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A Review on IOT Based Maintenance Management System for Industrial Equipments

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Abstract

Conservation and efficient artificial equipment are vital for each manufacturing organisation. The method requires the standardisation of the maintenance infrastructure and the implementation of a systematic maintenance schedule. Condition monitoring, on the other hand, must be a part of any smart manufacturing programme that aims to increase the operational efficiency of a production system. The internet of things refers to the billions of physical objects linked to the internet across the world that gather and share data. This article provides an overview of a predictive maintenance management system for industrial equipment based on the internet of things.

Keywords*: - Predictive maintenance, Internet of Things (IoT), Industrial Internet of Things (IIoT), Condition Monitoring, Industry 4.0*

INTRODUCTION

Objects equipped with sensors, processing power, software, and other technologies [1-4]. These things communicate with other devices and systems via the internet or communication networks. An IoT system is made up of sensors/devices that communicate with the cloud via some form of connection. When data reaches the cloud, the software evaluates it and chooses whether to conduct an action, such as automatically altering sensors/devices without the user's intervention or sending an alarm.

The goal of the Internet of Things is to have devices that self-report in real time, demonstrating efficiency and bringing crucial information to the surface faster than a system that relies on human involvement. The name "Internet of Things" is just 16 years old, but the concept of linked gadgets has been around for much longer, at least since the 1970s. The internet was a new trend in 1999, and the name "Internet of Things" was approved since it made some sense.

The Internet of Things (IoT) is characterised as detectors and selectors embedded in physical items that are linked via wired and wireless networks, frequently utilising the same Internet Protocol (IP) that links the internet. The phrase "Internet of Things" was used to promote Radio Frequency Identification (RFID, a wireless system made up of tags and readers). The term "Internet of Things" did not gain popularity until 2010/2011, and it only reached the mainstream market in early 2014. M2M is a nearby and crucial technology.

It is direct connection between machines via any communication route, including wired and wireless. Machine-to-machine communication can involve artificial instrumentation, which allows a detector or sensor to send the data it collects to operating software that can use it.

The Internet of Things has emerged as a result of the confluence of several technology such as ubiquitous computing, commodity sensors, more sophisticated embedded systems, and machine learning. Embedded systems, wireless sensor networks, control systems, home, building, and industrial automation, among other traditional sectors, individually and jointly strengthen the Internet of Things in the consumer market.

The Internet of Things (IoT) is a network of interconnected computing devices, mechanical and digital machinery, items, animals, or people having unique identifiers (UID) and the capacity to transfer data across a network without requiring mortal-to-mortal or mortal-to-computer trade.

In the Internet of Things, a "thing" can be a person with a heart monitor implant, a farm animal with a biochip transponder, a car with a built-in sensor to alert the driver, or any other natural or manmade object that can be assigned an internet protocol address and can transfer data over a network. An IoT ecosystem is made up of web-enabled smart devices that gather, send, and act on data collected from their environments using embedded systems such as CPUs, sensors, and communication gear. IoT bias gather detector data by connecting to an IoT gateway or other edge device, where data is either transmitted to the pall for anatomization or anatomized locally.

These biases occasionally interact with other linked biases and act on the information they get from one another. Although individuals can engage with the gadgets, the machines conduct the majority of the job without human participation. The connection, networking, and communication protocols utilised with these web-enabled devices are heavily influenced by the IoT applications that are implemented. IoT may also utilise artificial intelligence and machine learning to make data collection procedures more efficient and dynamic. Figure 1 depicts the operation of an IoT system.

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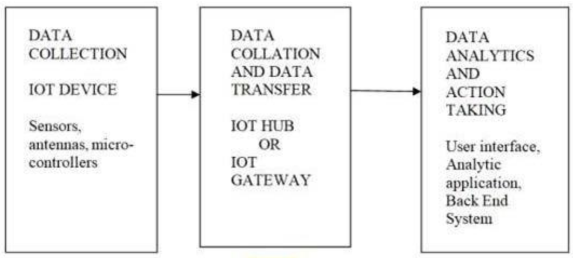

Fig.1:- Concept of working of Internet of Things (IOT)

WORKING OF INTERNET OF THINGS

The term "Industrial IoT" (IIoT) refers to the use of technology in industrial settings, particularly in the instrumentation and control of sensors and devices that use cloud technologies. Machine-to-machine communications have recently been employed in industries to enable wireless automation and control. However, with the rise of cloud and related technologies (such as analytics and machine learning), industries may accomplish a new automation layer, resulting in new income and business models.

The Internet of Things (IoT) is frequently referred to as the fourth industrial revolution. Smart manufacturing, linked assets and preventative and predictive maintenance, smart power grids, smart cities, connected logistics, and smart digital supply chains are the most prevalent applications of IIoT.

