Development of a Real-Time Fuel Monitoring System for Construction Industry using Internet of Things

Rajesh Bose, Sandip Roy, Srabanti Chakraborty, Indranil Sarkar

***Abstract:** Construction companies are, today, beset by numerous challenging issues in trying to carry out civil engineering projects to support growing urban populations around the world. Construction companies and contractors in civil engineering domain rely on heavy construction vehicles and mobile equipment that rely on internal combustion engines that consume copious volumes of fossil fuels in the form of diesel fuel. The price of diesel fuel combined with humongous volumes required to keep heavy construction vehicles as well as transport vehicles in operation, therefore, puts a considerable strain on the resources of a construction firm engaged in construction project requiring extensive resources in the form of both human, equipment, vehicular and machinery. Without an appropriate tracking mechanism to monitor fuel consumption of vehicles such as transit mixers operating at construction site, a construction firm can quickly run up huge fuel bills leading to operational and financial losses in both short- and long-run. Using Internet-of-Things (IoT), collection of fuel monitoring data followed by real-time analyses at a centralized location, construction companies can easily track movements of construction vehicles embedded with sensor devices. In this paper, we propose a new system that is based on a capacitive sensor that is open source, coupled to a controller embedded in a construction equipment vehicle. The function of the controller would be to provide global positioning data over GPRS radio module for data transfer from almost any remote location.*

***Keywords:** Cloud Computing, Global Positioning System (GPS), General Packet Ratio Services (GPRS), Global System for Mobile Communications (GSM), Internet of Things (IoT), Open-Source Hardware (OSH).*

I. INTRODUCTION

The underlying principle of Internet-of-Things is to make real-time transfer and synchronization of data possible among many dissimilar types of devices. For example, rooms equipped with IoT sensors can automatically report back to central systems if they are occupied or if there has been any change in temperature at any point of time. IoT makes it possible for inter-communication between any equipment or vehicle embedded with controllers and sensors in real-time and over any network path or digital services [1, 2]. Cognizant of rising costs per litre of fuel and combined with thirst for fuel across cities and semi-urban landscapes, fuel-filling station owners are keenly aware that theft of fuel can be lucrative for many who are out to make quick illegal profits. Today, many fuel-filling stations are equipped with sensors that communicate with controllers that have micro-processors to process real-time data on fuel entering or exiting fuel tanks at any given point of time.

While IoT has made the idea of electronics-enabled devices and equipment to communicate with each other and to central controllers possible, evolution in Cloud Computing technology has taken it further to a point where real-time information streamed back from IoT-enabled devices are stored in servers that may be hundreds or even thousands of miles away. Information processed by those remote servers can either be downloaded or consumed for taking decisions either immediately or strategically or transmitted to the same or different IoT-enabled devices to respond to changing stimuli or under dynamic environmental conditions [3. 4]. From the point of view of construction firms, there is no single system that can help monitor and report fuel consumption, distance travelled, and actual engine running hours of a transit mixer, and view all these information at a central location in a proper format [5]. Our research has revealed that there is a need for a system that can not only report a close approximation on fuel consumption of a transit mixer – either in operation, at standby / idling mode, or in parked condition, but also keep a daily track of all the metrics involved related to engine operational hours, distance travelled, fuel consumed, etc. Our research objective has, therefore, focused on the need to develop an IoT-based real-time fuel monitoring solution for construction companies.

II. ARCHITECTURE OF INTERNET OF THINGS

The architecture of IoT is a composite of various technologies layered in a manner such that each are able to communicate with one another. Thus, IoT-based systems can adapt to changing scenarios involving modularity, scalability and configuration [6]. The image shown below depicts functionality of each layer in an IoT-based system:

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* Correspondence Author
Dr. Rajesh Bose, Dept of CSS, Brainware University, Kolkata, India. Email: bose.raj00028@gmail.com
Dr. Sandip Roy*, Dept. of CSS, Brainware University, Kolkata, India. Email: sandiproy86@gmail.com
Srabanti Chakraborty, Dept. of CST, EIEM, Kolkata, India. Email: srabanti2k@gmail.org
Indranil Sarkar, Dept. of CSS, Brainware University, Kolkata, India. Email: indra.nil2004@gmail.com

