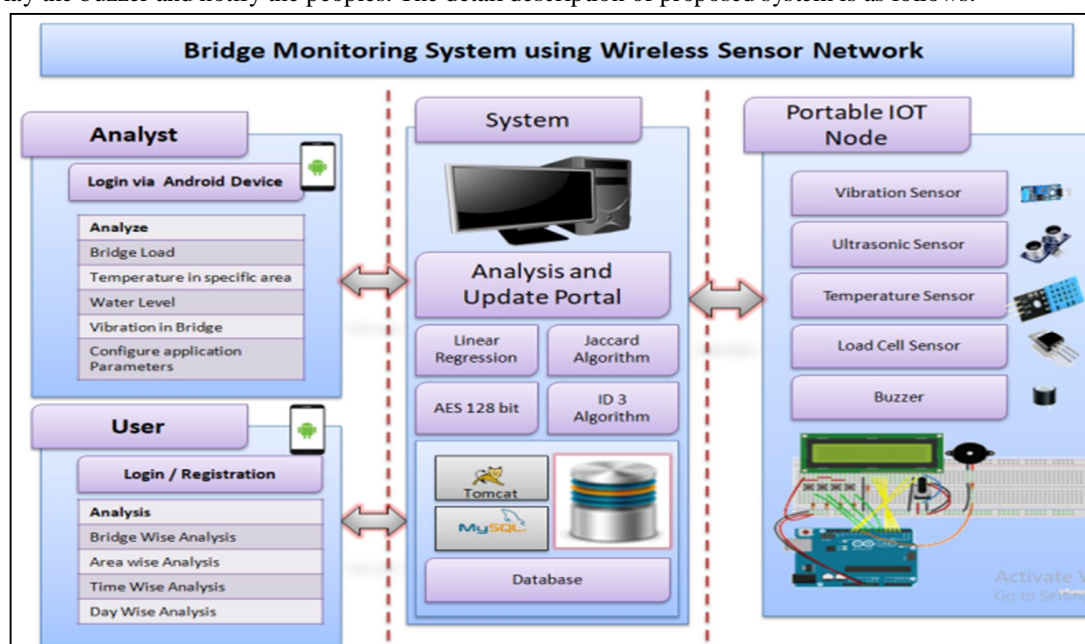


Fig 1 System Architecture



#### IV. ALGORITHM

##### A. AES algorithm

- 1) AES is based on a design principle known as a substitution-permutation network, and is fast in both software and hardware.. AES has a fixed block size of 128 bits, and a key size of 128 bits. By contrast, the Rijndael specification per it is specified with block and key sizes that may be any multiple of 32 bits, both with a minimum of 128 and a maximum of 256 bits.
- 2) AES operates on a 4×4 column-major order matrix of bytes, termed the state, although some versions of Rijndael have a larger block size and have additional columns in the state. Most AES calculations are done in a special finite field.
- 3) The key size used for an AES cipher specifies the number of repetitions of transformation rounds that convert the input, called the plaintext, into the final output, called the cipher text.
- 4) The numbers of cycles of repetition are as follows
- 5) 10 cycles of repetition for 128-bit keys.
- 6) The round is consists of several step .each step consists of four similar steps but all are different stages. It depends on encruption key ane reverse round is used to convert from cipher text to plain text.

##### B. ID 3 ((Iterative Dichotomiser 3) Algorithm

ID3 builds a decision tree Decision Tree is very simple model. It is widely known and used in many businesses to support decision making process and risk analysis. It is also one of legendary learning model which is heavily used in '60–80's to build expert systems. The leaf nodes of the decision tree contain the class name whereas a non-leaf node is a decision node. On each iteration of the algorithm, it iterates through every unused attribute of the set and calculates the entropy of that attribute. It then selects the attribute which has the smallest entropy (or largest information gain) value

- 1) Establish Classification Attribute.
- 2) Compute Classification Entropy.
- 3) For each attribute in R, calculate Information Gain using classification attribute.
- 4) Select Attribute with the highest gain to be the next Node in the tree (starting from the Root node).
- 5) Remove Node Attribute, creating reduced table RS. Repeat steps 3-5 until all attributes have been used, or the same classification value remains for all rows in the reduced table.

