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SINGLE NODE ARCHITECTURE FOR ANALYSIS AND CONTROL OF MRAC BASED INDUSTRIAL DC DRIVE SYSTEM EMPLOYING INTERNET OF THINGS (IoT)

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ABSTRACT:

The industrial revolution has seen a significant makeover in the last decade, with a major move towards wireless communication and control. Data Analytics has become a momentous part of this revolution, with decision making at its core. With the rise in usage of cloud computing, enterprise resource planning and office systems have experienced a major paradigm shift. It has all resulted in efficient control processes on the shop floor by bridging the information gap between the shop floor and the higher management. The next thing which has popped up as a part of this ever evolving Industrial Revolution 4.0 is Internet of Things (IoT), which has made connectivity a necessity more than a need. Eventually, low latency IoT devices will bridge the gap and turn out to be the key drivers for extensive penetration of wireless control technologies in industrial automation systems.

This paper provides an architectural overview for employing an IoT based solution to analyse and control DC Drives on the shop floor level. A general control model is derived from proposed architecture by refining some existing control methodologies employed previously. The proposed model will offer automation functions as services from evolving and scalable dynamic infrastructure.

KEYWORDS:

DC Drives, Control, Automation, OSHW, Cloud Computing, Signal Processing, Internet of Things (IoT), Wireless Communication Systems, Industrial Revolution 4.0

INTRODUCTION

Today, industrial automation systems are paced along with the emerging markets and their demands where agility and flexibility in production units is inevitable. From what is seen as a future, the fourth industrial revolution will grow based on and around “intelligent” production systems. The main focus for Industrial Revolution 4.0 are interconnected smart devices, autonomous objects and past experience based decision making processes [1], all of this employed by using new technologies from Information Technology (IT) domain.

Wireless communication systems have been employed as Industrial Automation Applications (IAA) for more than 10 years. With its subdivision into process automation and discrete factory automation, wireless systems are employed in context to connection of movable machine parts or mobile machines integrated as a part of distributed control systems. The other benefits of shifting towards this technology are cutting off of the high maintenance costs, wear and this reliability. Hence, they are the best choice for connecting machine parts being subsequently installed during unavoidable modernization process.

The newest trend in IT, IoT, has already become an enabler for futuristic automation systems by influencing multiple areas like office and enterprise systems. Owing to its many features, many enterprises worldwide have adopted and are focusing on moving their work over to cloud systems [2]. Today the cloud systems used majorly focus on data collection and analysis at the managerial level within industry. The challenge ahead is practically employing systems which will extract this analysis data, make informed decisions from past experiences and future performance guidelines, and execute control over the shop floor. This work aims at analysing this question further and proposes a reliable possible way out to ensure effective ways at developing human less control strategies.

2. RELATED WORK

The currently deployed cloud based automation systems, do not consider data analysis based closed loop control application. They put the outermost challenges on real-time behaviour of control systems. Existing works related to cloud computing in automation focus on individual automation levels. Most of these works aim at migrating data from hierarchical to flat architecture.

a. Management Level Automation

The current systems working at this level are responsible for gathering data from various lower level systems and analysing them for decisions to be made by the managerial level. This segment majorly deals with analytics and informed decision making.

”Cloud Manufacturing” is a business model which focuses to transform traditional manufacturing business model into intelligent factory networks which shall encourage effective collaborations. Similarly, P´erez et al. [3] proposed a new manufacturing model called “Cloud agile manufacturing”. The goal of this work is to offer industrial automation function as a service to enable the managerial level users to access functionalities of automation systems with minimum complexity. Gilart-Iglesias in [4] proposed a service based model to deliver industrial machinery as a service in order to incorporate them with ease during production process in order to provide for self-management and proactive management of the business logic for which it is supposedly responsible.

b. Process Control Level

Process Control level today comprises of systems based on Service Oriented Architectures (SOA). Related to this work, Delsing et al. [5] proposed an approach to migrate from legacy industrial systems to the next generation of SOA-based automation systems. Gerach et al. [6] proposed a private cloud model to host and deliver SIMATIC PCS7 to be recognised as a generic Distributed Control System (DCS).

Another interesting project is IMC-AESOP [7], which aims to develop SOA-based approach for next generation of SCADA/DCS systems while targeting process control solutions. Similar analysis was done by Combs et al. [8] in which he analyzed migration of the SCADA systems to cloud computing. As a consequence, SCADA providers and users were able to reduce costs and achieve improved scalability. Furthermore, Web-oriented Automation System (WOAS) [9] project aims at developmental research of a new architecture for automation systems based on intertwined web and cloud technologies. While Staggs et al. [10] proposed a system which included a computing cloud along with one data storage unit and one processing unit as a simple demonstrator for an industrial automation application, the works in this level is premature.

c. Field and Shop Floor Level

Work in this level is extensive but limited due to the tough requirements at these levels. These levels heavily comprise of physical devices and functions which are to be offered as services from the cloud. Therefore, the priority for works at these levels is to provide interactive interfaces between the cyberspace (cloud) and the physical world (real field devices). An automation deploying cloud solution has been introduced in [11] which show how an application is to connect with sensors and actuators inside wind turbines.