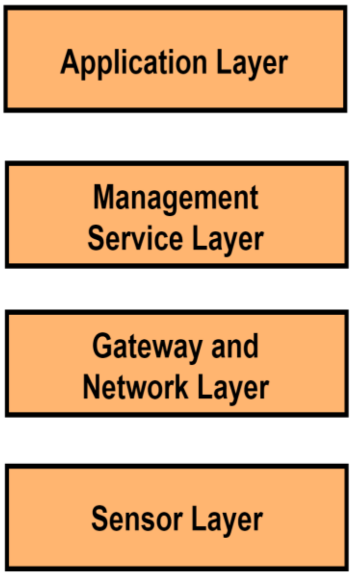

Fig. 1.Architecture of IoT.

A. Sensor Layer

The fundamental unit of an IoT-based system is the sensor layer. At this layer, capacitive sensors are embedded in equipment to stream back data. In the case of transit mixer – which is a heavy construction vehicle that requires large amounts of diesel fuel to stay in operations, sensor devices collect and stream back information either statically or dynamically across the Internet.

B. Gateway and Network Layer

Positioned on top of sensor layer is the Gateway and Network Layer. This is required to handle huge volumes of unstructured data that would pour in from sensors. Networks with robust protocols are deployed at this layer to aid in seamless machine-to-machine (M2M) network communication [7].

C. Management Service Layer

The purpose of this layer is to place security and access controls to data generated by the sensors. It is also at this layer that process modelling, and management of devices takes place. An important feature of this layer is also establishment of business and process rule engines. With this layer in place, information and analytical insights on data generated and stored can be viewed, aggregated and monitored [8].

D. Application Layer

The application layer is positioned at the very top for facilitating in delivery of associated software applications to users requiring access to data streamed from IoT-enabled equipment and vehicles. Using IP based networks to provide a stable communication interface and robust end-user services, this layer accords process-to-process communications [9].

III. COMPONENTS AND TECHNOLOGIES

A. Capacitive Fuel Level Sensor

Capacitive sensors have been proven to be reliable, stable and low-cost solutions that are yet able to provide data of high resolution. As such, their efficacy in applications that can dynamically determine level of fuel has been established beyond doubt. Capacitive sensors in fuel-level monitoring applications involve two parallel insulated conductors that are shielded by fuel or air present in the vessel or tank in which the conductors have been placed. As the level of fuel fluctuates, so does the value of capacitance that is related to the distance between conductors (as seen in Figure 2) and level of fuel. The capacitance being a part of oscillator circuit, changes with any change in oscillator frequency. The frequency is converted to voltage that in turn is transmitted to a fuel gauge displaying fuel remaining in tanks.

Fig. 2.Capacitive fuel level sensor.

While there are several types of capacitors available in markets, an ideal capacitor is considered to be the one that remains as much unaffected as possible despite being under the influence of changing temperature, capacitance in cables, and changes in capacitance caused by sensor and objects in proximity. The latter type is often referred to as parasitic capacitance. Cylindrical capacitive sensors are considered ideal [10]. The authors, Jin et. al., have discussed design and fabrication of a measurement system for determining levels in liquids [11].

In our manuscript, we have used shielded cable [11] for fabricating cylindrical capacitive sensor. The authors [12] have described how capacitive sensors can be constructed out of affordable materials such as PTFE-insulated wire and stainless-steel rod. Discussing a system for measuring water levels, the authors [13] point to the effectiveness of using inter-digital low energy and low-cost capacitive sensors that also offer good scalability coupled with ease of installation. Observing that metallic rods are known to undergo self-inductance effects, the authors [14] had proposed a theoretical model of a modified capacitance-type level sensor that offset self-inductance of metallic rods. Bended shielded cables [11, 12] are often used for constructing capacitive sensors instead of stainless-steel rods [15]. The latter not flexible and, therefore, a deterrent in case of applications or installations requiring transportation and installation at remote locations. For the purposes of our research, we have used this form of sensor for reasons as explained as follows and in the manner as shown in the following figure:

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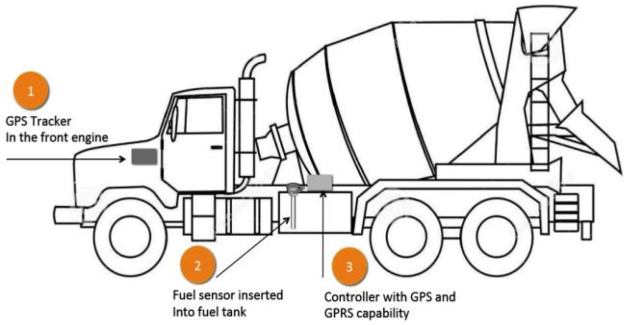

Fig. 3.Remote fuel monitoring system.

