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Paper Authors

PEDADA LEELA KRISHNA[1*], B.V.SHIVA KUMAR[2], M DURGA PRASAD[3***]**

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INTERNET OF THINGS IN CIVIL ENGINEERING

PEDADA LEELA KRISHNA[1*], B.V.SHIVA KUMAR[2], M DURGA PRASAD[3***]**
[1, 2 , 3] Civil Department, Wellfare Institute Of Science Technology and Management , Visakhapatnam, Andhra Pradesh, India
[*] p.leela9@gmail.com , ** shivakumar.bandaru@gmail.com , *** medisettydurgaprasad@gmail.com .

Abstract: IoT technology can have a huge impact in engineering by leveraging state-of-the-art information and communication technologies (ICT). In practice, however, it is challenging for IoT platforms to handle domain-specific engineering information (e.g., geometric model, engineering simulation model, etc.) An attempt has been made to implement IoT to monitor deflection of Bridge decks using piezoelectric sensors. In the first phase, as an initial step, a "Piezomat" which is an Assembly of Piezosensors is designed and developed to monitor deflection parameters in a 0.01x0.01x0.75m beam by connecting it to a Raspberry Pi 2. Data collected will be analysed and the system will be trained to behave as a "smart structure"

Keywords- Internet of Things, IoT platform, cloud computing, distributed data management, information modeling, interoperability, data integration

1. Introduction

With the advances in information and communication technology (ICT), sensors have been deployed widely in many engineering domains. The increasing use of sensors will realize the concept of Internet of Things (IoT) and cyber physical system (CPS) that physical systems and computational systems are tightly integrated. Physical systems can be monitored, analysed and controlled with or without human intervention. Furthermore, the massive data collected by sensors offers promising opportunities to find new insights about the physical systems. In practice, however, sensor data needs to be integrated with domain-specific engineering information to support decision-making. A data management platform that can effectively manage sensor data and engineering information is essential before IoT technology can find useful in engineering applications.

Internet of Things (IoT) is the hot-topic on research. While IoT is in its peak with Communication and Information Technology departments, it is still in its infancy with applications to Civil Engineering structures. There is a great need to bring Bridge monitoring by IoT into practical use[1].There is also a great need to devise Alternate Energy Conversion Systems, for self-sufficiency in electrical power generation for consumption. Movement of vehicles have great impacts on Bridges, and through a suitable system, we need to transfer this impact energy into electrical energy. Innovative Research leading to Engineered Solution could best resolve this challenge.

2. OVERVIEW OF IOT

Internet Applications on computers and mobile devices have revolutionised both our lifestyle and work culture. As a further advancement, Internet of Things (IoT) has brought to us a Smart Lifestyle & Smart Work culture.

The IoT platform is composed of three basic layers, namely, communication layer, mapping layer and storage layer, to support data store and retrieval. For data store processes, the communication layer handles communication with the data sources. Specifically, the web server and message broker in the communication layer provide standardized interfaces to receive data from different data sources via the Internet. The mapping layer includes a data mapper that maps the received semi-structured information models onto the database schema. The mapped data is passed to the storage layer which includes a distributed database system that partitions, replicates and stores data.

3. DATA STORE PROCESS

This section describes the process of acquiring and storing the data with the IoT platform. Data store requests are processed through three layers: communication, mapping and storage. The communication layer employs web server and message broker built upon standard protocols, so that various data sources can access the platform. The mapping layer defines the mapper to help store the semi-structured information models in the database. Finally, the storage layer employs a distributed NoSQL database to enable scalable data management.

4. Communication Layer

The communication layer is exposed to clients (e.g., data sources) via the Internet to enable remote access. The layer serves as intermediary, and accepts messages with the data from the clients, parses the message to extract the data and passes the data to the appropriate layer. To support different communication protocols often used in IoT applications, this layer includes two systems: a web server based on the Hypertext Transfer Protocol (HTTP) and a message broker based on the Message Queuing Telemetry Transport (MQTT). In the prototype implementation, both systems are deployed using Node.js [19], a server-side JavaScript runtime environment.

