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Development of an IoT Based Process Plant Emission Controller

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Abstract— *Climate change problems emanates largely from the process industries globally. A control scheme using Dynamic Resource Allocation (DRA) in an emissive process plant was developed in this thesis. A field survey was conducted at Coca Cola Nigeria Ltd. Plot 126 Trans Amadi Industrial Layout Road, Port Harcourt, Rivers State, Nigeria to ascertain better ways of managing Carbon dioxide (CO_2) emissions in concurrent process plants. With the aim of overcoming the challenges of conventional process plants and inspired works by relevant authors, the work adopted an Unsupervised Machine Learning Algorithm based on Pattern Discovery and Reinforcement Learning (UML-PDRL). A DRA that is SMS activated for the automation aggregated process plants was implemented to address the issue of industrial plant concurrency for emission conservation. An SMS control signaling using UML-PDRL was used to give an on-demand SMS signal to a plant agent such that the running plant shuts down on its allocated time and triggers another plant and also shuts down on its own when it gets to a certain threshold to solve the problem of CO_2 emission. C++ programming and Arduino Uno board was used to characterize an emulated process plants. A validation study on supervised, unsupervised and semi supervised algorithms were carried out through estimation inspection. The efficiency obtained were 4.24%, 4.94% and 90.82% respectively; the latency response was 33.33%, 41.67% and 25.00% respectively. The results showed better resource allocation in the clustered plants using unsupervised algorithm.*

Keywords— *Internet of Things: IoT Based Emission Controller: Process Plant Emission: Machine Learning Algorithm: Automation Aggregated Process Plants.*

I. INTRODUCTION

The advent of computing technology era brought more emphasis on the increasing importance and utilization of Internet of Things (IoT). IOT is a sort of "universal global neural network" in the cloud which connects various things. [1]. The IoT is an intelligently connected devices and systems which is made up of smart machines interacting and communicating with other machines, objects and environments. The Radio Frequency Identification (RFID), sensor network technologies and infrastructures have this as new challenge to rise up to. As a result, an large amount of data are being generated, stored, and processed into useful actions that can "command and control" industrial process plants which reduces our impact on the environment to a much easier and safer level.

The Internet of Things (IoT) is the network of physical objects, i.e devices, buildings, vehicles and other items embedded with electronics, sensors, software and network connectivity that enables these objects to collect and exchange data [2]. As a recent communication paradigm that envisions a near future, the IoT is the objects of everyday life equipped with transceivers for digital communication, microcontrollers, and suitable protocol stacks that enable them to communicate with one another and with the users, becoming an integral part of the Internet [3]. The IoT concept, hence, is geared towards making the Internet even more pervasive and immersive. Furthermore, by enabling easy access and interaction with a wide variety of devices such as surveillance, home appliances, cameras, monitoring sensors, actuators, vehicles, and so on, the IoT will facilitate the development of applications that make use of the potentially huge amount and variety of data generated by such objects to provide new services to individuals, public administrations and companies. Many different domains such as industrial automation, medical aids, home automation, mobile healthcare, elderly assistance, intelligent energy management and smart grids, automotive, traffic management, and many others actually find application in this paradigm [4]. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure**,** creating opportunities for more direct integration of the physical world into computer-based systems and resulting in improved accuracy, efficiency and economic benefit**.** Industrial process plant automation for emission control is achieved in this research work using the internet of things together with embedded system.

A typical embedded system has been designed as a control-dominated system making use of only one state-oriented model, such as Finite State Machines (FSMs). Highly distributed architectures with support for concurrency, control flow, data, and scalable distributed computations have been the trend in embedded systems design in recent years. This implies that a different approach is necessary [5]. An embedded computing and communications technology extends into all aspects of our everyday life from process automation, automotive, manufacturing and avionics control systems, through personal health-care monitoring and medical systems, local environmental monitoring for weather forecast and smart agriculture, to consumer electronics and home appliances. Within the more general area of embedded computing, the concept of distributed embedded systems refers to the collaboration among connected devices such as tiny stand-alone embedded microcontrollers, networking devices, embedded PCs, computer peripherals, robotics systems, wireless data systems, sensors, and signal processors resulting in networked systems of embedded computing devices whose functional components are nearly invisible to end users [5].