1) Resolution of 1 mm enables sensor to obtain accurate readings.
2) Enabling data from three memory registers simultaneously allows it for fast sensor reading.
3) Algorithms ensure that even in conditions of changing temperatures and resultant volumetric changes, the sensor is able to compensate and obtain readings accurately.
4) On-board temperature compensation mechanism enables sensor to counter temperature-related drifts in circuit of the sensor.
5) Since, transit mixers or any vehicle as such may halt in any incline, the sensor is equipped with circuits and hardware to accommodate gravitational angles and still provide accurate readings.
6) The sensor does not require strap chart for calibration. A fuel tank can have any shape or even uneven surfaces, and yet the sensor can be calibrated by marking high- and low-level of fuel inside the tank.
7) The sensor is equipped with 42 registers to store readings such as diameter of the tank, height of tank, high- and low-level calibration marks, etc.
8) Since, many vehicles may share fuel tank dimensions that are the same, a common profile can be saved in central software application. This profile can be re-used to speed up process of calibration to save time and maintain consistently accurate readings.

IV. GPS-GPRS FUEL MONITORING CONTROLLER

1) The controller has been built to withstand sudden electrical changes from equipment batteries, ignition systems, etc. It has twin level of protection circuits at the supply end making it capable to function even in case of frequent voltage fluctuations.
2) It also has a device hardening feature such as a signature-based circuit. This enables seamless recovery even in case of device becoming non-responsive.
3) The controller is equipped with an external serial flash device capable of storing 8 MB of data. Considering that GPRS networks are intermittent or even non-existent in many regions in India, the device is able to store sensor data offline. It is then able to transmit data to Cloud as soon as a stable Internet connection is detected making it suitable for operational conditions in the countryside and the most remote surroundings.
4) On-board sensors and electronics such as accelerometer enable detection of linear motion. It also provides inputs for gathering accurate geo-positional coordinates along with date and time, to support calculations involving speed and distance covered.
5) Firmware and configuration upgrades can be sent over-the-air. Algorithms built-in ensure that in case transmissions are lost while in the process of bulk data firmware upgrades, data integrity checks are conducted so as to ensure that only remaining portion of upgrades need only be transmitted either offline or over-the-air. This is a significant factor as it can help lower network connection costs and increase operational efficiency.
6) Since, the controller supports cellular, Bluetooth and Wi-Fi networks, it is possible to collect data from the controller using a smartphone even in areas where vehicle may be out of mobile network coverage areas.
7) The controller uploads and downloads data to the Cloud. Algorithms used in the controller ensure that data is compressed and secured in small data packets. This feature enables speeding in data transfer. In regions where mobile network is poor, this can be an invaluable facet to transmit as much data as possible.
8) The controller has been designed to operate under the most demanding conditions where it can be subjected to shocks and constant vibrations. It has been developed to sustain vibrations of up to 8G.
9) The controller can also be configured to monitor assets at construction sites and mines. It has support for 16 analog and 12 digital inputs.
10) The controller has GPRS support for quad band GSM services covering 850 MHz, 900 MHz, DCS 1800 MHz and PCS 1900 MHz. It has multi-slot class 10 / class 12 capability and is also capable of supporting GPRS coding schemes ranging from CS -1 to CS -4 [16].
11) The GPS tracking module used is Assisted GPS (A-GPS) capable. This feature aids in start-up performance of GPS tracker by reducing time-to-first-fix (TTFF) required by GPS satellite-based positioning systems [17].
12) GPS tracking is further support by Simultaneous GPS (S-GPS) that improves speed of data transfer through mobile networks [18].
13) The controller is further equipped with 10-30 V battery protection to handle voltage surges, ignition spikes, short circuits and reverse polarity.
14) The controller uses rechargeable lithium ion battery for a 4-hour non-stop operation.
15) To improve signal reception, a 3-meter external antenna is coupled to the controller.

