IoT based smart ferry system

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Abstract. This research work discusses an IoT based smart ferry system. The proposed system is implemented in NODE Red based simulations. Each component is considered as nodes and analysis is done. The technical process is explained with the help of a flowchart. And how the information is passed on to the sailors, ferry crew, ferry operators, ferry controllers and maintenance engineer is discussed. In addition it is displayed using the Node red dashboard as well as through ThingSpeak cloud server for further analysis. The proposed idea is to build an IoT infrastructure consisting of smart devices which will measure different attributes of a boat and notify the captain or the rescue team of the difficulties or the problem faced by the boat during a trip. The monitoring system is based on open source software to retrieve data from the sensors at intervals and send them to the cloud in order to easily monitor them via a dashboard. Fully automated and robust IOT enabled smart devices are developed to collect the data from the boat. The Data to measure the weight and passenger on board is collected by Weight Sensor and IR Sensor and the Captain of the Ship is notified for the same. Temperature of the engine room is monitored and under severe circumstances the rescue team is notified for the same. The wind speed is also monitored in case of stormy conditions.

1. Introduction

Waterways, plays a very important role in transportation sector because of its economical viable and higher accessibility. It creates a high demand for conveyance of articles, goods and passenger through water transport. Nevertheless, water transport has become very susceptible owing to the lack of hi-tech adoption, absence of care and appropriate infrastructure facilities to uphold and monitor the waterways vehicles such as ships, cargo and passenger vessels and ferries [1]. As a consequence, accidents have become a regular occurrence in the waterways. In the past few years, the accident cases are increasing. The major reasons behind the accidents are overloading, collision, and natural disasters like storms and cyclones. To ensure the vehicle safety, the vehicles should avoid overloading passengers, must be taken under regular maintenance. Above all, there must be enough preventive measures taken to safeguard passengers and goods from natural calamities, overloading, instability and collisions. Thus, the vehicles in the waterways should have a system that comprises of various sensors which usually helps in monitoring different parameters of the vehicles like passenger on board, total weight on board, speed of the boat, wind speed, various parameters which are essential to monitor the engine, location of the vehicle, weather conditions, etc. to avoid problematic situations. The data is sensed by the sensors and sent for further data processing and storing. The cloud server will then analyses the collated data and send notification about the issue to the concern authorities. The Internet of Things (IoT) is an ecosystem where massive number of objects or “things” interconnected through network and embedded with sensors, software programs, electronics components and other technologies. They
are interconnected to communicate information among themselves. The features of IoT are shown in Figure 1. They are allotted with unique identification number through data provisioning and have the ability to collect and exchange data over a network without requiring any human intervention [2, 3]. A major branch of smart city is smart transportation. Problems such as traffic congestion, road safety, accident detection, automatic fare collection and limited car parking facilities can be resolved by IoT which is proposed in [4],[5]. Same kind of smart water transport is also possible to implement with the help of IoT. The earlier research is carried out to give the current weather conditions, overloading conditions and tracking of the position of the launch [6]. The radio frequency identification and Near Field Communication technologies are very much useful for secured IoT scenarios and its applications [7]. A systemic hazard analysis and management process for the concept design phase of an autonomous vessel is proposed in [8]. Hence, IoT helps in communicating among various devices through communication protocols which is referred to as smart things or smart system. Machine-To-Machine (M2M) technology is a subset of IoT [9]. In M2M technology the smart objects or smart system interact and perform their tasks without any human interaction. The devices connected to IoT are capable of taking smart decisions based on the analytics. This is helpful in predictive maintenance of the system which is very useful in industrial applications [9],[10],[11].

![Figure 1. Features OfIoT](image)

M2M communication technology enables millions of devices to interact and talk to each other. A wide range of context and environment sensors are collecting data. M2M applications are basically used for the purpose of monitoring environment, monitoring self-driven cars, ATM, smart meters and many more. M2M is also useful in tracking things, block chain technology and wearable technologies. On connecting multiple devices via M2M network instead of data exchange through the cloud, an alert about the current status of the ferry can be sent to the captain and the rescue team simultaneously. In this article, smart ferry system is proposed and it is implemented in the Node Red platform and data analysis is performed in ThingSpeak. Finally dashboard visualization is presented in both ThingSpeak and Node Red.