New approaches are required to naming, routing, security, privacy, resource management, and synchronization for successful implementation of such a dynamically reconfigurable distributed system [6]. An embedded system is a computer system designed to perform only one or more specific functions [7]**.** Specifically, embedded system means a system with processor, memories and input/output integrated with software to control that hardware to perform specific objectives.

Due to the ongoing global crisis resulting from Global warming by excessive CO_2 emission into the atmosphere and when it gets to certain threshold, it begins to cause environment hazard. Nigeria has about 37.4% of CO_2 and it is the burning of hydrocarbons that are the causes of these emissions due to over dependency of fossil fuel gas. Most industrial plants run for a very period of time, and the more these plants run, the more they inject the atmosphere with the fossil fuel which are cancerous to human cells thereby causing health implications.

One major problem of industrial plants mostly in Nigeria which brings about more injection of fossils fuel to the atmosphere is the concurrent running of the industrial plants without timing control process which is very harmful and cancerous to human lives. Also, most of the industrial processes engage in partial automation (manually driven). Therefore, there is need to develop an efficient system to regulate the process operation by resource allocation to the distributed process plants with a time base scheduling in ensuring that the plants do not run concurrently and to save energy, thereby reducing the CO_2 emissions.

In recent years, the deployment of high quality, better efficient and automatic machineries have improved in the industrial region of distributed plants. Distributed plants have need of continuous monitoring and check at frequent intervals. There are possibilities of errors at measuring and various stages involved with the personnel and also the lack of few features of microcontrollers. Hence the enumerated issues necessitated the importance of this research work.

In the light of rising energy costs, limited deposits of raw materials and global warming due to CO_2 emissions, the efficient use of energy is continually gaining importance. The world's population is growing fast and, with it, the consumption of energy and resources. The consequence is a measurable change in climate. There is an immediate and urgent need for action in terms of reducing CO_2 output. In order to prevent devastating climatic damage (global warming of more than 2°C above preindustrial levels), man-made emissions must be reduced by at least 25 to 40% by the year 2020 [7]. The term energy management system in the stricter sense is a technical system for gathering, analyzing, documenting, and visualizing energy data, as well as for regulating and monitoring energy consumption in industrial plants. The science of remote sensing and control has emerged as one of the most fascinating subjects over the years.

In this research, an effective IoT based control in industrial plants is needed to regulate the process operations via resource allocation. This involves a time based strategy. Furthermore, an SMS activated Machine Learning Algorithm will be employed to manage the operations of the plant with the Distributed Control System (DCS) with the objective of reducing gas emissions. This research focused on field study and investigation, and process plant used for industrial application based on their plant control mechanism at Coca Cola company Port Harcourt and to create the awareness on IoT based control and also to make it a reality in Nigeria.

II. Literature Review

Several previous related research works have been done in the field of process plant emission control. The growing recognition of the effect of carbon dioxide emissions on global warming has sparked development of a number of technologies for reducing the impact of energy production [8]. The authors in [9] proposed a system using GPRS Technology for remotely monitoring of Industrial Plant. The research in [10] presented a remote monitoring system control of Industrial Plant using a ZigBee. Manufacturing industries have many different types of robots each with their own complex physical and logical structure. A research on the remote monitoring system control of Industrial Plant using a SCADA scheme is present in [11]. Another fundamental aspect is the necessity to make the data collected by the urban IoT easily accessible by authorities and citizens, to increase the responsiveness of authorities to city problems, and to promote the awareness and the participation of citizens in public matters [12].

Many research gaps are established in the above review of the works in literature. Most of the existing Industrial Processes in the Nigerian environment engages in partial automation (manually driven), therefore, there is need to develop an efficient IoT driven system to regulate these process plants. Overtime is has been observed that the issue of emission and its subsequent effect is terrible. Most research work in process plant control have not really investigated much on how to formulate strategy on resource allocation in controlling industrial plants. In order to control and manage the operations of industrial plant using a time based scheduling to avoid concurrent running of plants and to conserve emission.