V. RELATED WORK

Fuel monitoring systems have been explored by researchers. The rising costs of fuel coupled with human civilization's insatiable and almost unquenchable thirst for fossil fuels have necessitated researchers to focus efforts on finding out new and innovative ways to monitor fuel consumption. In their quest to seek operational efficiency in terms of fuel consumed over a period and to track consumption history, authors [19] proposed fuel monitoring and vehicle tracking system to fill the pressing need to control and regulate fuel consumption. In our proposed microcontroller-based fuel monitoring and vehicle tracking system, we have used reed switch that works off the principle of Hall Effect. Data collected is stored in the system's memory.

The authors [20] have presented their findings on research into liquid-level sensing. A new type of capacitive sensor was tested in two water storage tanks. In that research, the findings demonstrated that their proposed capacitive sensor displayed equivalent performance metrics comparable to that of commercially available ultrasound water-level sensing devices, but at a lower cost of manufacturing.

In order to detect liquid level variations, a capacitive sensor was installed inside a wafer channel vertically using silicon electrodes [11]. A six-mask IC-compatible process was used for developing this type of sensor. This capacitive sensor was able to return high resolution results and demonstrated that such type of sensor had applications in industrial applications under demanding conditions.

The authors [12] have conducted a survey on the usefulness of integration of various components involving cloud platforms, cloud infrastructure and IoT middleware. Several integration proposals and data analyses techniques were examined with challenges and issues pointed out.

VI. PROPOSED WORK

In our proposed work, we present an automated IoT-based transit mixer system. Our proposed model has been designed to monitor different operating parameters of transit mixer ranging from rear engine operations to geo-positional location of the vehicle itself. The overall tracking and monitoring system has been integrated with Cloud computing and cloud-based application software. With the help of this system, various parameters involving fuel consumption, speed, location, rear engine running hours, total fuel filled, total fuel extracted, etc. can be actively and accurately monitored. The following figure 4 illustrates the proposed architecture of our proposed remote fuel monitoring system.

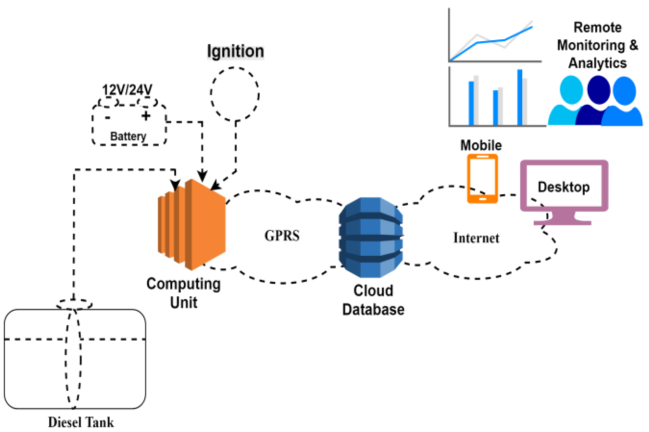

Fig. 4.Architecture of remote fuel monitoring system.

In our proposed design, the capacitive sensor in the fuel tank is automatically activated as soon as transit mixer fuel tank starts filling up with fuel. The sensor generates a series of pules proportional to the rate of flow of fuel. These pulses are converted into metric measurement of liters and are sent to the on-board controllers. This method of working has been based on Hall Effect sensor model. The controller of the hardware stores data and sends it to central server using GPRS. This is not only a cheaper arrangement but also a robust one. GPS detection is activated as soon as transit mixer's ignition is turned on.

A. Challenges and Solution

Since, the rear engine of transit mixer used for our research experiments did not have any point or terminal to enable detection of whether the main engine ignition has been turned either off or on (and this is typical in case of all known models of transit mixers), we proposed a dynamo with an output of 12V installed at the rear engine. This dynamo would be automatically activated by the main ignition and would continue producing 12V so long as the ignition was on and main engine running. The 12V output is necessary to power the GPS sensor unit of our proposed model.