2. Design of the proposed system

2.1 Block Diagram
The block diagram of the proposed smart ferry system is shown in Figure.2 which includes a temperature sensor, IR sensor, load cell, HX711 ADC, Wi-Fi module, wind sensor, Arduino controller board, and power supply. The gist of the IoT based model is explained via the help of the block diagram. It explains the use of microcontroller as well as culmination of the sensors used for monitoring. The SFS is controlled via an Arduino. A ESP8266 module (Wi-Fi Module) is the cheapest module for connecting the Arduino to the internet. The output is displayed on the node red dashboard for the users to help with System Monitoring.
2.2 Algorithm for the proposed SFS

The algorithm adopted for monitoring the smart SFS system is depicted in the flowchart shown Figure 3. The ferry is fitted with SFS consists a host of sensors consisting of weight sensors, IR sensor, temperature sensor, wind sensor. This set up helps in collecting the data of all the on-board passengers and the technical difficulties the boat may be facing in the Engine Room. The relevant information helps us in keeping a track on the on-board weight, passenger on board, temperature on the engine room and the wind speed. Approximately, a ferry can carry a maximum of 3500 kg of weight and on an average of 55 passengers per trip. The temperature inside the engine room should not be more than the atmospheric temperature +10°C and the speed of wind above 20m/s is considered for critical for ferry. With the help of the proposed system, if the on-board weight on the ferry becomes greater than 3500 or the total number of passenger count goes above 55, the captain will get a notification to stop the boarding. By this we could avoid the major problem of overloading on a ship. Ideally, the Engine Room temperature should not exceed 10°C above the ambient temperature. For example, if it’s a 32°C Day and the engine room temperature cannot be above 42°C. If such condition is not met, then rescue team will be notified. Similarly, if the wind speed increases above the critical level set by the SFS the rescue team will get a notification of the same and will perform rescue. The gist of the IoT based model is explained with the help of the block diagram shown in Figure 2. It explains the use of microcontroller as well as culmination of the sensors used for monitoring. The SFS is controlled via an Arduino. An ESP8266 module (Wi-Fi Module) is the cheapest module used for connecting the Arduino to the internet. The output is displayed on the node red dashboard for the users to help with System Monitoring.
2.3 Various physical devices required to implement the set up

Various physical sensors and controllers which are required for the real time implementation of the proposed system. The components are shown and description is given in Figures 4 to Figure 10.

2.3.1 Load cell
The load cell converts weight into an electrical signal. Load cell is then connected to HX711 ADC which receives the signal.

![Load cell](image)

**Figure 4.** Load cell

2.3.2 Arduino UNO
The Arduino UNO microcontroller as shown in Figure 5 acts as the main processing unit to gather inputs from the sensor calibrate their readings and feed them to the Wi-Fi module which is connected to the internet. It also acts as a pathway to deliver power to the sensors and the Wi-Fi module.
2.3.3 WiFi Module (ESP8266)
The Arduino needs a pathway to the internet to upload the readings of the input sensors on the internet server. The WiFi module ESP8266 makes use of Internet Protocol (IP) to connect the circuit to the internet and transmit the sensor readings to the online IoT server.

2.3.4 HX711 ADC
HX711 depicted in Figure 7 is an analog to digital converter chip with amplifier included and it send the measured data from load cell to the microcontroller.

2.3.5 Temperature Sensor (DHT11)
The temperature sensor as shown in Figure 8 will provide the temperature inside the engine room.

2.3.6 Wind sensor
The Wind Sensor shown in Figure 9 is used to determine the wind speed around the vessel.
2.3.7 IR Sensor

IR sensor depicted in Figure. 10 is used to keep a count on the total number of passengers on board.

3. The Proposed Smart Ferry System Design

The proposed IOT based smart ferry system is implemented in Node Red and verified. Node Red is a flow-based programming tool which helps to connect various nodes to achieve particular task. It utilizes the set of node palettes and flows which help to make simple code that can be connected to APIs, hardware, or online services. A node is a predefined code block. A flow is a connection of nodes, usually an input, processing, and output node. Node Red can be installed and run locally in our computer system, in a device like a Raspberry Pi, or in the cloud. The analysis can be performed locally or in the remote server based on cloud. It is an easy way to interface a real time application and visualize the data movement instead of writing lengthy programs.

