IOT based Bridge Safety Monitoring System

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ABSTRACT

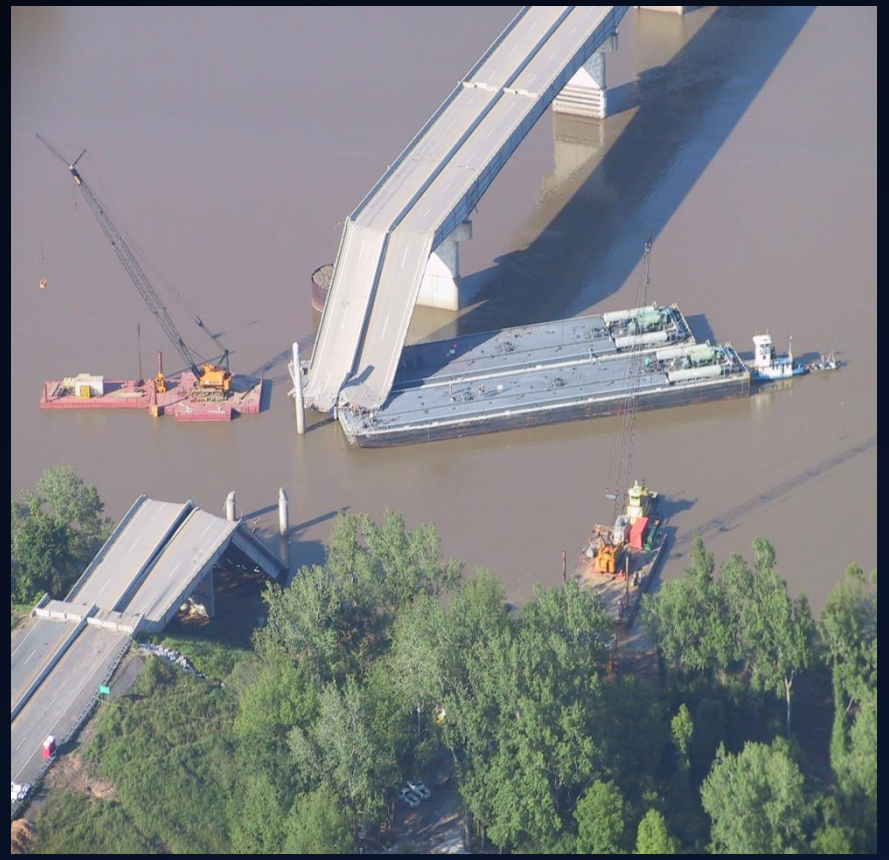
- Advancements in sensor technology have brought the automated real-time bridge health monitoring system.
- This system is composed of:
  - Monitoring devices installed in the bridge environment.
  - Communication devices connecting the bridge monitoring system and cloud based server.
  - A dynamic database that stores bridge condition data.
  - A cloud based server that calculates and analyzes data transmitted from the monitoring devices.

Keywords

- ✓ Bridge safety Monitoring
- ✓ Internet of Things (IoT)
- ✓ Flood Conditions
- ✓ Monitoring Centre
- ✓ TCP/IP
- ✓ WI-FI Module
- ✓ Sensors
- ✓ Data Analysis

INTRODUCTION

- Transportation plays a major role in today's life. In that bridge is one of the important transportation infrastructure for social and economic activities of country which has a long rivers.
- Now a day it is very essential to monitor, the bridges in our country or state as there were incidences happen earlier.
- The reason behind these incidents are as there is no such type of system, which will give information to the peoples if the bridge is not in good condition when sudden situations may occurs like flood, earthquake .



Introduction

- It means that the bridge is not in safe condition. When such situation arises, bridge may be collapse, which causes much kind of losses like accidents, human deaths, etc.
- This happens because there is no efficient system in existence, which will provide notification about conditions about current condition of bridge when bridge is not in safe mode.
- In the existing systems, Zig-Bee technology was used which is cost consuming and quite time consuming, but this system used the TCP/IP protocol which is suited for all types of bridges.

Introduction

- Therefore in this study, the IOT wireless sensor network and smart building technologies are adopted to solve the various problems of bridge safety information transmission and management.
- This is achieved by developing an IOT based bridge safety monitoring system capable of monitoring the environmental data of a bridge and transmitting the data to the mobile devices of bridge safety management staff for reference and documentation.
- The water level sensor is used through which system has to check manually the level of water. So for this the system is being developing an application in which everything is automated so less human efforts are required.

