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Real Time Condition Monitoring of Pipeline Network

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Abstract: ***This paper presents the technique for resolving the issue based on monitoring of the large pipeline network. Here we propose the system which monitors the pipeline network using computerized and mobile device system which helps incorporating multiple sensing parameters that measure pressure, temperature, humidity and vibration, for condition monitoring of long pipes. The information of the innovation policy of the pipeline monitoring plays very crucial role in building in robust network and easy accessibility of the system. Considerable attention is paid to the identification of the key problems faced by the on ground and underground pipelines. The paper presents a comprehensive assessment of the results by the sensors used such as DHT11, BMP180 and accelerometer. This paper presents the need to extend the functionality of currently available systems for condition monitoring rather than limited to leak detection. It is necessary to use the robust networks and to get easy access of the system so that the system may get available to the people from workers to the management level.***

Keywords: computerised monitoring, pipelines, wireless sensor network, temperature, humidity, vibration, pressure.

I. INTRODUCTION

The condition monitoring of pipelines is a top consideration for governments, due to the potential for severe economic damage. A pipeline network can be underground or underwater, therefore the maintenance and repair of these pipelines is very expensive. Hence, cost- effective and efficient methods have to be used for condition monitoring of underground and underwater pipes. Environmental factors such as natural disasters and weather changes result in the extension and contraction of pipelines, which may cause the pipelines to burst. Therefore, we can detect potential damage to the pipeline, at an early stage by monitoring these parameters in real-time. This type of condition monitoring for long pipelines is cost-effective and reduces the waste of economically significant resources.

The Sates Environmental Protection Agency (EPA) surveyed that the estimated investment in water utilities required for the next 20 years (2003-2023) to install, upgrade or replace water infrastructure will cost about $US277billion dollars. Due to damage in water pipelines, approximately 3281 mega litres of water was wasted in the United Kingdom from 2009-2010. In addition, leakage in gas pipelines can result in explosions where water leaks are less life-threatening, but still cause financial losses and environmental damage.

The condition monitoring of long pipelines requires multiple sensors, interfaced to a microcontroller that can send alert

signals when the condition of the pipeline becomes progressively worse. The arrangement of sensors is around the circumference of pipes for detecting corrosion, which causes leaks. Several systems have been proposed to detect damages in a pipeline, but these systems fail to monitor the conditions that cause the leak in the first place. The method developed in this projector to monitor the parameters can detect worsening conditions of a section of a long pipeline, at early stage.

II. Related Work

Starting from existing system [1] considered the basic architecture of pipeline sensor system. The system now a days is not automotive and thus it is time consuming and expensive. The existing system use different expensive components that can sense the multiple parameters at a time. The PIPENET [2] refer the automation of sensor network and importance of real time operation. In pipeline monitoring system pipe play very important role, so intelligent System for condition monitoring of underground pipelines [3] consider underground pipeline, failure of CCTV, ultrasonic and laser Network, Hybrid Intelligence System for data mining. An Integrated System for Pipeline Condition Monitoring [4] analysis Distributed Sensor networks, Vertical /horizontal ground movement, Effect of Pressure and their overall effect on different type of pipeline.

The environment and sustainable development [5] consider the composite gas pipe and different limits for gas pipelines and propose the details about composite pipeline. We also visited the onsite project to analysis the actual existing monitoring system.

III. Implementation Details

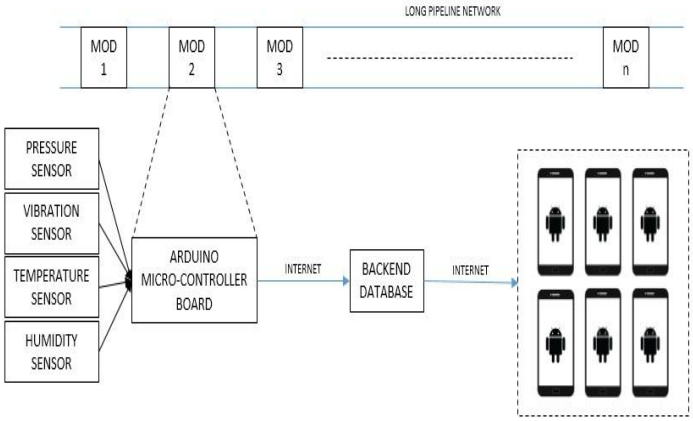


Fig.1. System Architecture

The above figure 1 shows the system architecture of project. N number of modules can be placed on a long pipeline. Each module consists of various components like Arduino board, various types of sensor, Ethernet cable & Ethernet shield. Each module is integrated as follows:

