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Feasibility Study of Internet of Things (IoT) in Construction Industry: A Review

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ABSTRACT: As the improvement of Internet of Things (IoT) organizations and its huge use by different industry, it is one dread might emerge that development industry might have left behind the other industry.That is the reason the development business should begin the utilization of uses presented by IoT to discover the perfection and quick advancement of the development process.At present, agricultural nations like India, needs quick advancement of foundation and development, so the better arrangement is to utilize IoT applications to support the speed of development. So this paper intends to really look at the achievability of IoT in the development business and to discover the IoT applications which might help for quick and quality advancement of development. Some examination papers and theory are to be assessed fundamentally to discover the adoptability of IoT applications in a few periods of development industry during project life cycle.

Keywords: Construction Industry, Drone, Internet of Things (IoT), Sensors, Smart construction

Introduction

Internet of Things (IoT) is a human-designed technology conceptualized by intelligent virtual objects, which are capable of knowing all matter and permit the devices around themselves to interact automatically without human‟scontrol.

In simple words, IoT is a network of sensors, appliances and devices competent of sending and receiving data about changes to their current physical situation and environment nearby themover the internet.

The figure 1 provides the simplest understanding of the IoT, as this is superior to all type of interactions like machine to machine, machine to environment, human to human, human to machine, machine to human, machine to environment and also than a cyber-physical system.

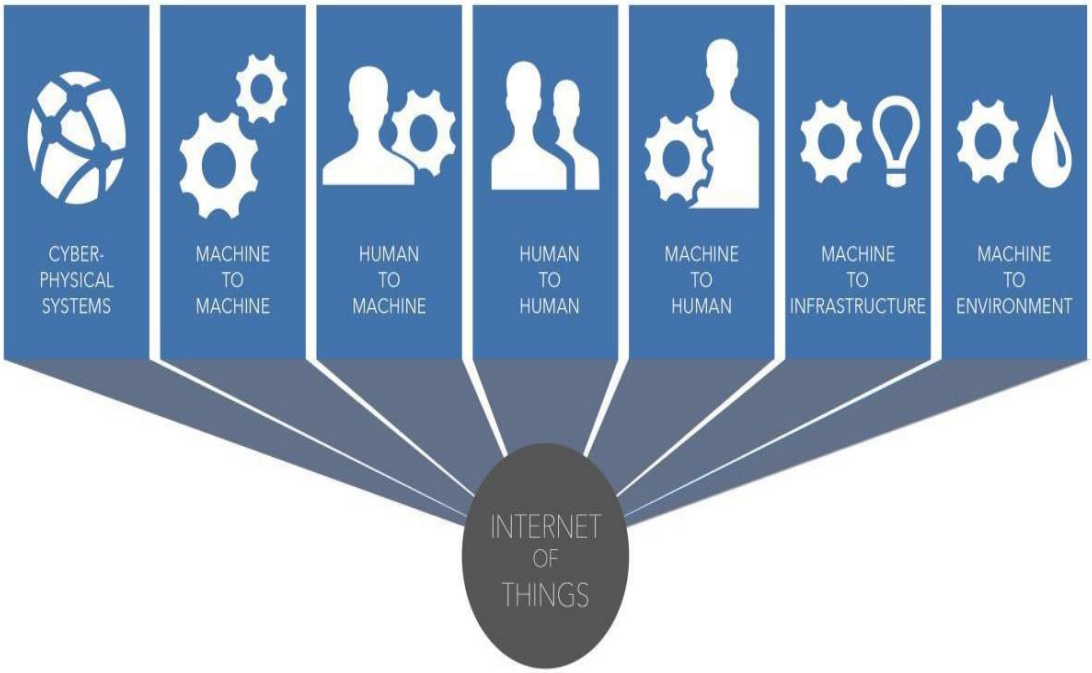

Figure 1: Internet of Things Environment [6]

Evolution of internet

The below discussed stages explains the evolution of internet:

(1) **Pre-Internet:** There was face to face conversation, Short Message Service (SMS), Phone are usedbefore theera of internet.
(2) **Internet of Content:** After the internet introduced, it was used to send information between peoplevia network. E.g. Electronic Mail (E-Mail).
(3) **Internet of services:** Then after that internet was utilized as a service to make or transfer themoney.E.g. E-commerce, E-business.
(4) **Internet of people:** Internet is for the people and it is created by the people and so it is utilized by the people. E.g. Social media like face book, Instagram, goggle plus and many more.
(5) **Internet of Things**: In IoT is interaction betweenmachine and devices, so no human interactionis required. E.g. Automation, Identification, tracking, monitoring & control can be done by the machine with the help of Internet and Information Systems.