Introduction

- The system developed in this study can help to promote the advancements of bridge safety management.
- This system aims at developing an application that is useful for the people working at the bridge department or for bridge engineers.
- PROBLEM STATEMENT:

  To develop a pervasive system to monitor and sense the conditions of bridge and share this information with admin to generate the alert.

Objectives of the Bridge Monitoring System

- To provide safety for bridges.
- To avoid accidents in case of heavy rainfall.
- To improve the bridge efficiency.
- To overcome the technical and cost obstacles.
- To overcome the difficulties in manual monitoring of bridges.
- Alert during the unsafe conditions ,saves the life of people.

LITERATURE SURVEY

- A new cable-stayed bridge is currently under construction across the River Yamuna in Wazirabad, Delhi.
- The bridge will be equipped with a sophisticated structural health monitoring system, supplied by a joint venture of Mageba India, Mageba Switzerland and Vienna Consulting Engineers.
- The paper describes the purpose of the system and the requirements it will fulfill, and presents the general system layout, a description of the equipment and the technical solution for data transfer. A special focus is given to the subject of data management, which includes the archiving, analysis and presentation of the recorded data.

LITERATURE SURVEY

- With Japan facing the recent social infrastructure issue of aging infrastructure, NTT DATA developed a solution which remotely monitors bridges in real time to provide valuable information for maintaining bridge structures, and estimating the extent of structural fatigue.
- NTT DATA helped the company by implementing the bridge monitoring system- BRIMOS with the support of ODA (Official Development Assistance) and successfully took the first step to expanding market share in SouthEast Asia.
- The Cau Can Tho Bridge is a newly constructed bridge built over the Mekong Delta basin where the foundation is naturally very soft.

LITERATURE SURVEY

- The grant, entitled “A Remote Bridge Health Monitoring System Using Computational Simulation and GPS Sensor Data” is collaborative effort with Cranfield University, Railtrack, W S Atkins and Pell Freischman.
- The work focuses on using kinematic GPS to create and validate finite element models of bridges, allowing the deflections and vibrations of the structures to be analyzed for any uncharacteristic movements.
- The paper details the progress of the work to date, including the way in which the field data gathered and analyzed by the Nottingham group is used by the Cranfied Group in order to assess the quality of structures.

EXISTING METHODS

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

EXISTING METHODS

- Shivan Haran, et al. 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.

EXISTING METHODS

- Ren-Guey Lee et al. 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.

EXISTING METHODS

- 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, which increases the overall cost of installation and maintenance cost of health monitoring system.