B. Methodology

The following steps are required to be followed for sensor installation (see Figure 5) for our proposed model:

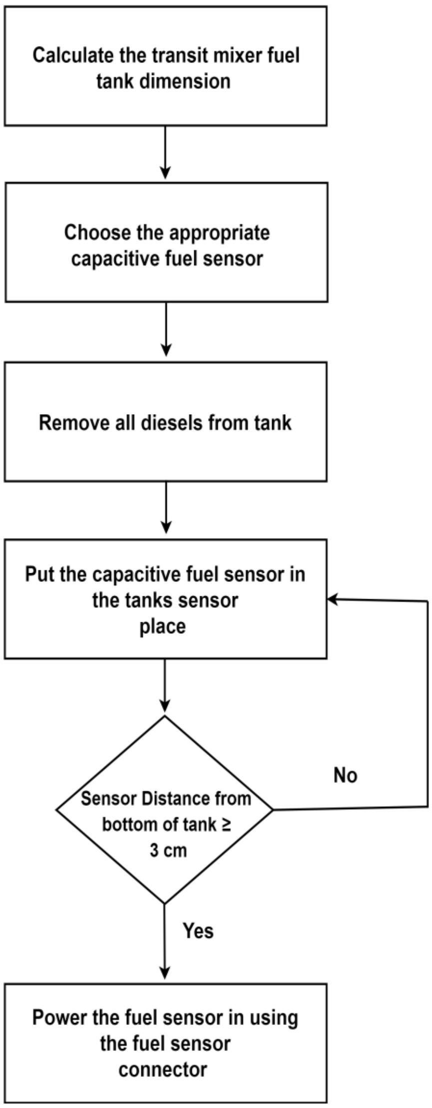

Fig. 5.Flowchart for sensor installation of real-time fuel monitoring system.

1) We calculate transit mixer fuel tank dimensions for selecting appropriate capacitive fuel sensor. The tank dimensions are computed thus (measurements shown are typical examples of a conventional transit mixer fuel tank):
   a. Fuel tank height (H): 1240 mm
   b. Diameter (D): 480 mm
   c. Radius (R): 240 mm
   d. Capacity of fuel tank computed: $\prod \times r^2 \times h = 3.142 \times 24 \times 24 \times 124$ cubic centimetre.
   e. Hence, capacity of fuel tank: 224475 cubic centimetre.
2) Remove all diesel fuel from tank.
3) Install capacitive fuel sensor in tank as shown in figures 6 and 7.
4) Install capacitive fuel sensor in manner such that it does not touch with bottom of the tank and stays at least 3 cm. clear off it. This is to ensure that the sensor does not accumulate dirt and, thus, shorts itself. In case the sensor is short-circuited as a result of improper installation, it needs to be taken out and dirt cleaned before reinstalling it.

Fig. 6.Diesel fuel tank.

Fig. 7.Capacitive fuel sensor in the fuel tank.

5) The fuel sensor has three wires as seen in figure 8:
   a. Red wire: 12 / 24 V positive.
   b. Black wire: Ground.
   c. Green wire: Signal output of 0 – 5 V depending on fuel level detected inside tank.

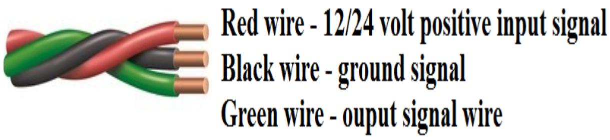

Fig. 8.Fuel sensor wire connections.

6) Provide electrical power to the sensor using the connector provided with the device.
7) To calibrate sensor, empty the fuel tank first and then fill the tank at intervals of 10% of the total fuel tank capacity. At each interval, measure and record voltage readings using an accurate multi-meter across the green signal wire.

C. Other Important Features

In majority of construction projects, and especially in sites that are very large, entry and exit points are usually more than one. Labour contractors supply manual labour force and record the tally through simple count of heads. In such scenarios, biometric facial recognition systems can prove to be beneficial for near accurate tracking of workforce used at any given work-hour period. Transit mixer drivers can be tracked through facial recognition biometric attendance devices with even exact location of transit mixers mapped on digital maps. All the data can be transmitted for instantaneous monitoring and supervision either at central location or at project offices to ensure that the chances of theft are minimized and a close watch maintained. Our proposed real-time fuel monitoring system also acts as an indoor tracking system using ultra-wideband (UWB) with accuracy ranging from 10 cm to 30 cm. This is significantly better than using beacons or Wi-Fi.