Literature review

Review of Literature is the core of review paper. In the last few years, analysts have noted that IoTis the hot topic for research. Also the researchers found that the IoT is very useful in many ways in construction industry at different stages of construction. The major benefit of the IoT application in construction industry is ease of working and it also boostconstruction speed with better quality output. Some of research works done in this field are as follows:

A. Medvedev et al.stated thatefficient waste collection should be considered as a fundamental service for Smart Cities and that Intelligent Transportation Systems (ITS) enable new services within Smart Cities. Theyexplained that Internet of Things(IoT)components

like, RFIDs,sensors, cameras and actuators are very useful into ITS and surveillance systems for efficientwaste collection. In the research they propose an advanced DecisionSupport System (DSS) for efficient waste collection in Smart Cities using IoT devices. They created a model for data sharing between truck drivers on real time inorder to perform waste collection and dynamic route optimization and also the same systemhandled the ineffective waste collection problems in inaccessible areas within theSmart City. Surveillance cameras wereused for capturing the problematic areas and provide evidence to the authorities of city. Researchers also mentioned that the waste collection system aimsto provide high quality of service to the citizens of a Smart City. **[3]**

A. Praba et al.explained thatIoT is mainly deals with Communication and Information Technology departments but it is also useful in many ways by its applications to Civil Engineering structures. Researchers stated that there is great need to perform Bridge monitoring using IoT into practical use and there is also a great need to devise Alternate Energy Conversion Systems, for self-sufficiency in electrical power generation for consumption. They found that movement of vehicles have great impacts on Bridges, and through a suitable system, one can transfer that impact energy into electrical energy. They researched two type of sensors that is piezo sensors and Piezo generators and also they suggested to use piezo generators with IoT to create a model to perform a work which they have already discussed in their paper. **[2]** The similar concept of durability and assessment is analyzed by **W. Taffese et al.** using IoT and intelligent data analysis for corrosion monitoring and durability assessment. **[18]**

J. Xu et al.aimed to develop a closed-loop lifecycle management system which can enable a consistent flow of information for use and reuse for all stakeholders. Theframework integrates the state-of-the-art smart construction using construction automation and internet of things (IoT) technologies to help practitioners to access and manage the information via a standard interface among various applications throughout the entire lifecycle. Into a closed-loop lifecycle management system for IoT based smart construction, several digital technologies such as 3D laser scanner, drone, building information modelling (BIM), augmented reality (AR), Auto-ID, global positioning system (GPS), wireless sensor network (WSN), robotics, mobile digital devices, and web-based applications are used to collect data from different stages which is then stored, shared, processed, and utilized in one unified platform for all stakeholders to support better decision-making and interaction throughout a project lifecycle. This framework will support a smart construction from topto bottom throughout the entire project life cycle. **[10]**

V.Jeevana et al.used a concept of IoT to achieve process improvement by minimization of time. Researchers followed qualitative research and found that the major cause for delay was poor site management in construction industry.After the expert opinionand the data collection researchers reached to a conclusion that monitoring day to day activity is required to minimize the delay of insufficient site management. So the sensors to capture information are set and the real time monitoring of the sensor are done so when the material needs or possibility of delay is identified then it is immediately connected to network and sent to the site manager. So the site manager can take action regarding the issue even though the site

manager is not present at the construction site. Figure 2 describe the framework for poor site management using IoT.**[17]**