##### C. Mathematical Model

###### 1) Entropy

$$H(X) = - \sum_{i=1}^n p(x_i) \log_b p(x_i)$$

- 2) *Jaccard Algorithm*: The Jaccard algorithm measures similarity between finite sets, to avoid the computational overhead we will discard the similar readings of the sensors at the receiving end.

The following will return the jaccard similarity of two lists of numbers:

RETURN algo.similarity.jaccard ([1,2,3], [1,2,4,5])

##### D. Mathematical Model

$$S(A)=3 \quad S(B)=4$$

$$S(\text{jaccard}) = S(A)/S(A)+S(B) \quad A \cap B$$

Result-

0.4

#### V. WORKING

##### A. User Flow

Jsp page will send the data on java script page it will serialize the data and forward to controller it will grab the request and will extract the method.

It will convert forwarded data to key-value pair and invoke the method from server class. It will perform the function and return the response value on controller.

It will send converted data to java script page and it will view on user.jsp page.

## B. System Kit(Aurdino Wemos D1 & R1)-



Fig 2-Aurdino Wemos D1&R1

WEMOS D1 is a WIFI development board based on ESP8266 12E. The functioning is similar to that of NODEMCU, except that the hardware is built resembling Arduino UNO. The D1 board can be configured to work on Arduino environment using BOARDS MANAGER. The ESP8266 Wi-Fi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Response is not grabbed by esp8266 because it will only send data. Kit is connect with the different sensor like vibration sensor, ultrasonic sensor, load cell sensor, temperature sensor which can continually collect the data and send it on the server. On the collected data from sensors the kit can compute and if the resultant data shows emergency situation then it Gives alert by playing buzzer placed on the kit.

## VI. RESULTS

### A. Graph Result

- 1) Graph is used for show the analysis of data based on time wise analysis, Day wise analysis, and area wise analysis.
- 2) Graph is the simplest data structure to show the analysis data.

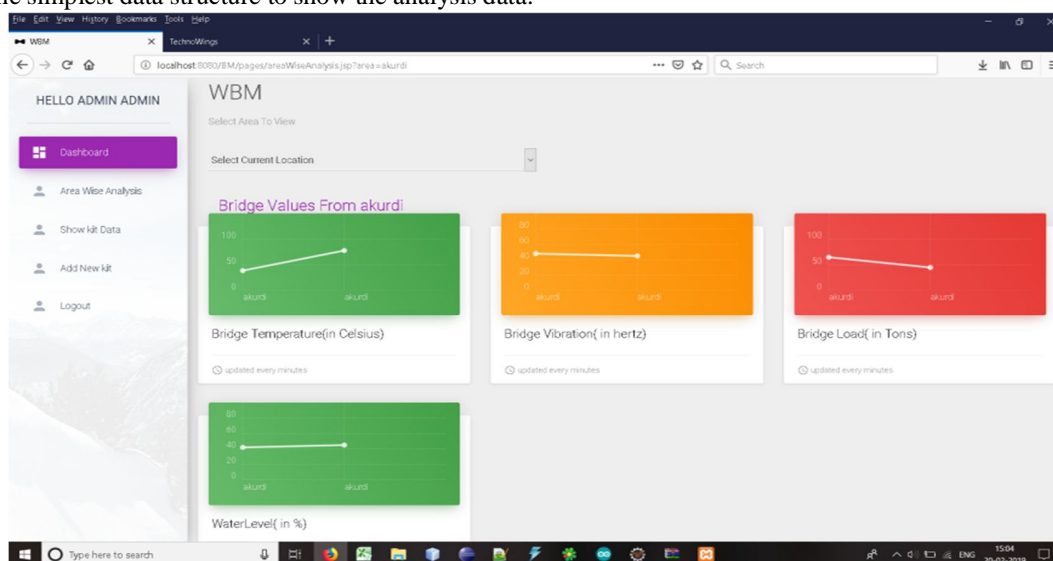


Fig 3-Graph Based Analysis Of Data

## B. Web Application

- 1) Web Application is built to show the real time bridge monitoring system analysis of data.
- 2) Web Application added area wise analysis, add new kit, show kit data.