Several solutions related to the sensor cloud are described in [12] for general purposes and IT applications. Most of these solutions focus on connecting devices and interfaces to the cloud and invest in futuristic virtual private networks.

d. Summary

It is observed that there is a lack of projects and research works in the area of cloud computing for automation, especially lower levels of automation are insufficiently addressed. The probable reason for this could be seepage of information about Cloud, IoT and Open Source Hardware (OSHW), in automation industry, which is historically known for its conservative nature against new technologies.

Since cloud computing and Internet of Things is one of the potential solutions for integration between different automation levels, the necessity for research to provide integration between available applications is to be considered. As reviewed, couple of requirements, like real-time and security are insufficiently addressed and continue to remain as open research questions for the future.

3. PROPOSED IoT BASED ANALYSIS AND CONTROL ARCHITECTURE

a. Single Node System

In recent years, industrial automation has witnessed the new demands and trends in different aspects. Field devices have become more intelligent by embedding new functionalities inside IO devices, sensors and actuators at the field level. The devices in the lower levels are able to communicate with the upper level control machinery through the interface provided by the means of embedded functionalities.

The recently developed Open Source Hardware (OSHW) comes as a rescuer for all the problems faced by researchers and engineers all throughout the interconnectivity paradigm. By use of these hardware solutions now available we are efficiently able to communicate with devices at the lower levels and extract function data from them. The entire decision making and control domain has seen a new sunrise through the developments in the segments of cloud computing, network hardware, OSHW and Internet of Things.

The drives produce best possible results when implemented through a Model Reference Adaptive Control (MRAC). In MRAC, the drive input characteristics are controlled by real time output characteristics through a feedback control loop. This is demonstrated through Fig (1). The desired mechanical output at the end is cumulatively controlled by the integral control methods which are influenced by electrical input, control parameters feedback and DC drive reference model. Each time the drive is to be controlled the controller connects with the reference model, understands the current requirement, compares with the analogous data presented by the reference model, and then generates the required control signals for the DC drive.

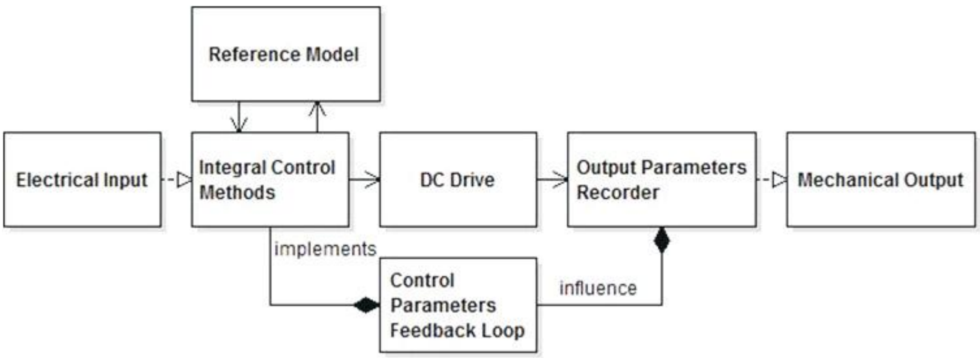

Fig (1). Model Reference Adaptive Control for DC Drive

The proposed single node architecture considers single DC Drive as shown in the following Fig (2) as a node. The node is interfaced with an OSHW through signal processing devices as illustrated. The DC Drive has two sided connections, one side - the input side, controls the device and the other side - the output side, is responsible to produce desired results. The parameters influencing the conversion of input to output are related to each other through predefined formulae and descriptive methodologies.

Input parameters are monitored and controlled through a MRAC layout. The feedback control loop is implemented through OSHW, which runs a Linux based Operating System, like CentOS, Archlinux, etc. The output parameters, like speed, torque, angle, etc.; which influence the drive functionalities are monitored on a real time basis using information trapping mechanisms like sensors. The information in the form of signals which are trapped through these sensors are sent to a signal filtering unit which filters the signals and implements an Analog to Digital Converter (ADC). It is important to convert analog data into digital data for OSHW to understand and process the signals further.

The OSHW hosts programs which are supposed to inherently control the input parameters. The programs are designed in a fashion, which enables the OSHW to analyse the output parameters, refer the ideal data present in the reference model and then send control signals to the controlling unit at the input side of the entire system. The digital control signals generated by the OSHW are converted back into analog control signals using a Digital to Analog Converter (DAC). These analog signals are them amplified to a level wherein the input controller can understand and use these signals to reform the input signals in order to produce the then desired output.