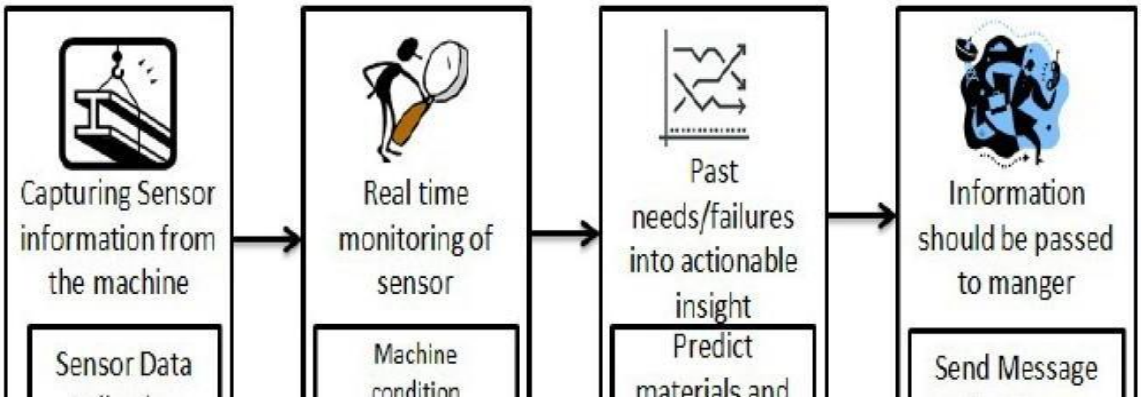

Figure 2: Framework using IoT for poor site management [17]

S. Mahmud et al.used the questionnaire method to identify the types of IoT applications used in construction industry of Malaysia. The questionnaire was analysed using nominal analysis. The study was conducted on construction industry players which comprising of government agencies, developers, architects, engineers, quantity surveyors and class G7 contractors covering all states in Malaysia. By this survey the concluded majorly used IoT based applications which were WhatsApp, Telegram, Facebook Messenger, email, GPRS and less used IoT based applications, which were sensor technology, Scan-Marker, Smart Watch etc. **[16]**

Bhavna et al.concluded that there are many devices that support IoT like Arduino, Raspberry PI[3], and other micro-electronic devices and IoT itself capable of using the Internet and wireless technology. So to produce a smart home automation system, IoT is to be connected with some components like, IR Sensors, LCD display, Power Supply, Capacitors, Wifi and the same concept is to be carried out by M. Peruzzini et al. [12] researcher established smart home information management and proposed energy efficient network usin information and communication technologies (ICT) tools and internet of things (IoT). **[4]**

A. Kumar et al.stated that the timely updates and delivery of construction material on a job site could have a significant impact on the overall duration, quality, and cost of the project. The study focused on analysing the role of Internet of things in providing a real-time update on the delivery and data for material handling in supply chain management, and review the role of IoT in the function of value addition into it.Researchers concluded that the use of IoT coupled with smart sensing devices could help in the communication and material tracking with high accuracy and free of noises such as human error, and other environmental factors. So it would help project manager in schedule updates and improve material efficiency. **[1]**

C. Cho et al. found out the solution for the collapsing scaffolding structure, researchers derived a smart prevention system using BIM, sensors, FEM analysis and IoT application to monitor and prevent the scaffolding structure collapse possibility. **[5]**

H. Reddy et al.as well as **J. Shah et al.** talked about the very critical point of construction industry that digitaltransformation is an ongoing challenge in the constructionindustry. they also mentioned that utilization of digital technologies is helpful to improve businessprocess

and IOT is one suchrobust system which helps to solve the above problem. So the researchers have investigated and concluded that the IoT sensors can used with various type of connection devices like GlobalPositioning System, Radio Frequency Identification, ZigBeeModule, Wireless Sensor Network etc. and it allows objects to be sensed and controlled remotely across existing infrastructure. **[6] [8]**