III. Objectives of the Research

The main objective of this research is the development of an IoT based process plant emission controller. The specific objectives of this research include:

a) To formulate a strategy in resource allocation in distributed process plants for the reduction of Green House Gas (GHG) emissions into the atmosphere.
b) To design an IoT remotely managed plant operation device based on a time based scheduling technique to avoid concurrent running of process plants and to conserve emission.
c) Using an Unsupervised Machine Learning Algorithm for an SMS based control.
d) To validate the developed system using real time prototype and simulation experimentations.

IV. Process Plant Controller Design

The actual design and development of an IoT based process plant emission controller is achieved in this section.

The strategy for allocation of resource in distributed process plants is formulated to reduce the emission of Green House Gas (GHG) into the atmosphere is presented. This is followed by the design of an IoT for remote management of plant operation device based on a time based scheduling technique to avoid concurrent running of process plants and to conserve emission. Furthermore, an Unsupervised Machine Learning Algorithm is used for an SMS based control in order to validate the developed system using simulation experimentations and real time prototype.

Some of the main components used for the research include: A PIC16F877A microcontroller, Liquid Crystal Display (LCD), GSM module, User phone, Relay, Diodes, Transistors, Temperature sensor (lm35). The Software tools used in the course of this research includes; MP LAB development environment, C++ and Discrete event modeler.

The controller is also connected to sensors used for monitoring and to provide data in order for a process to be controlled remotely. This could be as simple as the use Android devices. This task can be done in real time by sending the data to a remote computer, analyzing it and bringing a command back to the line such that various control actions can be taken to improve the process without any human intervention.

To derive a strategy in resource allocation in distributed process plants for the reduction of Green House Gas (GHG) emissions into the atmosphere, an IoT controller is employed whose architectural design description is presented in figure 1.0.

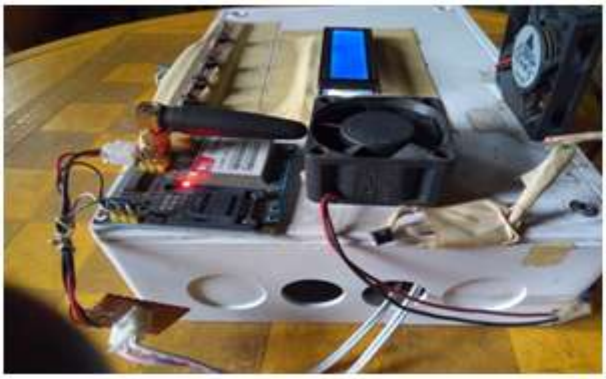

Fig. 1.0. Design of the IoT Controller Test bed.

The physical system design of the controller is shown in figure 1.0. The design modules and subsystems for the IoT controller are discussed in the following subsections.

A. Controller Design Architecture/Analysis

This controller design of the emission based process plant control system is presented considering its application in addressing industrial problem of emission control. Through this IoT controller, the plant control system is established to control a user agent using the low-power ZigBee. With the ZigBee agent embedded in the IoT controller, the remote process plant and agent-based users are able to obtain the access right of controlling the IoT controller driven process plants. GSM communication with the ZigBee-based IoT controller is activated.

B. Controller IoT Serial Port Control Module

The main task of this module is to establish the USB serial port in the Linux operation system (OS). This module provides read and write functionalities for the Command Process Module. The IoT ZigBee transceiver could communicate with other devices through a ZigBee USB dongle that is connected to the controller access point for the IoT controller. Machine language source library is used to control the serial port. This open-source library is used to enable the 8N1 (eight data bits, no parity, one stop bit) for the serial port. It also supports data reading and writing functions for the serial port, which is applicable in Windows and Linux OS. As such, the serial port is able to support command sending and receiving functions for the Command Process Module and the HTTP Command Process Module.

C. IoT Command Process Module

The IoT controller ZigBee transceiver sends a streaming command with several requirements to a remote agent for plant controls. Upon receiving the command from the IoT Rx-ZigBee module, the Command Process Module sends it to the corresponding Tx module for execution.