PROPOSED METHOD

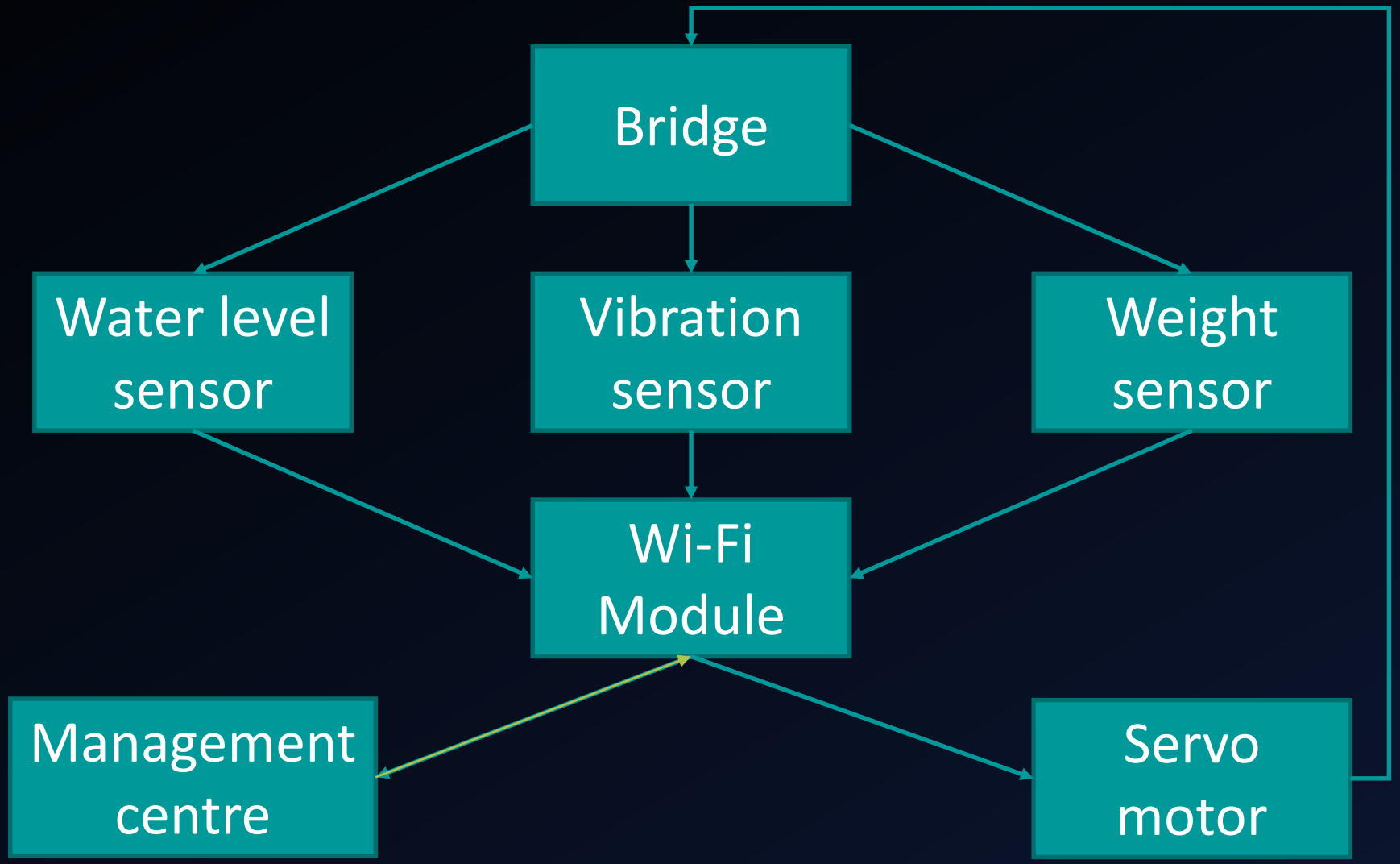
- The **WI-FI module** itself act as sever through which status of condition of bridge is transmitted to the monitoring Centre.
- The Monitoring devices like **water level sensor**, **vibration sensor** and **weight sensor** are continuously monitoring the structural health of bridge.
- If water level is increased or weight is too high and if bridge is being vibrated then barriers with **servomotor** will close and at the same time, status of bridge condition is directed to the **monitoring Centre**.

PROPOSED METHOD

- It has a technology called **MBM (Monitoring Based Maintenance)** that enables maintenance engineers to monitor the condition of the bridge in real time.

- The System includes the **web application** which is useful for the engineers working in the bridge department to monitor the current position of bridge.