Michael Uriestated that Currently, many existing building management systems (BMS) do not fully utilise the large amount of operating data being generated. IoT can help identify operational issues more easily as most building operators do not have the time to analyse historical trend data in order to identify these operational problems.Author mentioned that IoT technology has the scope to benefit projects on site during the construction phase as well as in completed buildings from a facilities management perspective. Also he listed some of the capabilities which are, Sensors Placed in Completed Buildings and Structures, Augmented Reality (AR), Power/Fuel Saving, Remote Usage and Activity Monitoring, Enables „Just-In-Time" Provision, Tracks Tools and Equipment etc. **[13]**

L. Parra et al.decided to find out the combination of different systems aimed to monitor different aspects of the smart city such as e-health, air quality monitoring, gas, water and electricity monitoring, or emergency situations detection etc., which can be used to create a more sustainable and a securersmart city. Researchers have described the systems which will compose the future smart cities by combining different networks in charge of monitoring and controlling. Which are, IoT with WSN for e-Health and Human Well-Being Monitoring, Utilities Monitoring Systems, Emergency Situations Monitoring, Air Quality and Climate Monitoring Systems. Figure 3 displays Proposed architecture for smart city combining different systems. **[11]**

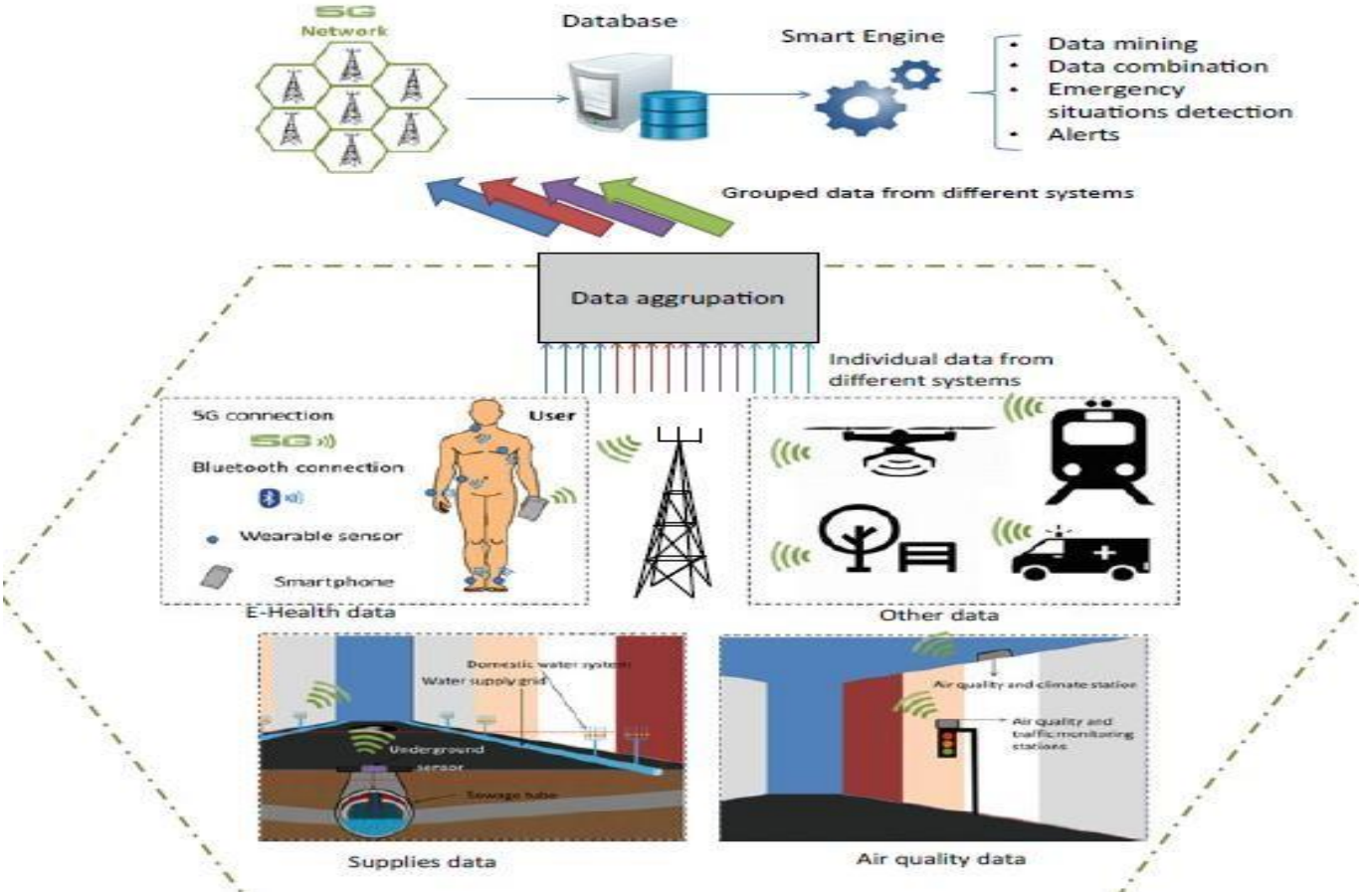

Figure 3: Proposed architecture for smart city combining different systems [11]

S. Okishiba et al. discussed about the use of excavator using tablet and Wi-Fi modules autonomously. Using wifi and microcontrollers an operator can use the tablet to operate the excavator as per required directions. **[15]**

Literature summary

From the above literature review several type of IoT applications that can be used at different phases in construction industry, some of these are represented in the tabular form displayed below in table 1 and also the literature summary about the IoT used in construction industry as per several authors is displayed in the table 2 shown below,

Table 1: IoT applications used in different phases

Phase	IoT Appliances
a) Smart Communication	1. Social media 2. Websites 3. E tender 4. Scan marker 5. Wi-Fi