INDUSTRY 4.0 AND ITS RELATION WITH IIoT

The global industrial environment has altered dramatically in recent years as a result of different technical breakthroughs, improvements, and inventions. The fourth industrial revolution (Industry 4.0) is distinguished by a wide range of new applications and services, as well as numerous networked gadgets and revolutionary production processes. Industry 4.0 is a highly interconnected, computerised, automated, self-sufficient, and efficient industrial environment. The following technical clusters are driving Industry 4.0: data, computing power and connection, analytics and intelligence, human-machine interaction, and digital-to-physical conversion.

Assiduity 4.0 blends classical diligence's skills with cutting-edge technology, allowing smart goods to be incorporated into integrated digital and physical processes. These processes interact with one another and traverse geographical and organisational boundaries. Industry 4.0 focuses on the complete digitization of all physical assets and their connection with digital ecosystems, allowing them to collect, analyse, and share data in real time.

The leading driving factors of Industry 4.0 are digitalization of horizontal and vertical value chains, digitalization of product and service offerings and digital business models and customer access. Industry 4.0 aims at enhancing and upgrading the current manufacturing facilities, management and maintenance systems and technologies to an intelligent level by utilizing key technologies such as Internet of Things (IoT) , Internet of Services (IoS), Cyber Physical System (CPS), autonomous, flexible and co-operative robotics, simulations that leverage real time data and mirror real world into a virtual model, big data analytics, augmented reality (AR), additive manufacturing, information and communication technology (ICT) and advanced networking technology (e.g cloud computing).

Industry 4.0 seeks to address the dynamic global market and the competitive nature of today’s industries in line with continuously changing customer’s and market needs. Integration of horizontal and vertical systems will allow that enterprises, departments, functions and capabilities evolve in an interconnected network that enables an automated value chain.

Out of various subsystems of Industry 4.0, IIoT is a specific category of IoT which focuses on its applications in intelligent manufacturing and modern industries. IIoT, which is used in the context of Industry 4.0, is considered as a complex integration of diverse devices and systems. More specifically, with a view of producing a system which functions more efficiently than the sum of its parts.

IIoT provides solutions and functions through the use of appropriate services, networking technologies, applications, sensors, software, middleware and storage systems, which develop insight and improve the potential of monitoring and controlling enterprises, processes and assets and provides vital solutions for more effective planning, scheduling and controlling of manufacturing operations and systems.

MECHANICAL FAILURE OF EQUIPMENTS AND RELEVANCE OF IIoT

As technology continues to evolve, industrial machines and equipment that were installed ten to twenty years ago have become outdated. Larger plants are more likely to employ advanced manufacturing technology than the smaller ones [5]. Still there are industries that use the outdated machines due to sunk costs and uncertain market conditions, lack of justification for upgrading or they cannot afford to shut down the plant for upgrades [6].

In case of industrial low voltage motors, which are used in wide range of industrial applications viz. oil, paper, food, pharmaceuticals, water and packaging, are designed to operate under specific conditions. Industrial low voltage motors use a specific amount of energy, have a certain operating temperature uses certain insulation system, vibrate at certain frequencies and are capable of handling load according to the peak torque. Any change in these factors may indicate a pending failure and there is a need for upgradation and maintenance.

Mechanical failures are ranked as the most frequently occurred cause of breakdown and stoppages in the world wide petrochemical plants [7-8]. From the previous studies [9-14] on several areas of application have shown that monitoring and analyzing the key performance indicators and physical parameters associated with operating machines, results in increased safety and usage of limited life parts, reduction in unscheduled maintenance and manual inspection and reduction in faults.

Further the cost of operating problematic components can be reduced when they can be detected prior to a failure and when on time maintenance is performed with minimum disruption to productivity.

The impact of condition monitoring in mechanical maintenance on the economics of manufacturing industries is observed in several countries over the world [15]. It was found that the condition based maintenance caused 50-80% reduction in maintenance costs, 30% reduction in spares inventories and 20- 80% increase in overall profitability of plants.

Vital utilities that are accompanied by the Internet of Things applications in both domestic [16,17] and industrial settings are monitoring and hence prompt decision making for efficient management [18]. Predictive maintenance using IoT technology capable of 10-40% savings in cost per year [19]. Considering more sophisticated and expensive machines that are being used now-a-days makes it easier for companies that use outdated technology to justify condition monitoring expenditure.

Low cost real time condition monitoring system for managing industrial equipments using Internet of Things can be designed and developed. The Equipment Management System (EMS) can be developed consisting of monitoring system to record vibration and temperature of equipment and transmit data through a wireless network to a data logging centre. The IoT device can identify abnormal operating conditions from sensor input values that exceeds predefined set points.