The closed loop feedback system created through this method provides a real time control over the drive. The engineer can recreate and recalibrate the drive in real time by just adjusting the programs hosted by the OSHW. The node thus created by the OSHW connected to the drive is allotted an IP address to incorporate the concept of machine control through IoT. This implies, the drive can now act as an independent machine with a unique identification. This unique identification in the form of an IP Address makes it possible to distinguish and identify the drive individually in a network of multiple devices.

Now, the OSHW hosts rules for intercommunication of nodes and the world wide web (www). So, when connected via the Ethernet the machine can be accessed throughout the internet web. This is the way through which the drive is brought in the web. The OSHW implements a User Interface which can be accessed through the web servers. The host application is designed to log and represent the data monitored by the entire drive control system. This way a node is made active and established as a controller on the field control level.

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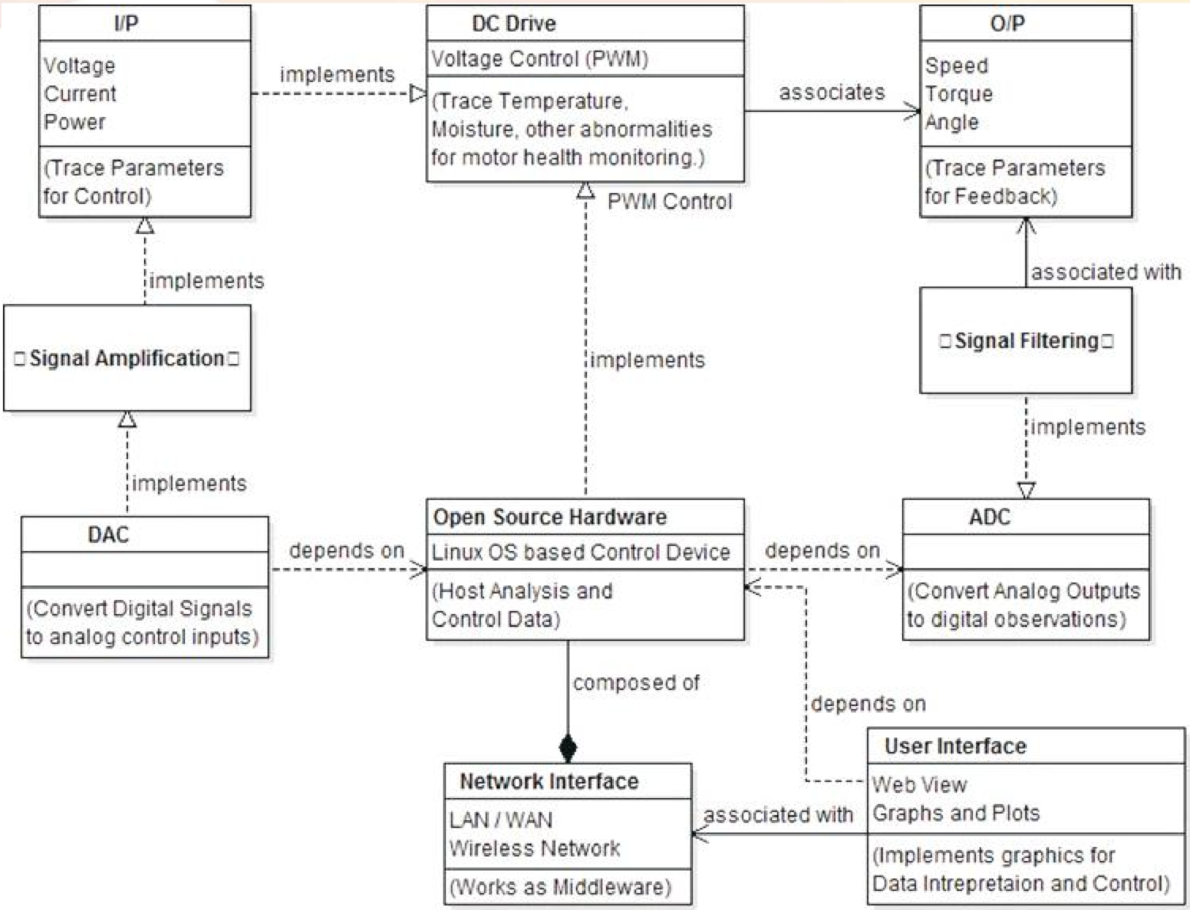

Fig (2). Single Node Architecture for Analysis and Control of DC Electrical Drives using Internet of Things (IoT)

b. Analytical Deductions through Past Experience

With developments in the domain of Machine Learning and Data Mining, it has become evidential to have self learning and improvising devices. The same concepts are deployed on the OSHW in its rules. The OSHW records the monitored input and output data on a recurring basis in its databases. This data is used to make informed decisions by the controller. For example, a drive stalls under a specific output scenario, the OSHW records the data which caused this condition and it also records the decisions taken by control engineer in order to solve the problem. This recorded information is revisited by the machine in case a similar situation arises in the future. The OSHW also records the consequences of this decision and takes into account the possible alterations on the output side owing to these changes and their consequences.