DATAFLOW DIAGRAM



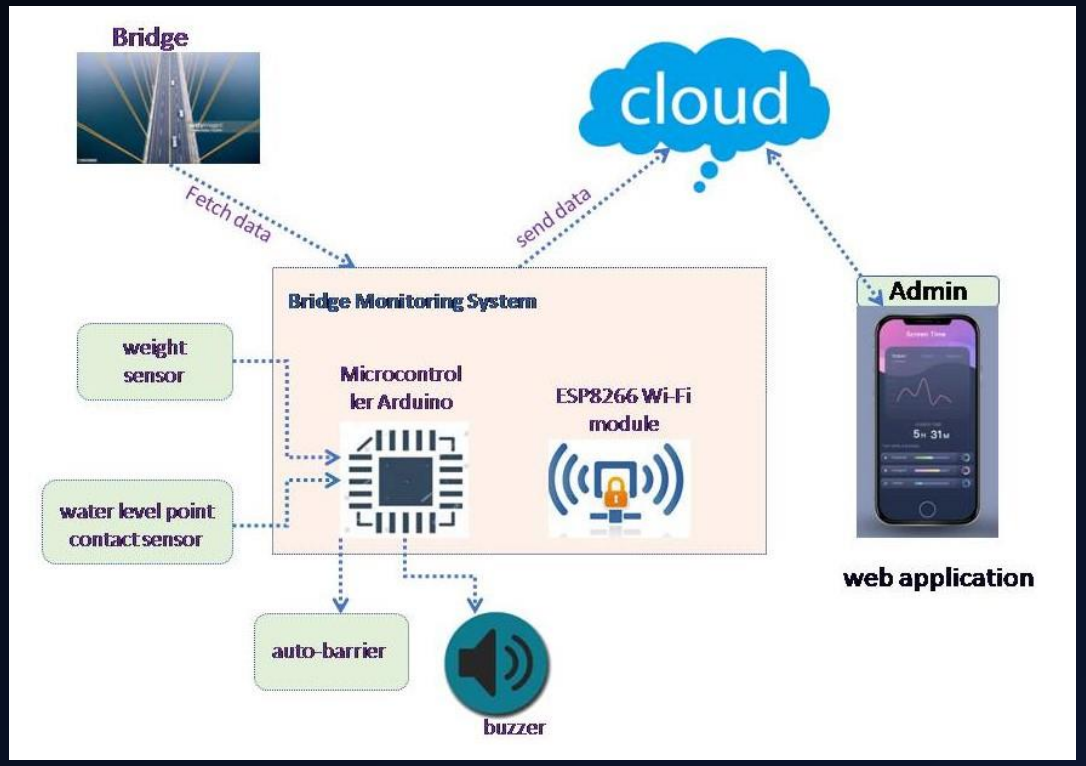
DESIGN

The methodology implemented includes:

1. Structural Design Components
2. WI-FI Module & TCP/IP protocol
3. IoT Components
4. Experimental Setup

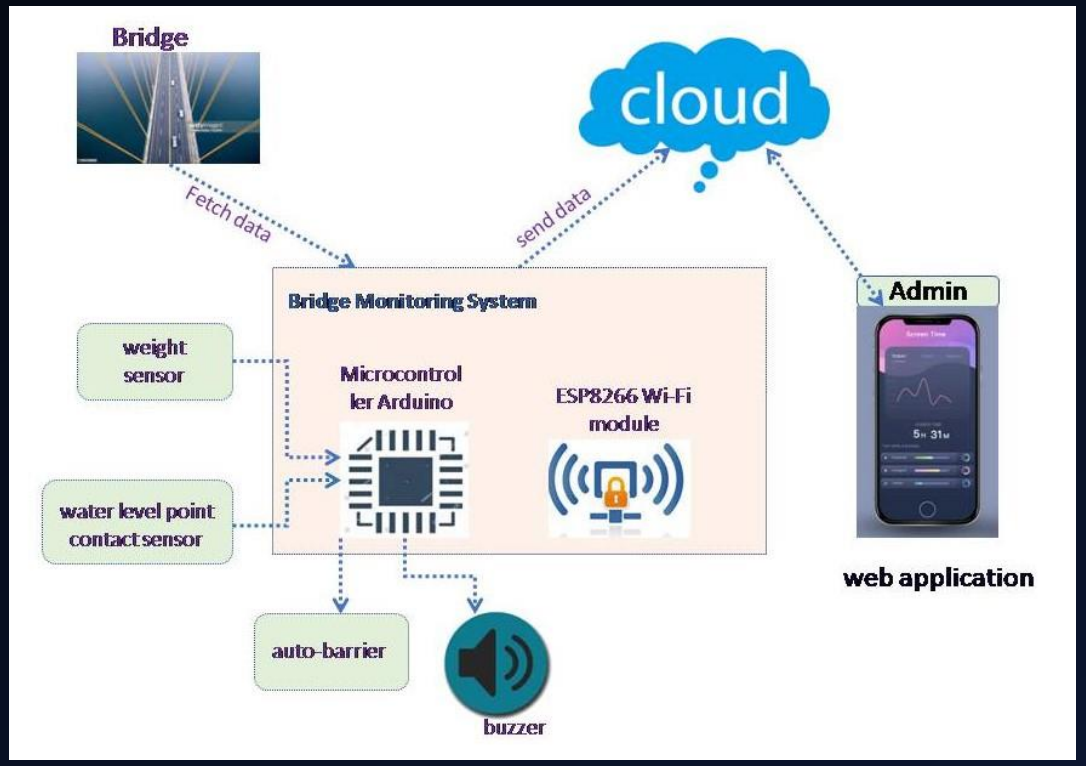
DESIGN - Structural Design Components

- Design of Vibration sensor, weight sensor and Water level sensor which is the Assembly of communicating devices.
- Ultrasonic sensor senses the water level.
- Vibration sensor detect the motion of bridge in case of Heavy wind and environmental parameters.
- Weight sensor detect the load of the bridge.
- The output value or status is collected on ESP8266.