5. IoT and Civil Infrastructure

Internet of Things (IoT) has triggered a new communication pattern that all the objects in our life and work could be possibly communicated in both a sensory and an intelligent manner [2]. Two typical information exchange modes, i.e. human to thing (H2T) talk and thing to thing (T2T) talk, are thereby available anytime at anywhere to facilitate dissemination of information in a smart way2. Smart Appliances make way for a smart home and thereby also to a smart city, where all the Civil Infrastructures could be efficiently operated and other Public Service facilities could also be effectively administered. Just the way Money transactions are performed on the Internet, so too, Product Monitoring (Bridges, Buildings) and Project Management (Traffic Regulation, Water Supply, Sanitary disposal, Pollution control) could be done SMARTLY using IoT.

6. METHODOLOGY

The methodology adopted includes
1) Structural Design Components
2) Experimental Setup
3) FEM Analysis
4) IoT Components

A. Phase I

1) Structural Design Components

1. Design of Piezomat which is the Assembly of Piezoelectric sensors.
2. Calibration of Piezomat to give deflection properties.
3. Design of Beams for Piezomat installation.
4. Beam loading and corresponding Output deflection values connected to Raspberry Pi 2. 5. Remote Monitoring of the performance of beam.
6. Bridge Deck design and analysis using FEM.

2) Experimental Setup

A proper model for the Piezomat to be placed inside the concrete beam has to be designed. The Piezomat has to be embedded between two shock absorbing elastic layers that can enable it to undergo deformation to generate electrical output. A resistant elastic covering layer needs to be provided on top. A standard mix design will be adopted all through the project. Casting of beams with embedded Piezomat will be done with outlet probes properly positioned to take readings.

3) FEM Analysis

Wheel movement on beams need to be simulated to relate to Dynamic testing. Piezosensors give electrical output only on impact and not on static loads. Concrete cylinders will be rolled over the beams and the output from Piezomat will be collected on a Raspberry Pi 2. The Piezomat and its sensitivity to Impact load needs to verified and validated. The Test Beam is designed on FEM and loaded with similar loading. Analysis and results are obtained. Bridge deck slabs are designed and Tested for dynamic wheel loading using FEM. The co-related Test Beam with Piezomat on FEM needs to be extrapolated for Analysis of Bridge Decks using FEM.

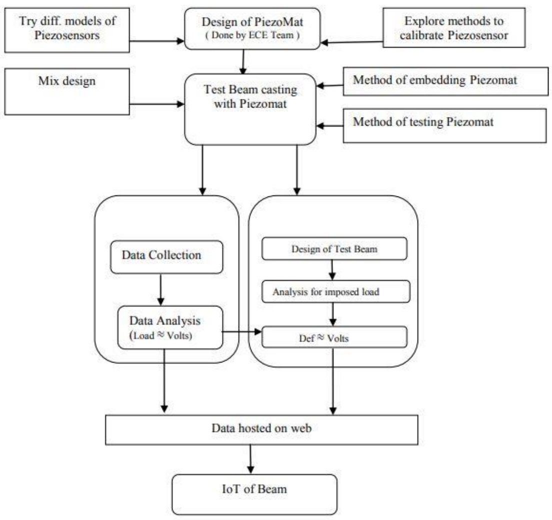

Fig. 3. Flow Diagram for IoT of Bridge Deck

7. CONCLUSION

IoT for Civil Infrastructures is introduced in this paper. An inter-disciplinary approach of Project specific Piezomat Assembly Design, innovative Sensor embedding method, FEM Analysis and IoT integration is presented. Research on Alternate Energy Conversion system and a very successful model for practical implementation will have great significance. This could contribute to better livelihood in remote areas in India where there is great demand for electrical

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energy for better living. The findings will significantly contribute to research and development and when put to practical use, will enable practicing Civil Engineers to monitor and manage projects through IoT.

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