D. IoT ZigBee Device Management Module

In order to allow the IoT ZigBee agent to manage several plant generated data process simultaneously, The IoT ZigBee Device Management Module handles both the plant and user commands received from the Command Process Module. According to the plant/user command, this module collects the information with regards to the required data and translates each of them into a specific streaming format with several fields, i.e., management information. After that, the ZigBee Device Management Module provides the management information to the UPnP Device Management Module and the HTTP Command Process Module. In implementing the highlighted feature, this module is configured to efficiently manage each IoT ZigBee device (Rx and Tx) and stipulate a data structure to save the management information.

E. UPnP Device Management Management Module

To allow remote users to discover the plant processes/devices, the IoT UPnP Device Management Module applies the UPnP MLA protocol to broadcast the information of ZigBee devices on to the network. Therefore, the remote users are able to discover the plant process devices and subsequently perform the control accesses of these devices. In this research, the UPnP is a service discovery via MLA whose purpose is to allow various devices connect together via Internet communication network. This module services the plant device, its services, and the GSM user agent via a smartphone. It is responsible for searching and controlling all the devices/processes on the network. In this situation, this module provides streaming to execute the command for processing discovered events/activities.

F. IoT HTTP Command Process Module

The IoT controller sends and receives commands to/from remote user through HTTP standard protocol and from the interface plants. Therefore, a web server is required for the IoT ZigBee agent side and the user agent controller. The IoT

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HTTP module connects the embedded processes with remote web servers built on top of the device management framework.

G. IoT Channel Allocation Module

As shown in Figure 2.0, to avoid channel interference, a Channel Allocation Module is designed for channel negotiation and allocation between GSM, Wi-Fi/ZigBee networks. The Wi-Fi interface has a quick response time for channel scanning and report to the Channel Allocation Module. A channel that does not overlapped with the existing channels used in GSM, Wi-Fi or ZigBee is allocated to the IoT controller coordinator so as to avoid contention and collision.

H. IoT Energy Process Module

This module allows IoT driven networks to switch mode from power saving to emergency. Staying in the emergency model, the IoT controller utilities a short frame that allows each device reporting their readings to the coordinator for upward transfer to end users. It is also accounts for energy efficiency in the complete network design. It regulates the channel allocation, Interface bridge as well as external connections to the IoT controller.

The Proposed System Architecture of the IoT Controller running with MLA is shown in figure 2.0.

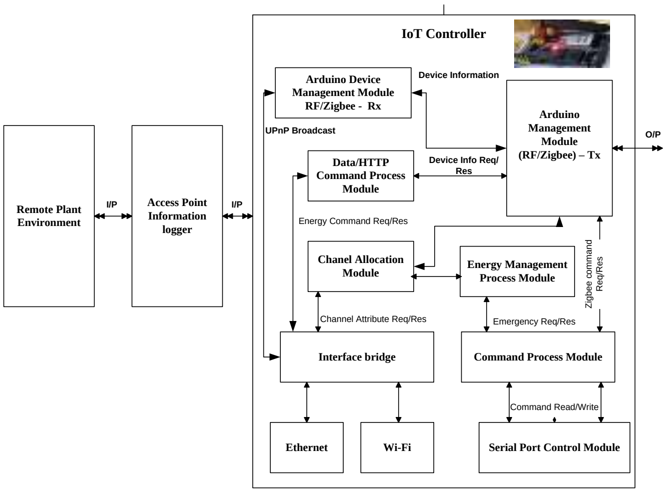

Fig. 2.0. Architecture of the IoT Controller running with MLA.

V. Experimental Methodology

The experimental methodology adopted in this research involves a physical survey and investigation on a process plant used for industrial application. This is desirable in other to develop an emission control system device for industrial process. The system design for emission control of IoT system is developed considering the network plant parameter viz: network timing, traffic heat and resource allocation. This will facilitate the development of an experimental prototype for validation.

A. Survey Methodology

In the context of this research, the methodology adopted involves a Physical Survey and Investigation of the Process Plant used for Industrial Application. The physical survey was carried out in a plant industry in Rivers State, Nigeria and investigations were produced for the design frame work.