DESIGN - WI-FI Module & TCP/IP protocol

- WI-FI module itself act as a server which is connected to the Nodemcu.
- Through WI-FI module the status or condition of bridge is transmitted to the monitoring Centre. This transmission is done through TCP/IP protocol in the form of packets.
- TCP/IP protocol is the transmission control protocol and internet protocol through which the transmission of data is easily possible without any interruption.



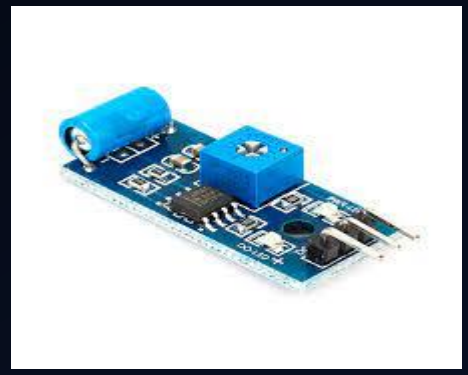
DESIGN - IoT Components

- **Sensor layer:**
  - The sensor layer leads to detect or collect all kind of necessary information from physical world like physical, identification, audio, video data.
- **Network layer:**
  - The network layer mainly responsible for transmitting data reliably and safely through wider and faster networks connections like TCP/IP.
- **Application layer:**
  - Application layer performs the function to support information coordination, sharing and interconnection across monitoring center and bridge.

IMPLEMENTATION – Hardware required

ESP8266 Nodemcu:
The ESP8266 is an micro controller which have the Inbuilt Wi-Fi module to Connect the device to internet. Esp8266 have 1 analog pin and 11 data pins to connect many sensors in an single system.

Water Level Sensor:
Ultrasonic Sensors use to detect the level of substances that can flow. These kinds of substances include liquids, slurries, granular material and powders. These measurements can be used to determine the amount of materials within a closed container or the flow of water in open channels.



Vibration Sensor:
Vibration sensor is use for measuring, displaying, and analyzing linear velocity, displacement and proximity, or acceleration.