When the equipment approaches an abnormal condition, the system changes state and informs the user through an alert to perform an RFID enforced inspection. The alarm system remains actuated until an inspector visits the outfit. The EMS can be accessed remotely to allow the user to examine the current condition and behavior of the equipment.

IIoT PROTOTYPE CONCEPT

An IIoT prototype can be developed consisting hardware architecture and software.

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HARDWARE ARCHITECTURE

The configuration of the hardware consists of an XBee shield mounted on the top of the micro-controller. A non-contact infrared temperature sensor and a thermistor are connected to the XBee shield as input sensor devices to provide the information about the temperature conditions.

An accelerometer gyroscope sensor can be used as input for monitoring the motor vibration frequency level. Two XBee radio frequency communication modules were used to send and receive signals for all the notifications as well as to allow the wireless connectivity between the EMS and a computer logging station. The XBee modules were tested, paired and configured through an open access multi-platform application that allows developers to set up and configure the modules. The one XBee module was

configured as an output device to communicate and transmit real time data of the input sensors to another XBee receiver module. The XBee receiver was set up as an input connected to a stationary computer workstation that was used as a central point for data logging and analysis. The Equipment Management System is shown in Figure 2.

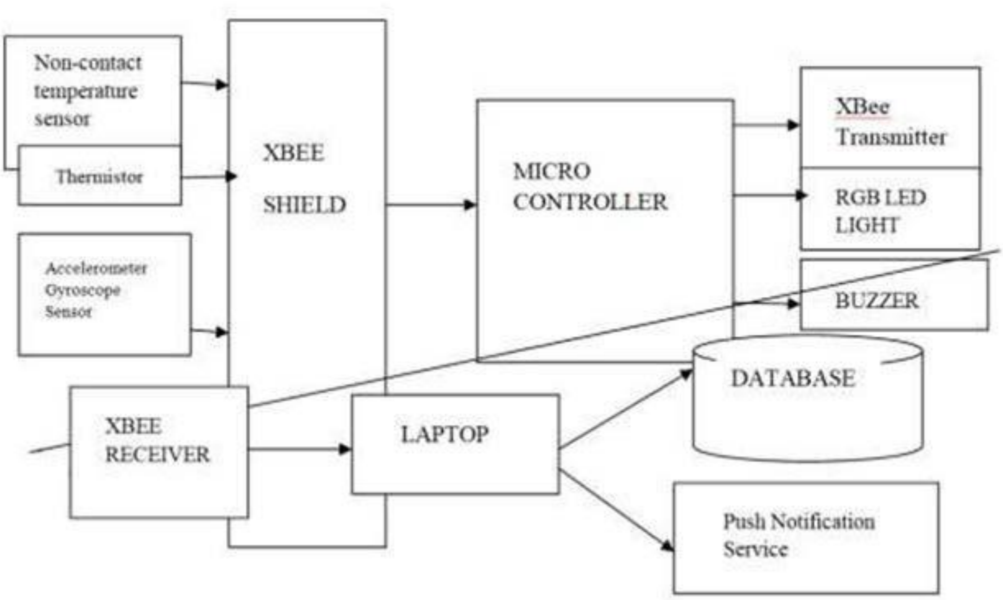

Fig.2:- Equipment Management System Architecture

In addition the Equipment Management System (EMS) should be equipped with an

RFID reader, an RGB LED and a passive buzzer to further increase the situation awareness of the operator on the shop floor. The LED and the sound alarm are to be used as outputs for extra precaution to indicate the current state of the equipment and provide visual and audio feedback when critical and abnormal situations are detected. An authorized individual can manually turn off the alarm by swiping the RFID card onto the RFID reader. The architecture diagram illustrates the internal view of the system architecture in order to understand the interactions of different components.

EQUIPMENT MANAGEMENT SYSTEM ARCHITECTURE SOFTWARE

Several algorithms were developed and integrated for capturing the most dominant vibration frequencies, for notifying the operator via an email about the motor's condition and for enforcing equipment inspection through an RFID batch to dismiss the alarm. The memory and sampling rate limitations of the micro-controller should be considered for developing the algorithm in order to capture the most dominant frequency and a signal generator should be used to adjust the frequency, waveforms, offset and amplitude of standard vibration signals. For example Fast Fourier Transformation (FFT) can be used for algorithm for the micro-controller [20].

Prior to the completion of EMS activation the user must define the maximum allowable temperature and the vibration range depending on the specification of the equipment and desired safety factors. The temperature boundaries are to be specified in 3 different states --- stable, warning and alarm.