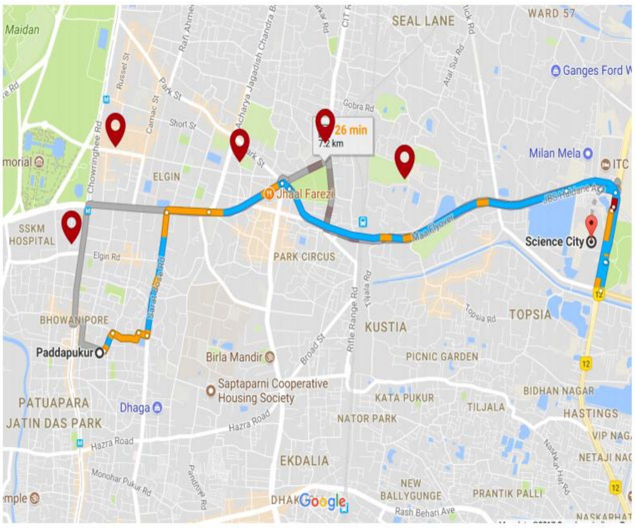

Fig. 9.Live location tracking using fuel tracking system.

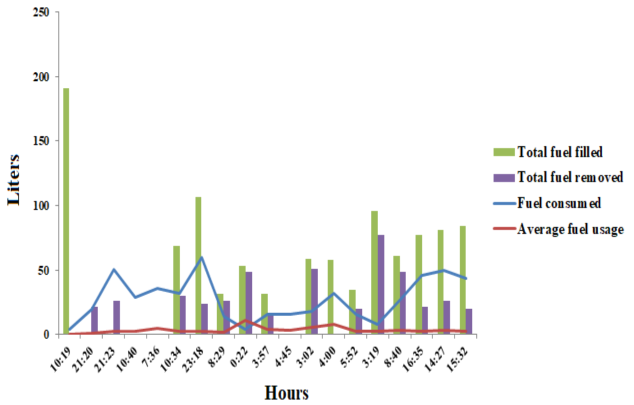

Fig. 10. Fuel consumption analysis of real-time fuel monitoring system.

VII. RESULT ANALYSIS

The results of our experiments have been presented in table 1. We have measured performance of the transit mixer used for our experiments across a range of parameters such as total operational hours, fuel consumed, average fuel consumption, total amount of fuel filled and total fuel removed from a sample period beginning from February 08, 2019 to February 28, 2019 (see figure 10). Approximately 491 litres of diesel fuel was removed from February 08, 2019 through to February 28, 2019 (i.e., 21 days). The loss of fuel as a result of removal was computed at approximately 23 litres per day (491 litres divided by 21 days). Thus, the fuel loss was estimated to be 701 litres. The financial implications of such loss were found to be approximately INR 50000.00 at the prevalent market rate of INR 71.80 per transit mixer truck. The annual loss per year per truck was, thus, estimated to be around INR 600,000.00.

Table- I: Output for real-time remote fuel monitoring system

Asset Number	Date	Total run hours	Fuel consumed	Average fuel usage	Unit	Total fuel filled	Total fuel removed
Asset-#1	18/02/08	10:19	4	0.4	ltr/hr	191	0
Asset-#1	18/02/09	21:20	20	0.9	ltr/hr	0	22
Asset-#1	18/02/10	21:23	51	2.4	ltr/hr	0	26
Asset-#1	18/02/11	10:40	29	2.7	ltr/hr	0	0
Asset-#1	18/02/12	07:36	36	4.7	ltr/hr	0	0
Asset-#1	18/02/13	10:34	32	3	ltr/hr	69	30
Asset-#1	18/02/14	23:18	60	2.6	ltr/hr	107	24
Asset-#1	18/02/15	08:29	14	1.7	ltr/hr	32	26
Asset-#1	18/02/16	00:22	4	11	ltr/hr	53	49
Asset-#1	18/02/17	03:57	16	4.1	ltr/hr	32	16
Asset-#1	18/02/18	04:45	16	3.4	ltr/hr	0	0
Asset-#1	18/02/19	00:02	N/A	N/A	ltr/hr	40	33
Asset-#1	18/02/20	03:02	18	5.9	ltr/hr	59	51
Asset-#1	18/02/21	04:00	32	8	ltr/hr	58	0
Asset-#1	18/02/22	05:52	16	2.7	ltr/hr	35	20
Asset-#1	18/02/23	03:19	8	2.4	ltr/hr	96	77
Asset-#1	18/02/24	08:40	27	3.1	ltr/hr	61	49
Asset-#1	18/02/25	16:35	46	2.8	ltr/hr	77	22
Asset-#1	18/02/26	00:02	N/A	N/A	ltr/hr	0	0
Asset-#1	18/02/27	14:27	50	3.5	ltr/hr	81	26
Asset-#1	18/02/28	15:32	44	2.8	ltr/hr	84	20
Total		194:14	523			1075	491