The main Arduino Uno board is the base of each module, all the sensors are connected on to the board via cables and power supply is given by using batteries to each module. There are 4 types of sensors used:

1. Temperature Sensor
2. Humidity Sensor
3. Vibration Sensor
4. Pressure Sensor

Each sensor will be programmed and mounted onto the Arduino Uno board .Each module will be connected to internet via the Ethernet cable. All the collected readings will be stored in the database and the logs will be maintained on the basis of per 2hours. All the readings and push notification will be displayed on 'Android Application' on user smart phone.

This project is divided into two parts: 1) Hardware implementation of nodes. 2) Wireless communication between nodes like mobiles via android application and formation of wireless sensor networks. The initial stage will connect all the sensors with Arduino Uno board using connecting wires and breadboard. This project will utilize the open-source environment provided by Arduino for embedded system development & embedded system programming and also sensors which are compatible with Arduino for wireless communication. The system will include an android application through which the readings will be taken on the android smart phones.

- **Modules**

The proposed system is divided into following four modules:

1. Sensing Unit:

This module will be designed for sensing all the external parameters which are affecting to the pipe. It will include all the sensing components like DHT11 (for temperature and humidity), BMP180 (pressure sensing) and also an ADXL335 (for vibration sensing). With the help of libraries and header files defined by the companies, all these components will be programmed using embedded C to analyze the situation outside the pipe. If the external parameters of the pipe will exceed its limits which are predefined (for temperature limit will be 30 degree Celsius, for pressure limit will be 50 Pascal's, for vibration any changes onto the X-axis and Y-axis and for humidity limit will be 80% depending upon regional conditions with respect to air), then the push notification will be directly sent onto the developed android application.

2. Sensor Processing Unit:

The sensor processing module will be developed to process the data which is generated in the sensing unit. The actual values and predefined values in the program are compared with the formulae and methods like,

Return (RAD_TO_DEG * (atan2 (-yAng, -zAng) + PI));

It uses the functionalities supported by Ethernet board using Arduino defined "Ethernet.h" library file. The methods and functions used from this library file are Ethernet.server, server.start, Ethernet.client, client.start. The Arduino acts as a client and post the sensing data and flags on the PHP page that acts as an intermediate between Arduino and online database system.

3. Data Processing Unit:

This module will be consisting of the database connectivity and maintaining the logs. The database which we will be using is from Go-Daddy domain. There will be a PHP page which will act as a mediator between the Arduino Uno board and database. The PHP page will extract all the readings from the Arduino board and it will give it to the database. The readings will be stored in the database and if any kind of alert are detected it's time, date and location will be stored and maintained as a log. The logs will be maintained so that it will be accessed whenever required.

4. Display Module:

This module will consist of Android Application which will provide interactive GUI. The login privileges will be given on 2 aspects that are Manager and Employee.

The manager will have access to whole system and also the push notifications in the form of ALERTS will be to the manager whenever manager is logged in. If any kind of alerts are detected, the manager will check what kind of alert it is and also the location of the alert and it will assign that job to particular employee who is specified for that area and also for recovering the detected alert. Once the job is assigned to employee, the manager will just keep the track of the work. Once the work is done by the employee, manager will be able to see the progress of work that is whether it pending or completed.

The employee will not have access to the whole system but whenever a job for that particular employee is to be given; the employee needs to log in & the system will send the push notification specifying the kind of alert and location of alert. And once the work is done by the employee, the progress will be maintained by the manager. Once the employee completes the work, he/she will notify the manager that the work is completed by him/her.

IV. EXPERIMENTAL SETUP

The following are the hardware and software requirements for the proposed system:

- HARDWARE REQUIREMENTS:

1. Arduino Microcontroller-ATmega328
2. DTH11 Sensors
3. BMP180 Sensors.
4. Accelerometer Sensor.
5. Ethernet Shield- Wiznet W5100 Ethernet Chip
6. REES52 Premium USB AB Cable
7. RI193 Jumper Wires

- SOFTWARE REQUIREMENTS:

1. Arduino IDE
2. JDK- Eclipse
3. Database- MySQL

V. DATASET

The values from the sensors are a part of the dataset. The maximum range of the DTH11, BMP180, Accelerometer sensor are 30 degree Celsius, 1000 Pascals, 50 degrees respectively. The blind spot for the DTH11 sensors is 2 degree Celsius. The database has entries for the readings from the sensors as well as the entries are made for the employees and manager. Specific areas are entered for detection of the damage at particular area.