Once the user has manually input the temperature and vibration thresholds, the vibration and temperature sensors scan for input data, send them to a computer (data logging centre) and using a python script program are stored in a csv train for farther analysis. Contingent upon the vibration frequency and temperature values, the color of the RGB LED changes. Green LED can indicate the stable state, yellow LED indicate the warning state and red LED color indicates an alarm state.

CONCLUSION

This study proposed concepts for the design and implementation of an IoT-enabled real-time status monitoring and maintenance management system for industrial equipment. The gadget wirelessly communicates data from industrial equipment's temperature and vibration frequency level to a logging station and provides a push message in the event of an alert. The current condition monitoring system may be improved by including data mining and machine learning technologies to detect early warning signs of probable failures.

Another strategy may be to create a digital twin of the system to replicate abnormalities and collect simulation data to feed into a predictive maintenance machine learning algorithm.

REFERENCES

1. Alam, T. (2018). A reliable communication framework and its use in internet of things (IoT). CSEIT1835111| Received, 10, 450-456.
2. Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of things: A survey on enabling technologies, protocols, and applications. IEEE communications surveys & tutorials, 17(4), 2347-2376.
3. Atzori, L., Iera, A., & Morabito, G. (2017). Understanding the Internet of Things: definition, potentials, and societal role of a fast evolving paradigm. Ad Hoc Networks, 56, 122- 140.
4. da Costa, K. A., Papa, J. P., Lisboa, C. O., Munoz, R., & de Albuquerque, V.H. C. (2019). Internet of Things: A survey on machine learning-based intrusion detection approaches. Computer Networks, 151, 147-157.
5. Dunne, T. (1994). Plant age and technology use in US manufacturing industries. The RAND Journal of Economics, 488-499.
6. Lambson, V. E. (1991). Industry evolution with sunk costs and uncertain market conditions. International Journalof Industrial Organization, 9(2), 171-196.
7. Garrison, W. G. (1986). One Hundred Largest Losses—A

Thirty-Year Review of Property Damage Losses in the Hydrocarbon. Chemical Industries, 9th ed., M & M Protection Consultants, Chicago, Ill., USA.

8. Carson, P. A., & Mumford, C. J. (1979). An analysis of incidents involving major hazards in the chemical industry. Journal of Hazardous materials, 3(2), 149-165.

9. McInerny, S. A., & Dai, Y. (2003). Basic vibration signal processing for bearing fault detection. IEEE Transactions on education, 46(1), 149-156.

10. Nandi, S., Toliyat, H. A., & Li, X. (2005). Condition monitoring and fault diagnosis of electrical motors— A review. IEEE transactions on energy conversion, 20(4), 719-729.

11. Bergasa, L. M., Nuevo, J., Sotelo, M. A., Barea, R., & Lopez, M. E. (2006). Real-time system for monitoring driver vigilance. IEEE Transactions on Intelligent Transportation Systems, 7(1), 63-77.

12. Yang, W., Tavner, P. J., Crabtree, C. J., & Wilkinson, M. (2009). Cost- effective condition monitoring for wind turbines. IEEE Transactions on industrial electronics, 57(1), 263-271.

13. Hodge, V. J., O'Keefe, S., Weeks, M., & Moulds, A. (2014). Wireless sensor networks for condition monitoring in the railway industry: A survey. IEEE Transactions on intelligent transportation systems, 16(3), 1088-1106.

14. Goyal, D., Chaudhary, A., Dang, R. K., Pabla, B. S., & Dhami, S. S. (2018). Condition monitoring of rotating machines: a review. World Scientific News, 113, 98-108.

15. Rao, B. (Ed.). (1996). Handbook of condition monitoring. Elsevier.

16. Kelly, S. D. T., Suryadevara, N. K., & Mukhopadhyay, S. C. (2013). Towards the implementation of IoT for environmental condition monitoring in homes. IEEE sensors journal, 13(10), 3846-3853.

17. Angelopoulou, A., Mykoniatis, K., Carlson, K., & Kim, S. J. (2014,

June). UCF Smart Mailbox: Reinforcing Communications in the Neighborhoods. In International Conference on Human-Computer Interaction (pp. 393-398). Springer, Cham.

18. Asghari, P., Rahmani, A. M., & Javadi, H. H. S. (2019). Internet of Things applications: A systematic review. Computer Networks, 148, 241-261.

19. Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J., & Aharon, D. (2015). Unlocking the Potential of the Internet of Things. McKinsey Global Institute, 1.

20. Fast Fourier Transformation for Arduino [Online] Available

21. https:// github.com/kosme/arduinoFFT [Accessed 2019].