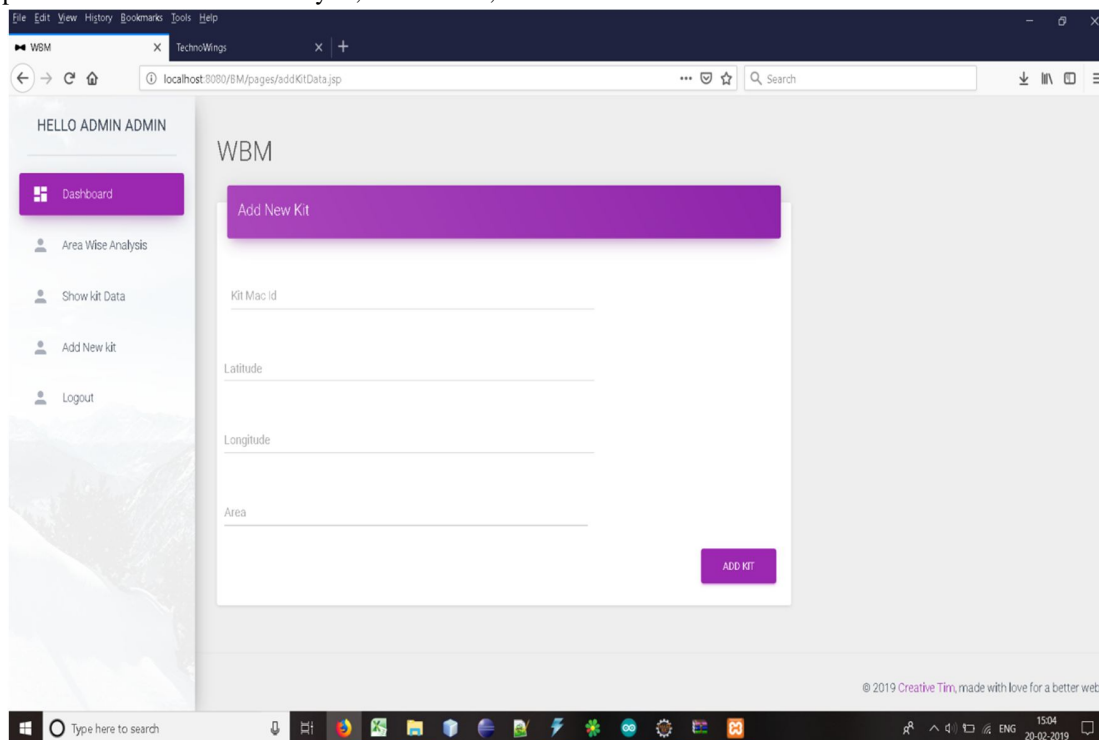
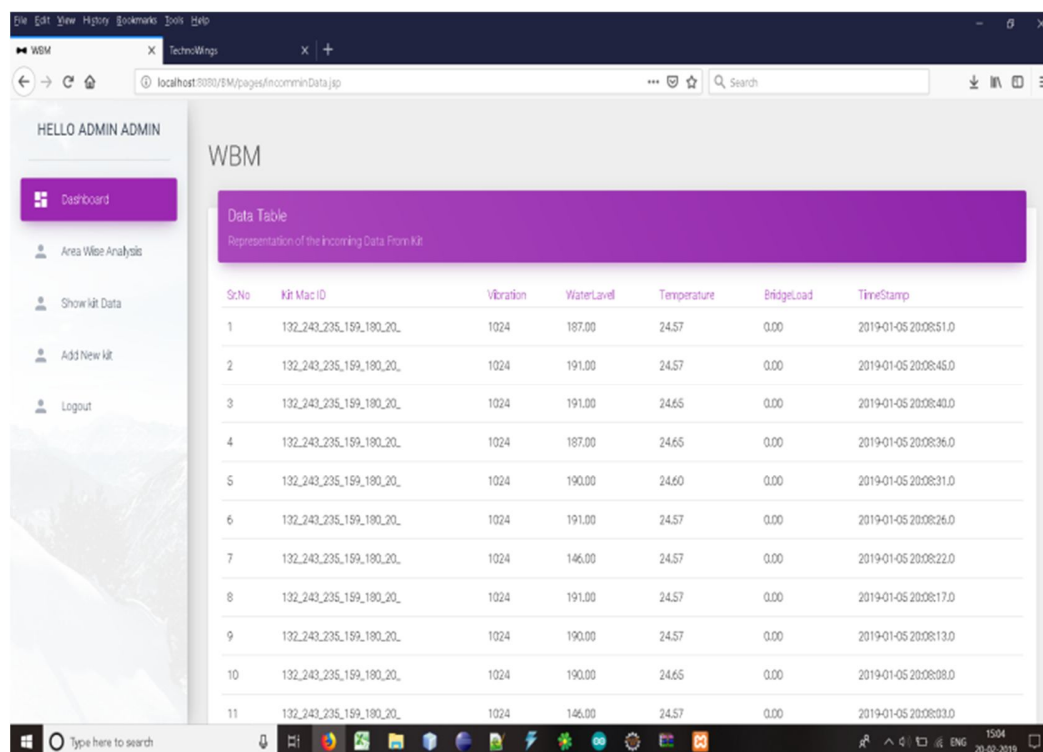