IMPLEMENTATION – Hardware required

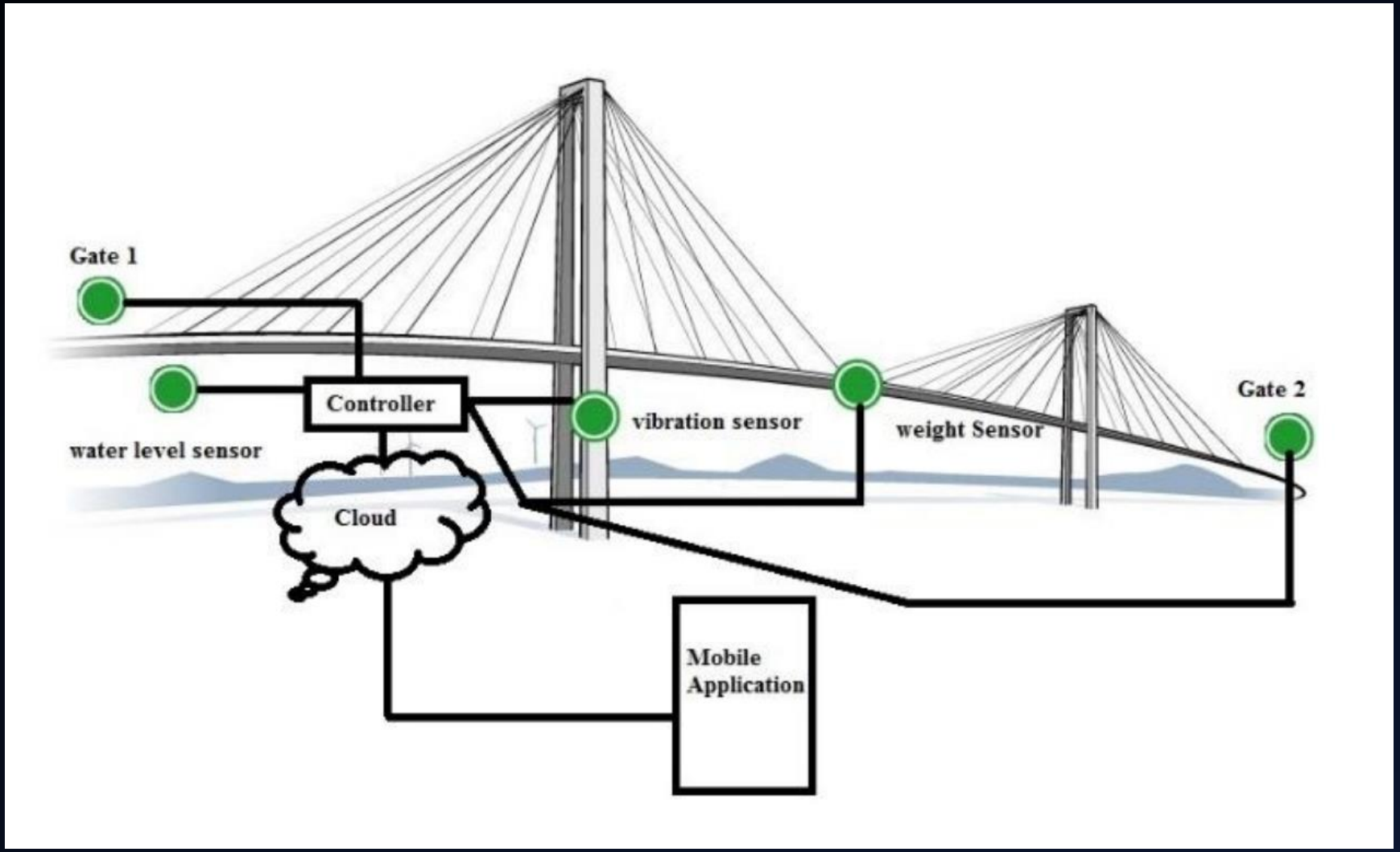
Weight sensor:

The HX711 Load Cell Amplifier Module is uses 24 high-precision ADC converter chip hx711, is meant for high-precision electronic scale and style , with two analog input channel, the interior programmable gain amplifier was integrated with multiplier 128.HX711 uses a two wire interface (Clock and Data) for communication.

Servomotor :

A servomotor may be a simple motor ,controlled with the assistance of servomechanism. the motor as a controlled device, related to servo mechanism is DC motor, then it's commonly referred to as a DC Servo Motor. If AC operates the controlled motor, it's referred to as a AC Servo Motor.

EXPERIMENTAL SETUP



Algorithm Details

- Declare the variables Loads and Vibration and waterLevel as input.
- Declare stepper as output.
- Initialize ESP8266 Nodemcu.
- Initialize GSM.
- If maximum load is detected using weight sensor then stepper motor should close the gate.