VIII. CONCLUSION

Our proposed IoT based design for a real-time fuel monitoring system involving transit mixer trucks in operational use at construction projects and at remote sites can be of significant use for construction companies in India. Our primary goal was to extend a solution that would allow managers and supervisors to monitor any number of transit mixer vehicles in operation, from a central location using a Cloud computing infrastructure. Through our research, we have been able to show average running hours, fuel consumed, fuel removed and other related parameters. However, the crucial factor of removal of fuel (whether authorized or unauthorized) is of significant concern for most construction companies as it is one of those parameters that have direct financial consequences. The benefits of our research can be extended to similar other industries where fuel monitoring is of critical concern. Through use of our novel IoT-based fuel monitoring system, we have demonstrated that it is possible to have a detailed operational view of vehicles and engines requiring fuel to operate, across cloud computing systems using cheap yet reliable capacitive sensors.

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REFERENCES

1. M. Lohstroh, E. A. Lee, “An Interface for the Internet of Things,” SEFM 2015, LNCS, vol. 9276, 2015, pp. 20 – 34.
2. R. Lanotte, M. Merro, “A semantic theory of the Internet of Things,” Information and Computation. vol. 259, April 2018, pp. 72 – 101.
3. S. Roy, R. Bose, D. Sarddar, “A Fog-Based DSS Model for Driving Rule Violation Monitoring Framework on Internet of Things,” IJAST. vol. 82, 2015, pp. 23 – 32.
4. S. Roy, R. Bose, D. Sarddar, “Impaired Driving and Explosion Detection on Vehicle for Ubiquitous City,”. IJCIR, vol. 13, 2017, pp. 1167 – 189.
5. TATA MOTORS.: LPK 2518 RMC BS IV-Technical Specifications, 2018.
6. P. Sethi, S. R. Sarangi, “Internet of Things: Architectures, Protocols, and Applications,” J. Elect. and Comp. Engg. vol. 2017, Article ID 9324035, January 2017, pp. 1 – 25.
7. M. Shanmugasundaram, “M2M/ IoT Protocols: An Introduction,” happiest minds blogs, 2016.
8. A. – E., M., M. Hayajneh, N.A. Ali, “Data Management for the Internet of Things: Design Primitives and Solution,” Sensors (Basel), vol. 13, November 2013, pp. 15582 – 15612.
9. D. Bandyopadhyay, J. Sen, “Internet of Things: Applications and Challenges in Technology and Standardization,” Wireless Personal Communications, vol. 58, 2011, pp. 49 – 69.