Fig 4-Web Application



The screenshot shows the same web browser window, but the URL is `localhost:8080/BM/pages/incomingData.jsp`. The main content area is titled "Data Table" and contains a table representing incoming data from a kit. The table has the following columns: Sr.No, Kit Mac ID, Vibration, WaterLevel, Temperature, BridgeLoad, and TimeStamp. The table contains 11 rows of data.

Sr.No	Kit Mac ID	Vibration	WaterLevel	Temperature	BridgeLoad	TimeStamp
1	132_243_235_159_180_20_	1024	187.00	24.57	0.00	2019-01-05 20:08:51.0
2	132_243_235_159_180_20_	1024	191.00	24.57	0.00	2019-01-05 20:08:45.0
3	132_243_235_159_180_20_	1024	191.00	24.65	0.00	2019-01-05 20:08:40.0
4	132_243_235_159_180_20_	1024	187.00	24.65	0.00	2019-01-05 20:08:36.0
5	132_243_235_159_180_20_	1024	190.00	24.60	0.00	2019-01-05 20:08:31.0
6	132_243_235_159_180_20_	1024	191.00	24.57	0.00	2019-01-05 20:08:26.0
7	132_243_235_159_180_20_	1024	146.00	24.57	0.00	2019-01-05 20:08:22.0
8	132_243_235_159_180_20_	1024	191.00	24.57	0.00	2019-01-05 20:08:17.0
9	132_243_235_159_180_20_	1024	190.00	24.57	0.00	2019-01-05 20:08:13.0
10	132_243_235_159_180_20_	1024	190.00	24.65	0.00	2019-01-05 20:08:08.0
11	132_243_235_159_180_20_	1024	146.00	24.57	0.00	2019-01-05 20:08:03.0

Fig 5- Data Table



### C. Android Application

- 1) After completing the graph result, we have to create android application. Android application to send the condition of the bridge structure to the people.
- 2) Java programming is used for completing and creating the android application.
- 3) Java is high level programming language, and write once, run anywhere.

## VII. DISCUSSION & CONCLUSION

Here we have discussed the different methods used by the researcher to monitor the bridge condition. Such a system will help to control the dynamic parameters of the bridge for preventing it from the disaster which can save the many lives and also wealth. This system is unique in its ability to monitor the bridge environment, transmit the environmental data through wireless communication and send alerts to the bridge management staff in real time for prompt reactions. This system can enable 24x7 bridge safety management as well as prompt and appropriate

Responses to emergency incidents.

The system continuously monitors the bridge parameter value and judges whether the bridge is safe or not for traveling. In case the parameter values are beyond the threshold values then an alert sound is given to the people. This implementation is greatly useful to provide safety for the human.

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