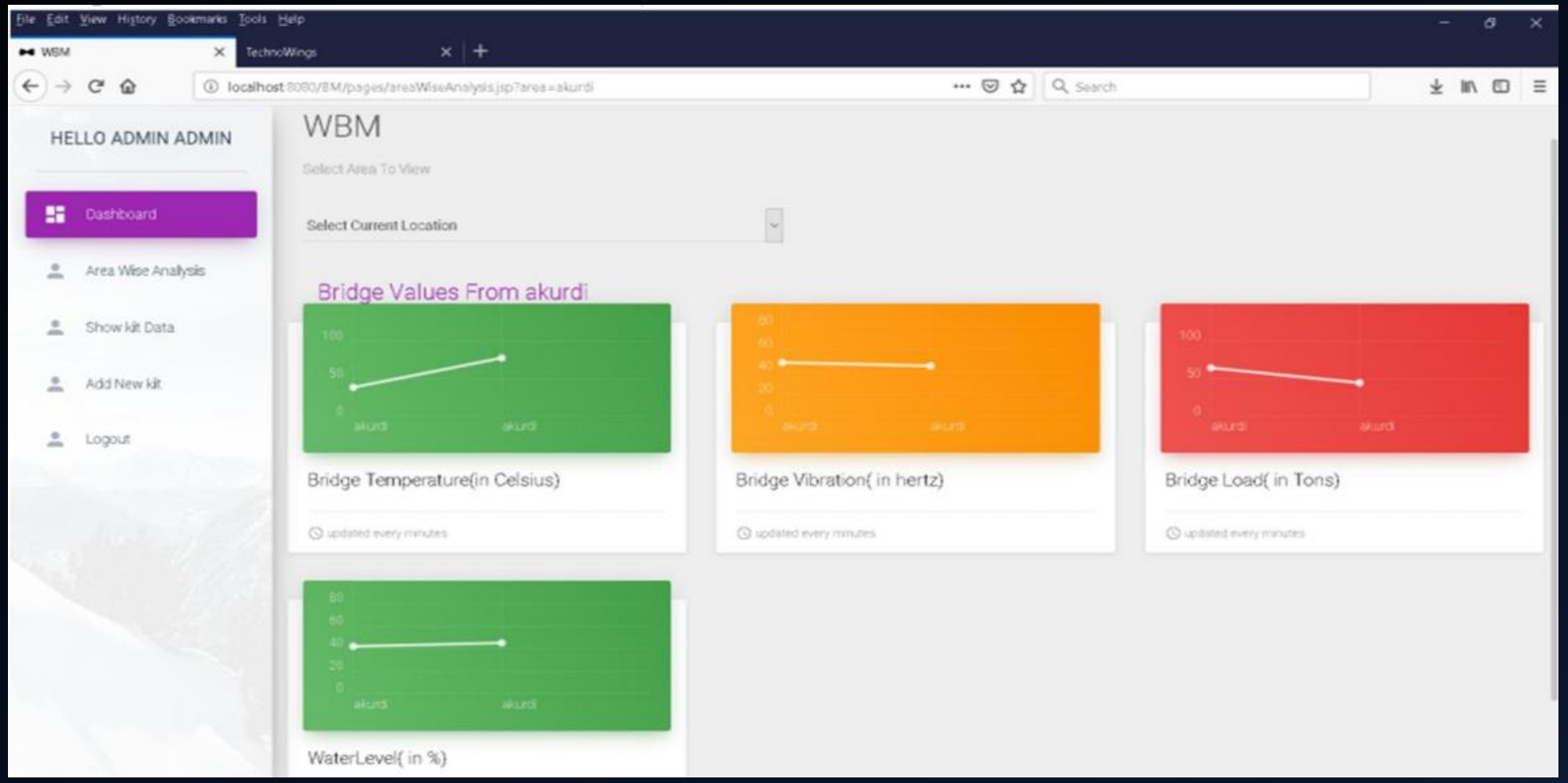
Algorithm Details

- If the vibration sensor reaches the maximum threshold then send message to monitor house. The gate is closed and opened once we get message from the monitor house.
- Water level sensor senses water level and once the water level crossed the maximum threshold then the gate is closed.
- The readings are sent to database and update in web application.
- Notify required authorities.

RESULTS

- Graph Result
  - Graph is used for show the analysis of data based on time wise analysis, Day wise analysis, and area wise analysis.
  - Graph is the simplest data structure to show the analysis data.
- Web Application
  - Web Application is built to show the real time bridge monitoring system analysis of data.
  - Web Application added area wise analysis, add new kit, show kit data.