B. Field Survey and Investigation

The first step applied in the field survey was to find out issues that are peculiar to existing plant control system. A Field study report was carried out of a process plant at Coca Cola Nigeria Ltd. Plot 126 Trans Amadi Industrial Layout Road, Port Harcourt, Rivers State, Nigeria. The name of the plant is called a bottling Plant (Manufacturing Plant) and the control automation currently embedded in the system is electromechanical and pneumatic control automation.

The observations are based on most of the process plants found in manually driven industrial settings visited. The plant is made of three key components modules/units namely the Line 2 (RGB: Returnable Glass), Line 4 (OWP: One Way Pack) and Line 5 (OWP: One Way Pack)

C. System Block Diagram Decomposition

Figure 3.0 shows the block diagram of the IoT control model system based on ULPR. The remote operator (agent base) connects to the plant through an SMS activated by an IoT. Any Android device could be used for this purpose. An emission control command is sent to the system to shutdown process plant machines in a localized area. The command reaches the system through the GSM/IoT module which passes it to the processor. The processor reads the commands, understands them and then switches ON or switches OFF the plant machines through the power switch. The plant machines are then examined by the processor to ensure that they are OFF or ON as the case may be. This information is then sent back via SMS/IoT to the remote plant operator as feedback. The remote operator can also send command to know the plant temperature.

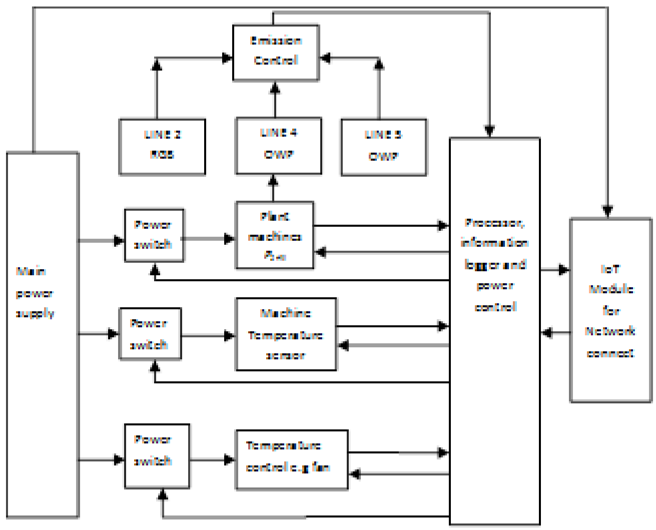

Fig. 3.0. Block Diagram of IoT Based Plant Control System.

The processor reads the process plant machine temperature sensor and back to the remote plant operator. At this stage, the Agent remote plant operator can know the operating temperature of the plants. Subsequently, the plant agent can switch ON the fan so as to reduce the temperature at the event of very high temperature scale. Similarly, the system switches

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OFF the fan if temperature is too low. The agent can equally switch OFF the temperature sensor if the temperature is fairly constant and wants to save power or implement some power optimizing algorithm.

VI. Validation of IoT Emission Controller

The proposed emission control design for resource allocation considering four selected process plants were deployed in a validation testbed in Figure 1.0 using the flow diagram. Riverbed 17.5 Modeler was used with extended defined libraries.

The simulation settings for evaluating the proposed algorithm is as follows: 2 IoT processor nodes with the four process plants were randomly deployed in 100 ×100 m^2 sensor field. The transmission range of each sensor was set to 100*m*. Maximum communication channel bit rate was set to 250*kbps*. Each packet size was set to 128bytes. The control packet size (RTS, CTS, and ACK) was set to 3 bytes. The maximum receive lifetime was set to 0.5J and the weight used in the weighted moving average distribution set to 0.1.

In the simulation, the sensor nodes emulated the MAC layer protocol while sensing and sending the traffic parameters to the sink. For optimal simulation response, the node buffer size was varied in consonance with the data rates from 10 to 250kbps. Each queue size was set to hold maximum of 15000 packets. The total queue length for the node was set to 10000 packets. Throughout the simulation, this work used a fixed workload that consists of 7 sources and 1 sink.