3.1 Node – Red Flow design for SFS

In this work, visualizing the process and monitoring status of each ferry on the basis of sensor data gathered in node red platform. The node red flow for weight and IR sensor is shown in Figure 11. The flow consists of a inject node for weight sensor to generate random values between 3000 and 4000. If the value is greater than 3500 it shall set a new condition labelling “Maximum Capacity Reached” and also send an alert to the Captain.

A inject node for IR sensor us used to generate random values between 50 and 60. If the value is greater than 55 it shell set a new condition labelling “Maximum Passenger Capacity Reaches” and also send an alert to the Captain.
Node Red flow for temperature and wind sensor is depicted in Figure 12. A inject node for temperature sensor us used to generate random values between 35 and 60. If the value is greater than 50 it shell set a new condition labelling “Temperature Above Critical Level” and also send an alert to the Rescue Team. A inject node for Wind sensor us used to generate random values between 15 and 30. If the value is greater than 20 it shell set a new condition labelling “Wind Speed Above Critical Level” and also send an alert to the Rescue Team.

ThingSpeak node is used to collect the real time data from the temperature and wind sensor and it can also be used as a dashboard. The data stored in ThingSpeak can further be downloaded for data mining purposes. Figure 13 shows the Node Red flow for Sending Notification to the Captain and Rescue Team.

### 3.2 Dashboard of the proposed system

The SFS is executed using a combination of sensor to measure values for temperature, wind, weight and passenger count. Using the function node to configure the settings, if the weight is more than the maximum weight for safe travel the captain is notified. Similarly, if the passenger count goes above the limit set in the program the captain will be notified. If safety conditions are met the captain can commence his journey. This will insure safety of the passengers and avoid overloading.
Node Red Dashboard for weight and IR sensor is shown in Figure 14. If the temperature and wind speed values are greater than the critical value then the rescue team will be notified of the situation. This will ensure the safety of both passengers and ferry under problematic circumstances.

Node Red Dashboard for Temperature and Wind sensor is depicted in Figure 15 and ThingSpeak dashboard is shown in Figure 16. The ThingSpeak Cloud Platform can act as both dashboard and a cloud server. The data uploaded on ThingSpeak or any other cloud server can be stored and used for further research purposes in water transportation system.
4. Advantages and summary of IoT based Smart Ferry System

With SFS, every passenger vessel and goods vessel in water is under SFS’s network coverage area. The SFS monitoring and control system will be installed in every vehicle and send the sensed data to the application server at a particular interval by which the status of the vehicle will be always be known. Thus SFS is expected to have foreseeable impacts on the safety measures in the water transport system. Some of them are mentioned below [6]. The vehicle in water is contentiously monitored with the help of the sensors and various data is sent for analysis to the cloud server. The total weight and the number of passengers on board is continuously monitored and the same data is sent to the captain and the respective authorities.

As the vehicle status will always be known, passengers overloading will be reported immediately and the possibility of occurrence of accidents due to overweight will reduce. The rescue team will be monitoring the vehicle throughout the journey, in case of any emergency or accident the rescue team will be able to act much faster as it will beforehand know the problem and this will help in avoiding to any major loss of lives or property. Enhancing the safety in the waterways will lead to increase in use of this mode of transport.

5. Research scope and conclusion

The proposed IOT based Smart ferry system is implemented in Node red—a flow based programming software where the sensor nodes are similar to the physical sensors, function nodes are used to model like the programming controllers and dashboard nodes are similar to the display screens which is conveyed to the technical team such as ferry operators, ferry crew and ferry controllers through apps. Thus the proposed system is verified with the help of the simulation based results. The same can be implemented in real time as well. The model is simple and easy to implement and ensures safety of the people. The system easily detects abnormal conditions in and out of the vehicle moving in the water. In case of an emergency the rescue team can take actions immediately. This smart ferry system not only ensures the safe travel but also makes the water transport system a joyful and reliable one. This paper has considered very few aspects in inland water ways. Further research can be extended in water transport to ensure safety of the passengers and the boat. As there is vast development in 5G spectrum, 5G or even 6G can be used for faster upload or communication with the cloud. GPS can also be added to ensure easy navigation; it will not only help in navigation but also help the rescue team to locate the vehicle in case of emergency. In case of high traffic, it will help in determining the fastest route. Further we can add Machine Learning and Deep Learning to predict the weather pattern around the ferry and also the engine life by considering various parameters of the engine.

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