VI. EXPERIMENTAL RESULTS

In experimental result we get the following results which consume less memory and required less time as compare to existing system which are shown by figure. To get this result first we read humidity, temperature then we read the x, y, z value for accelerometer and pressure. The difference between applied and absolute is calculated. If difference is more than zero return difference value otherwise return zero. If humid is more than 70% set humidity alert otherwise return zero. Convert the read values to degrees -90 to 90 and calculate 360deg values. If the checked temperature is more than 30 degree Celsius then set temperature alerts. Check humidity if it is more than 70% then set humidity alert, Check vibration if it moves more than 15 degrees on x-axis then set vibration alert, Check pressure if it is more than 1000 Pascal then set pressure alert and finally send data to database server using web server.

Here we develop the android application as well as website to display the result. In android application separate logins are given to admin and employee as per our constraint if the pressure, temperature and humidity exceed the threshold value the alert will be send to employer through notification then employer will observe the pipe location as per notification and perform the appropriate action and finally it will send the response of work to the manager.


```
Connecting to server...
Connected

Readings stored in database
Humidity: 62
Temperature: 32 *C
X-axis reading: 167*
Absolute pressure: 29244Pa
Pressure Applied: 0Pa
TEMPERATURE ALERT!!
HUMIDITY ALERT!!
VIBRATION ALERT!!
```

Screenshot 1: Output on Serial Monitor in Arduino

These readings are sent to the website "www.pipelinemonitoring.in/login.php" and it is shown as follows:

Sensing Record Table

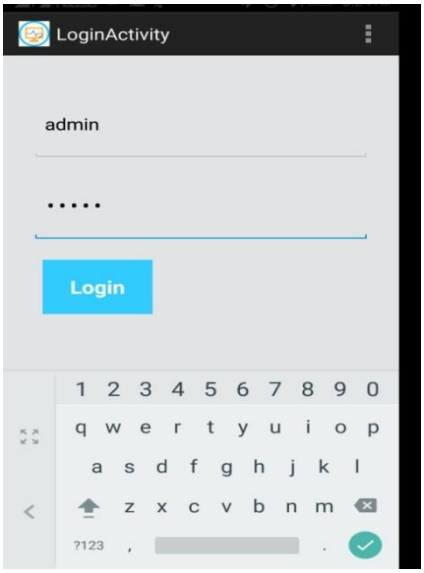
Kolhapur

Show 10 entries Search:

Sr. No.	Date and time	Temperature	Humidity	Vibration	Pressure	Temperature Flag	Humid Flag	Vibration Flag	Pressure Flag
563	10-03-2017 01:22:10pm	29	65	165	0	0	1	1	0
562	10-03-2017 01:21:59pm	30	67	165	0	1	1	1	0
561	10-03-2017 01:21:45pm	32	62	167	0	1	1	1	0
560	10-03-2017 01:21:34pm	26	17	170	975	0	0	1	0

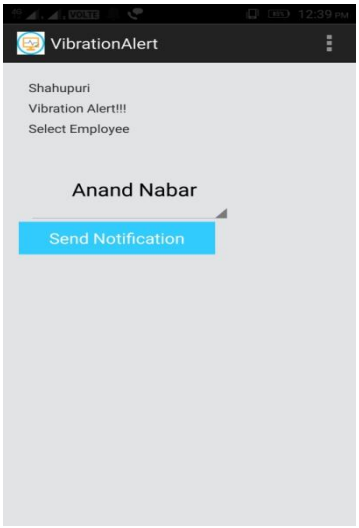
Screenshot 2: Output on website

This way the output is displayed on the website. The manager gets the notification when the flag is set to 1 for respective sensors. Following are some screenshots of the Admin Panel on his/her Smartphone.