Algorithm interfacing is simply done in the discrete event Riverbed stimulation engine after importing it. This is seen as the trace file if the complier successfully executes the procedure or algorithm. This then facilitates the simulation run time and generates the expected result plots concurrently. In the simulation, the term buffer and queue were interchangeably used to express the traffic conditions on the nodes. The three schemes and their algorithms were setup in concurrent scenario event which lasted for 120secs.

VII. Performance Evaluation

The emphasis of this research is to determine the emission control efficiency of the proposed Unsupervised MLA (Machine Learning Algorithm). This work has compared the proposed Unsupervised ML algorithm with Semi-supervised and supervised schemes. Both Semi-supervised and supervised schemes perform distributed rate adjustment of the FIFO queues on the IoT nodes, but not scheduling of the FIFO queues. So in order to quantify the performance of the proposed unsupervised ML scheme, an experimental validation procedure was set up in the Riverbed simulation environment taking cognizance of the common metrics for the three scenarios.

In the new environment involving a production testbed, the essence of a simulation analysis is to enable this work to have good basis for its justifications. In this work, an extensive simulation verification to evaluate the performance of proposed unsupervised ML algorithm is presented in Figures 4.0 and 5.0.

Fig. 4.0. IoT Emission process control testbed with MLA.

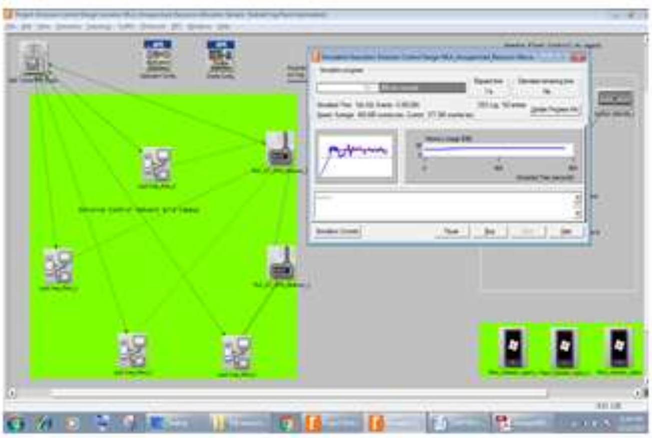

Fig. 5.0. IoT Emission process control simulation run with MLA.

VIII. Results and Discussion

A. *Emission Control Efficiency*

The on-demand trigger from the IoT processor as well as the control SMS from a plant agent represents a typical full duplex interaction at specific intervals. In the scenarios, each node sources traffic at the rate specified and forwards same to the sink based on the status of each process plant. From Figure 4.1, the normalized emission efficiency behavior is depicted in the plot. The Unsupervised ML, Semi-supervised and supervised offered 90.82%, 4.94% and 4.24% respectively. This implies that the unsupervised association rules and K-clustering have significant impact in emission control of process plants. The implication of this result is that the system can sufficiently reduce the high emission index values as shown in table 1.0 and figure 6.0.

B. *Latency Response for End-to-End Signaling*

Figure 7.0 shows how in the presence of the offered machine learning algorithms varies with each other given the same number of process plant concurrency. From Figure 7.0, the normalized latency behavior was depicted in the plot. The Unsupervised ML, Semi-supervised and supervised gave 25.00%, 41.67% and 33.33% respectively. Since the IoT point to point communication requires lower latency response, the unsupervised offers the best alternative for signaling.

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TABLE 1.0. Emission Control Efficiency.