These methods of data storage and mining make machine control an autonomous task in the near future. Based on the past experiences and user decisions, the drive mechanism is able to decide for the future control strategies all by itself.

When this drive is brought into a grid network using IoT, the monitor data can be stored on the cloud and then used to analyse its effect on allied systems and other networks. All other nodes then can communicate with each other and make informed decisions throughout the entire drive network. This forms to be the basis of Industrial Revolution 4.0; interconnected intelligent and smart machines. And this single node is a step towards creating a self learning and fully self sustainable industrial shop floor.

4. CONCLUSION AND OUTLOOK

The main purpose of this paper was to illustratively showcase a possible architecture for analysis and control of MRAC based DC drive through the concept of Internet of Things, which can be deployed as a part of Industrial Revolution 4.0.

Nowadays, automation at higher levels in the control hierarchy is implemented through a variety of means and methods. State of the art control solutions are present in certain amount of industrial automation, for example, in process control, sensor actuator networks, belt drives and so on. Typically, these solutions are built on technologies like PLC, SCADA, and communication platforms like Bluetooth and WLAN. Furthermore, many industrial control mechanisms, especially those employing closed loop control algorithms on field control level and discrete factory automation, require hard or isochronous real-time control with cycle times in the range of milliseconds. Obviously, these requirements cannot be served by the current control solutions. However, if low latency OSHW could be provided, many use cases with moving machine parts would significantly benefit from IoT, Cloud, and thus, reducing the costs, simplifying machine installations, and even enabling remote controlled mechanisations with new application development and expansion opportunities.

During the state of the art research in this paper, it was realized that there is a gap for Internet of Things enabled devices and IT enabled machine control methodologies, especially in the lower control segments, and this should remain as the main objectives for future work. Particularly, the signal control and data processing level must be further investigated in order to address the issues of reliability and real-time control. To satisfy industrial companies for migration to these new companies, new approaches should be devised for IoT applications and standards should be established to ensure the interoperability of machines with emphasis on data security.

REFERENCES:

1.W. Wahlster. From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution. Forum Business meets Research, 2012.

2.J. Bughin, M. Chui, and J. Manyika. Clouds, big data, and smart assets: Ten tech-enabled business trends to watch, Aug. 2010.

3.F. Maci´a P´erez, J. Bern´a Mart´ınez, D. Marcos Jorquera, I. Lorenzo Fonseca, A. Ferr´andiz Colmeiro, et al. A new paradigm: cloud agile manufacturing. 2012.

4.V. Gilart-Iglesias, F. Macia-Perez, D. Marcos-Jorquera, and F. Mora-Gimeno. Industrial machines as a service: Modelling industrial machinery processes. In Industrial Informatics, 2007 5th IEEE International Conference on, volume 2, pages 737−742, 2007.

5.J. Delsing, J. Eliasson, R. Kyusakov, A. Colombo, F. Jammes, J. Nessaether, S. Karnouskos, and C. Diedrich. A migration approach towards a soa-based next generation process control and monitoring. In IECON 2011-37th Annual Conference on IEEE Industrial Electronics Society, pages 4472−4477. IEEE, 2011.

6.S. Gerach, S. Runde, M. Schneider, and M. Glaser. Cloud Computing im Kontext eines Prozessleitsystems. atp edition, 01-02, 2013.

7.S. Karnouskos and A. Colombo. Architecting the next generation of service-based scada/dcs system of systems. In IECON 2011 - 37th Annual Conference on IEEE Industrial Electronics Society, pages 359−364, 2011.

8.L. Combs. Cloud computing for scada. Control Engineering Magazine, Available at: http://www. controleng. com/index. php, 2011.

9.R. Langmann, O. Makarov, L. Meyer, and S. Nesterenko. The woas project: Web-oriented automation system. In Remote Engineering and Virtual Instrumentation (REV), 2012 9th International Conference on, pages 1−3, 2012.

10. K. Staggs and P. McLaughlin. Cloud Computing For An Industrial Automation and Manufacturing System, 22 2010. WO Patent 2,010,120,440.

11. S. Kuppinger. Cloud in der automation. Computer Automation, Feb 2012.

12. M. A. Hossain. A survey on sensor-cloud: Architecture, applications, and approaches. International Journal of Distributed Sensor Networks, 2013, 2013.