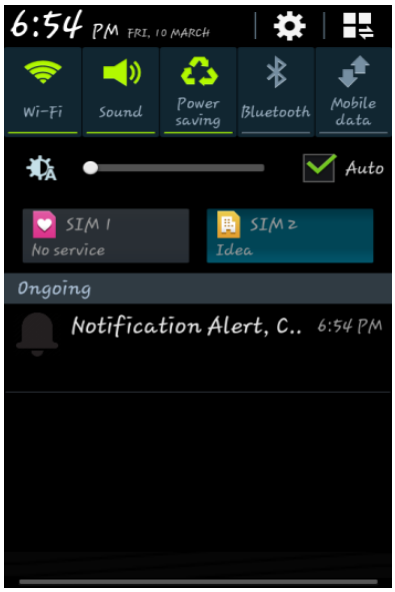
Screenshot 3: Login Page on Android application

When admin logs in the system with accurate credentials then he can select to whom he should assign work.



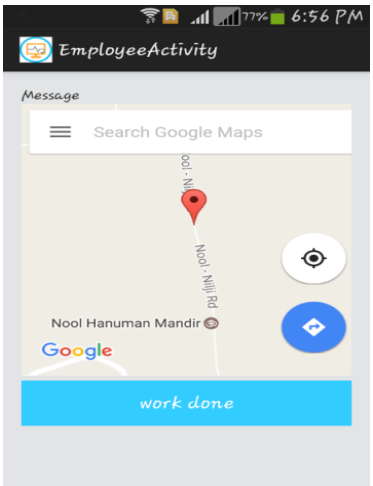
Screenshot 4: Selecting employee page on Android application

When the employee is finalized, the manager sends the notification to that employee and then the employee will get the notification on his notification panel as follows:



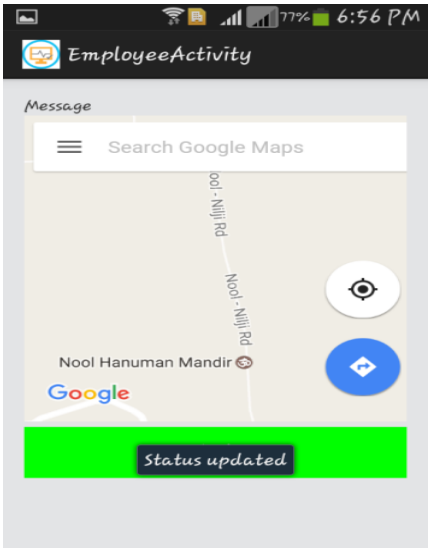
Screenshot 5:The Notification Panel on employee's Smartphone(Android Application)

The employee has to log in the android application and he will see the following page:



Screenshot 6: Page for employee with Google Map on his Smartphone (Android Application)

When the employee completes the work, he will click on the "work done" button and then the manager will get to know the work is done successfully by the employee and the button appears to be in the 'green' color.



Screenshot 6: After updating the status on employee's Smartphone (Android Application)

VII. Conclusion

This paper will focus on the condition monitoring of long pipelines in real-time. Multiple sensors such as pressure, temperature and accelerometer are used to detect parameters that can damage the pipeline.

To implement this project, wireless sensor network is established. The development board used for this project is Arduino Uno as it supports easy interfacing and low-cost implementation.

The wireless communication is carried out using Arduino board and Ethernet shield for reception of data and transmission of signals. The android application is developed which helps the manager to communicate with the employee.

The alert signals will generate the faults and the manager will get the push notifications, then manager assigns the task to the employee.

We have also used the Google Maps so that the employee will easily trace the location of suspected area.

VIII. Further Scope

- The condition monitoring of pipeline solutions are still in the infancy state. As these solutions mature, additional features will be offered that will make monitoring of pipeline easier.
- The whole system can be turned into wireless system with the help of WiFi compatible Arduino board.
- The use of more accurate industrial sensors will help to get very accurate results.
- The manager may send the text message to the employee if the employee is not having the internet connection.
- The manager may get the location of the employee with the help of GPS, so as to trace the employee's current location.

IX. Discussion

Based on the results of an assessment it was found that the implementation of this prototype is to be carried out by the sensors and the limitations associated with it. The emphasis should be done on the specific areas which are more vulnerable to the earthquake and damage prominent Therefore, our project determines the location of each area where the sensors are functioning. During research, one project with similar concept was found. Researchers in the University of Birmingham designed a system which would be capable of detecting leaks using a pressure sensor. The main purpose of their project was to

develop a smart wireless sensor network for monitoring water pipelines, based on measuring pressure changes in PVC pipes. Unlike their study, this project will not only measure pressure changes ,but will also monitor the other parameters temperature, humidity and vibration.The project also include the android application as it is been discovered that the products delivered to the android operating system are about 64% as in India by 2016.

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