SimulationTime (sec)	Emission Control Efficiency-MLA_Semisupervised_Resource Allocation Senario-DES-1	Emission Control Efficiency-MLA_Supervised_Resource Allocation Senario-DES-1	Emission Control Efficiency-MLA_Unsupervised_Resource Allocation Senario-DES-1
0	1.60099E-05	1.60099E-05	1.86928E-05
18	1.58318E-05	1.58318E-05	1.90037E-05
36	1.60911E-05	1.60911E-05	1.86929E-05
54	1.63224E-05	1.63224E-05	1.91715E-05
72	1.5871E-05	1.5871E-05	1.95975E-05
90	2.44755E-05	2.02249E-05	3.51921E-05
108	3.38145E-05	2.48938E-05	4.18158E-05
126	3.99196E-05	2.86591E-05	5.13414E-05
144	4.28572E-05	3.08374E-05	5.99116E-05
162	4.62564E-05	3.39863E-05	6.3208E-05
180	4.91519E-05	3.41922E-05	6.77438E-05
198	4.65815E-05	3.29834E-05	6.36721E-05
216	4.56901E-05	3.38667E-05	7.15326E-05
234	4.38901E-05	3.41675E-05	8.34778E-05
252	4.3485E-05	3.55153E-05	8.42243E-05
270	4.48744E-05	3.74427E-05	8.67351E-05
288	4.49231E-05	3.73065E-05	9.02224E-05
306	4.56016E-05	3.63833E-05	9.15098E-05
324	4.82554E-05	3.57861E-05	9.23612E-05
342	4.67714E-05	3.75582E-05	9.43652E-05
360	4.79825E-05	3.71832E-05	9.30584E-05
378	4.69488E-05	3.69602E-05	9.33699E-05
396	4.7218E-05	3.73889E-05	9.51117E-05
414	4.605E-05	3.86527E-05	9.76236E-05
432	4.66369E-05	3.93224E-05	9.95584E-05
450	4.72351E-05	3.91739E-05	9.92488E-05
468	4.91439E-05	4.05364E-05	9.73462E-05
486	4.95636E-05	4.06454E-05	9.47149E-05
504	4.97999E-05	4.12849E-05	9.63662E-05

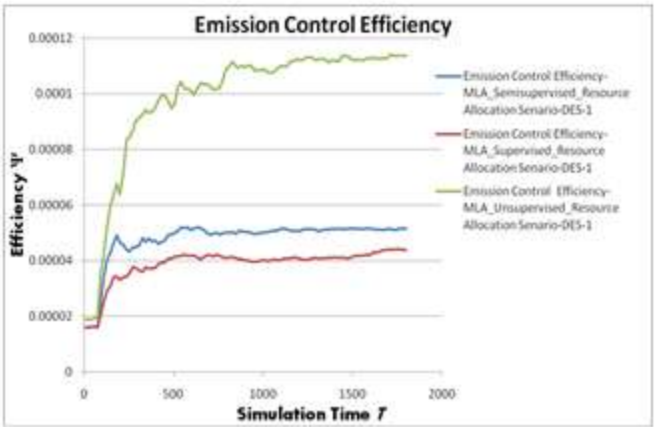

Fig. 6.0. Emission control Efficiency plot.

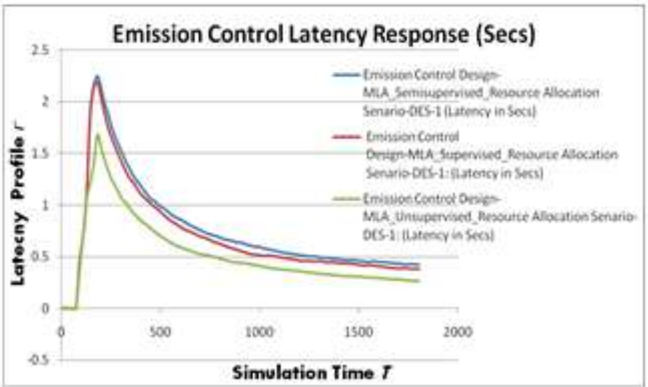

Fig. 7.0. Emission control End-to-End latency response plot.

C. Emission Control Utilization Response

Figure 8.0 shows the utilization behavior of the emission control system. Using the unsupervised ML algorithms, the resource utilization is optimal and contributes to control efficiency when compared with other related algorithms.

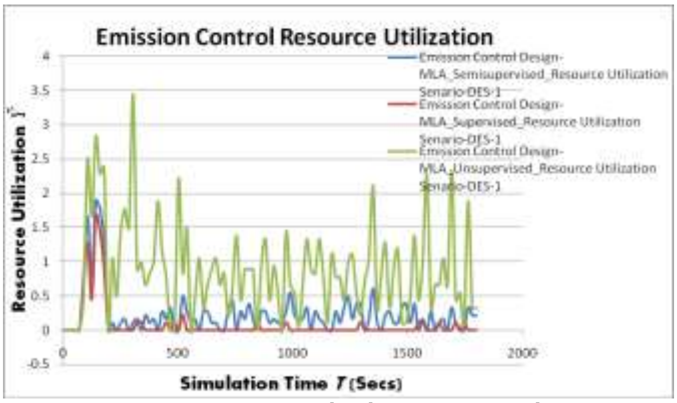

Fig. 8.0. Emission control Utilization Response plot.