10. K. Loizou, E. Koutroulis, D. Zalikas, G. Liontas, “A low-cost capacitive sensor for water level monitoring in large-scale storage tanks,” ICIT, 2015, pp. 1416 – 1421.
11. B. Jin, Z. Zhang, H. Zhang, “Structure design and performance analysis of a coaxial cylindrical capacitive sensor for liquid-level measurement,” Sensors and Actuators A: Physical, vol. 223, 2015, pp. 84 – 90.
12. F. Reverter, X. Li, G. C. M. Meijer, “Liquid-level measurement system based on a remote grounded capacitive sensor,” Sensor and Actuators A: Physical, vol. 138, July 2007, pp. 1 – 8.
13. K. Chetpattananondh, T. Tapoanoi, P. Phukpattaranont, N. Jindapetch, “A self-calibration water level measurement using an interdigital capacitive sensor,” Sensor and Actuators A: Physical, vol. 209, 2014, pp. 175 – 182.
14. S. C. Bera, H. Mandal, S. Saha, A. Dutta, “Study of a Modified Capacitance-Type Level Transducer for Any Type of Liquid,” IEEE Instrumentation and Measurement Society, vol. 63, March 2013, pp. 641 – 649.
15. V. Milosavljevic, Z. Mihajlovic, M. Zivanov, “Implementation of low cost liquid level sensor (LLS) using embedded system with integrated capacitive sensing module,” MECO, June 2012, pp. 58 – 61.
16. T900 User Guide. Shanghai SIMCom Wireless Solutions Ltd. 1.02, 2013, pp. 1 – 35.
17. A. K.-s Wong, T. K. Woo, A. T.-L. Lee, X. Xiao, V. W.-H. Luk, K. W. Cheng., “An AGPS-Based Elderly Tracking System,” ICUFN, June 2009, pp. 1 - 6.
18. G. Milette, A. Stroud, “Professional Android Sensor Programming,” John Wiley & Sons, June 2012, vol. 6, pp. 1 - 552.
19. S. Aher, R.D. Kokate, “Fuel Monitoring and Vehicle Tracking,” IJEIT, vol. 1, 2012, pp. 166 – 169.
20. K. Loizou, E. Koutroulis, “Water level sensing: State of the art review and performance evaluation of a low-cost measurement system,” Measurement, vol. 89, 2016, pp. 204 – 214.

AUTHORS PROFILE

Dr. Rajesh Bose is an Associate Professor of the Department of Computational Science at Brainware University, West Bengal, India. He was awarded a doctorate degree in Computer Science and Engineering from University of Kalyani, India in 2017. Before completing his PhD, he had graduated with B.E. in Computer Science and Engineering from Biju Patknaik University of Technology (BPUT), Rourkela, Orissa, India in 2004. He completed his M.Tech. in Mobile Communication and Networking from Maulana Abul Kalam Azad University of Technology, West Bengal (formerly known as West Bengal University of Technology or WBUT) in 2007. Dr. Bose has industry experience of over 14 years working for one of the largest civil engineering construction companies in India helping build, modernize and maintain one of its kind Data Center. He holds several certifications on Citrix and has served on several special task groups charged with designing, developing, conducting proofs-of-concept with leading vendors in the field of Cloud Computing and IoT technologies. His research interests span Cloud Computing, Fog Computing, IoT, wireless communication, virtualization and networking. There are currently more than 50 publications to his name and with over 10 published books. A major portion of his research works have been published by leading global journals and conferences worldwide. Prior to joining industry, he held teaching positions at colleges for a number of years. His academic and professional experience accords him a unique position among his peers.

Dr. Sandip Roy is the head of the Department of Computational Science at Brainware University, West Bengal, India and an Associate Professor. Dr. Roy was awarded his PhD in Computer Science & Engineering in 2018 by the University of Kalyani, India. Prior to his PhD, he completed his B. Tech. and M. Tech. from Maulana Abul Kalam Azad University of Technology, West Bengal (formerly known as West Bengal University of Technology or WBUT) in 2008. Dr. Roy has more than 40 research papers published in peer-reviewed journals and conferences. He is also the recipient of the Best Paper Award from ICACEA in 2015. In addition to publishing research papers, he has written several books on Cloud Computing, Fog Computing, Wireless networking, IoT and related technologies. His areas of research interests include Data Science, Internet-of-Things, Cloud Computing and Smart Technologies.

Ms. Srabanti Chakraborty is an Assistant Professor at the Elitte Institute of Engineering & Management, Kolkata. She is also the head of department of Computer Science & Technology at the said institute. Ms. Chakraborty holds a M.Tech. degree in Computer Science & Technology from Maulana Abul Kalam Azad University of Technology, West Bengal (formerly known as West Bengal University of Technology or WBUT) which she completed in 2012. She also successfully completed MCA degree programme from Indira Gandhi National Open University (IGNOU) in 2009. Ms. Chakraborty has several peer-reviewed research papers to her name that have been published in several prominent national and international journals as well as in conferences. Her main research areas of interest are Cloud Computing, Internet-of-Things and Big Data.

Mr. Indranil Sarkar is an Assistant Professor at the department of Computational Science, Brainware University, India. He completed his MCA from Kalyani Government Engineering College in 2005, and M. Tech. in CSE from SKFGI in 2018. Mr. Sarkar is also a B.Sc. (Hons.) graduating with mathematics in 2000. He currently works on embedded systems and Internet-of-Things.