b) Remote Operation	1. Autonomous machinery 2. Drone 3. Robotics

c) Supply Replenishment	1. RFID 2. GPS tracking
d) Maintenance of Machinery	1. Sensors 2. Microcontrollers
e) Power, Fuel & Energy Savings	1. Lighting & electricity sensors 2. Fuel saving sensors 3. Microcontrollers
f) Augmented Reality (AR)	1. AR with Google Glass
g) Building Information Modeling (BIM)	1. BIM modelling 2. Sensors in building
h) Give an Efficient Way	1. GPRS 2. Google map 3. Mobile/Tablet
i) Security Control	1. RFID 2. CCTV 3. ERP
j) Managing Workers	1. ERP 2. CCTV 3. Drone
k) Worker Health	1. Smart watch 2. Drone 3. E-Health Monitoring
l) Environmental Monitoring	1. Sensors
m) Structure Health Monitoring	1. Sensors
n) Waste Management	1. Sensors 2. Micro controllers 3. Wi-Fi

Table 2: Literature summary of IoT in construction industry

IoT Application / Authors	RFID	Sensors	CCTV	Drone	BIM	AR	GPS	WSN	Robotics	Mobile/ Tablet/ PC	Scan Marker	Smart Watch	Wifi	CAD	Microcontroller
M. Peruzzini et al.(2013)		*	*					*		*			*		
Medvedev et al. (2015)	*	*	*												
A. Praba et al. (2016)		*													
J. Shah et al. (2016)		*						*					*		*
J. Xu et al. (2018)				*	*	*	*	*	*	*					
Jeevana et al. (2018)		*													
Mahmud et al. (2018)		*					*			*	*	*			
Bhavna et al. (2018)		*	*										*		
A. Kumar et al. (2018)		*					*								
C. Cho et al. (2018)	*	*			*									*	
Reddy et al. (2019)	*						*	*							
Michael Urie (2019)		*		*		*	*		*			*			
L. Parra et al. (2019)		*										*			
W. Taffese et al. (2019)		*						*							

S. Okishiba et al. (2019)										*			*		*

Conclusion

Based on critical literature review, following conclusions are being made:

(1) IoT is the latest technology which is capable to connect with several devises using internet.
(2) The development in this technology and the use of that in construction industry may very helpful in many ways.
(3) Using IoT applications find out the solutions of problems raised in construction at different stages and speed up the construction with better quality with less number of flaws.
(4) IoT is very helpful for construction industry as it can be used in pre-construction stage, construction stage as well as it is also used in post construction stage, so IoT is beneficial in construction for whole lifecycle of a project.

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