RESULTS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Bridge Load(in Tons)
updated every minutes
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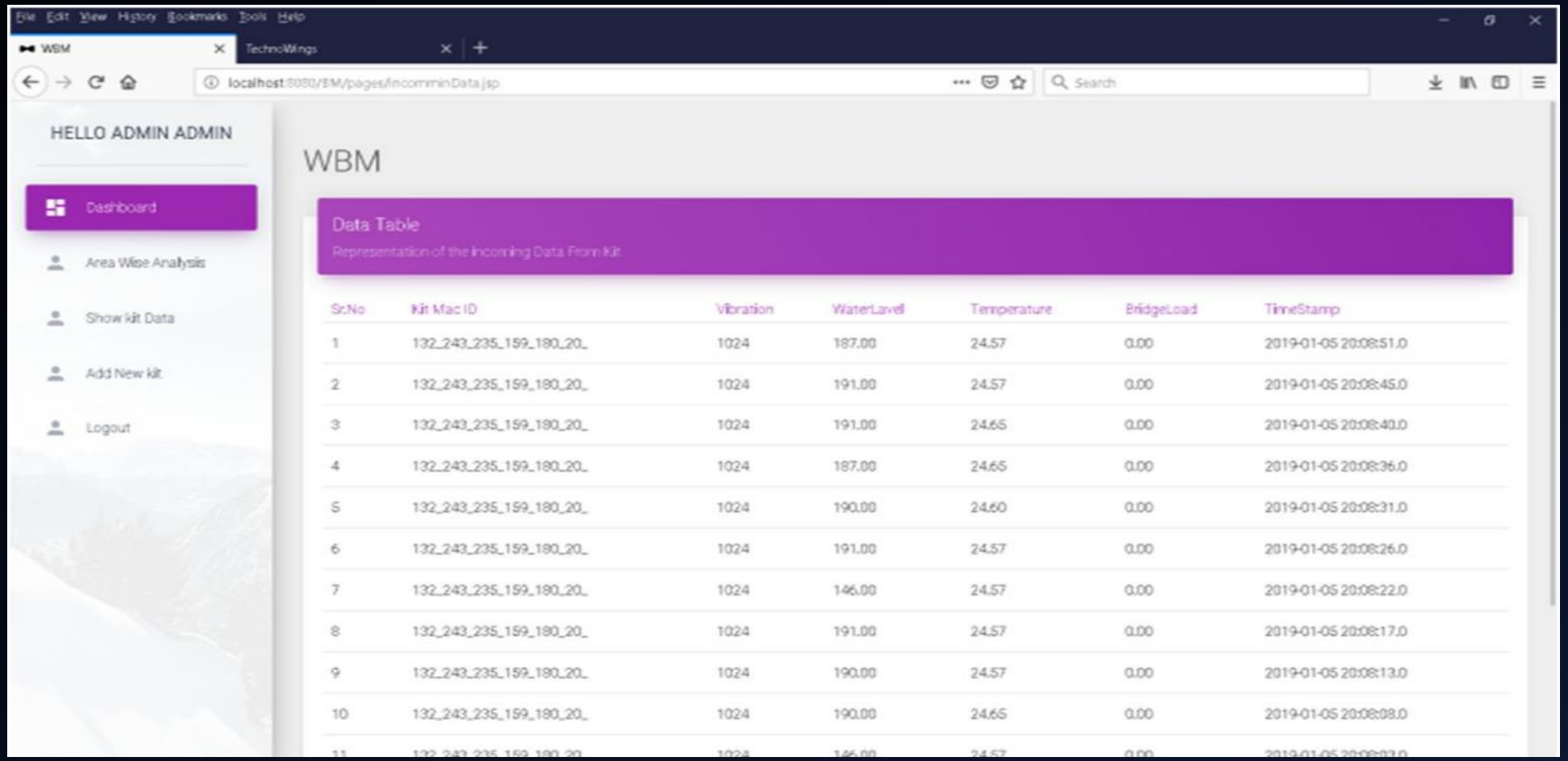
RESULTS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CONCLUSION

- Bridge health condition monitoring in real time has been popular issue. The sensor technology is continuously advancing and condition monitoring has never been accurate and easier before.
- This system checks the water level and the position of bridge for safety purpose.
- In the emergency conditions like earthquake, flood, etc. the facility of broadcasting the message is added

CONCLUSION

- This System is unique in its ability to monitor the bridge environment, it transmits environmental data through wireless communication and sends alerts to the bridge management staff i.e. Monitoring Centre in real time for prompt action also to user's.
- The system continuously monitors the bridge parameter value and judges whether the bridge is safe or not for traveling.
- The main aim of Bridge Monitoring System is to save the lives of the people, to protect from accident.

FUTURE ENHANCEMENT

- In future this system can be extended to perform additional activities like recording vibrations at the foot of the bridge using ses70 sensor.
- Use tilt sensor along the bridge and warn if there is any aberration.
- Use anemometer to measure wind speed and warn about hurricane or typhoon.
- Implementation of LCD projection on the bridge used to indicate critical conditions for people near the bridge.

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THANK YOU