IX. CONCLUSION

This research has presented an IoT based emission control system that could influence the mean surface temperature. The work discussed various emission control schemes in the light of rising energy costs. The work established that the global warming due to CO_2 emissions can be addressed by leveraging a conceptual framework involving IoT driven Machine Learning Algorithm. The Machine Learning Algorithm is SMS activated and was implemented in the IoT device to

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address the issue of concurrent running of industrial plants and to conserve emission. In context, an Unsupervised Machine Learning Algorithm based on Pattern Discovery and Reinforcement Learning (UML-PDRL) was employed. An SMS control signaling using UML-PDRL was used to give an on-demand SMS signal to a plant agent such that the running plant shuts down on its allocated time and triggers another plant and also shuts down on its own when it gets to a certain threshold to solve the problem of CO_2 emission. C++ programming and Arduino Uno board were used to characterize an emulated process plants. A validation study on supervised, unsupervised and semi supervised algorithms were carried out through estimation inspection. The efficiency obtained were 4.24%, 4.94% and 90.82%, respectively; the latency response are 33.33%, 41.67% and 25.00% respectively. The results showed better resource allocation in the clustered plants using unsupervised algorithm.

REFERENCES

[1] Vandana Sharma, Ravi Tiwari, "IOT" & It‟s Smart Applications," Journal of Mathematics and Computer Science," *International Journal of Science, Engineering and Technology Research (IJSETR)*, vol. 5, issue 2, pp. 113–127, 2016.

[2] Anjaly Subhash and Bibi Mohanan "Supervisory Control and Data Acquisition for A DHDS Substation," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 4, Special issue 1, pp. 61-68, 2015.

[3] Atzori, L., Lera, A., and Morabito, G., "The internet of things: A survey," *Computer Networking*, vol. 54, issue 15, pp. 2787–2805, 2010.

[4] P. Bellavista, G. Cardone, A. Corradi, and L. Foschini, "Convergence of ManeT and WSN in IoT urban scenarios," *IEEE Sens. J.*, vol. 13, issue 10, pp. 3558–3567, 2013.

[5] M. Sergey, S., and Peter, P., "International Symposium on intelligent manufacturing and Automation", DAAM, 254–275, 2014.

[6] Kopetz, H., "Real Time System: Design Principle for Distributed Embedded Application," Sprinyer Science + Business Media, 2011-378, 2011.

[7] Won-Hyuck, C., and Min-Seok J., "International Journal of Multimedia and Ubiquitous Engines" vol. 11, issue 4, pp. 147-156, 2016.

[8] Richard, E., and Debnath, P., "Stopford Projects Ltd, Chestes UK. Waste to Energy Plant Process Safety Challenges", vol. 3, issue 4, pp. 309–312, 2011.

[9] Kirubashankar, R., Krishnamurthy, K., and Indra, J., "Remote Monitoring System for Distributed Control of Industrial Plant Process," *Journal of Scientific and Industrial Research*, vol. 68, issue 10, pp. 858-860, 2009.

[10] Shivani, B., Bhargav, G., and Ameya, S., "Industrial Automation and Sensing using ZigBee," *International Journal of Computer Applications*, vol. 105, no. 10, pp. 37-40, 2014.

[11] Priyanka, S., Nikita V., and Tejaswini J., "Automation Based Industrial Plant using SCADA," *International Journal of Latest Engineering and Management Research (IJLEMR)*, vol. 1, issue 3, pp. 20-24, 2016.

[12] E. A. Mulligan and M. Olsson, "Architectural implications of smart city business models: An evolutionary perspective," *IEEE Commun. Mag.*, vol. 51, issue 6, pp. 80–85, 2013.