

## Developing a Cloud Intelligence-Based Energy Management Architecture Facilitated with Embedded Edge Analytics for Energy Conservation in Demand-Side Management

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**Abstract :** Demand-Side Management (DSM) has the potential to reduce electricity costs and carbon emission, which are associated with electricity used in the modern society. A home Energy Management System (EMS) commonly used by residential consumers in a down-stream sector of a smart grid to monitor, control, and optimize energy efficiency to domestic appliances is a system of computer-aided functionalities as an energy audit for residential DSM. Implementing fault detection and classification to domestic appliances monitored, controlled, and optimized is one of the most important steps to realize preventive maintenance, such as residential air conditioning and heating preventative maintenance in residential/industrial DSM. In this study, a cloud intelligence-based green EMS that comes up with an Internet of Things (IoT) technology stack for residential DSM is developed. In the EMS, Arduino MEGA Ethernet communication-based smart sockets that module a Real Time Clock chip to keep track of current time as timestamps via Network Time Protocol are designed and implemented for readings of load phenomena reflecting on voltage and current signals sensed. Also, a Network-Attached Storage providing data access to a heterogeneous group of IoT clients via Hypertext Transfer Protocol (HTTP) methods is configured to data stores of parsed sensor readings. Lastly, a desktop computer with a WAMP software bundle (the Microsoft® Windows operating system, Apache HTTP Server, MySQL relational database management system, and PHP programming language) serves as a data science analytics engine for dynamic Web APP/REpresentational State Transfer-ful web service of the residential DSM having globally-Advanced Internet of Artificial Intelligence (AI)/Computational Intelligence. Where, an abstract computing machine, Java Virtual Machine, enables the desktop computer to run Java programs, and a mash-up of Java, R language, and Python is well-suited and -configured for AI in this study. Having the ability of sending real-time push notifications to IoT clients, the desktop computer implements Google-maintained Firebase Cloud Messaging to engage IoT clients across Android/iOS devices and provide mobile notification service to residential/industrial DSM. In this study, in order to realize edge intelligence that edge devices avoiding network latency and much-needed connectivity of Internet connections for Internet of Services can support secure access to data stores and provide immediate analytical and real-time actionable insights at the edge of the network, we upgrade the designed and implemented smart sockets to be embedded AI Arduino ones (called embedded AIduino). With the realization of edge analytics by the proposed embedded AIduino for data analytics, an Arduino Ethernet shield WizNet W5100 having a micro SD card connector is conducted and used. The SD library is included for reading parsed data from and writing parsed data to an SD card. And, an Artificial Neural Network library, ArduinoANN, for Arduino MEGA is imported and used for locally-embedded AI implementation. The embedded AIduino in this study can be developed for further applications in manufacturing industry energy management and sustainable energy management, wherein in sustainable energy management rotating machinery diagnostics works to identify energy loss from gross misalignment and unbalance of rotating machines in power plants as an example.

**Keywords :** demand-side management, edge intelligence, energy management system, fault detection and classification

**Conference Title :** ICAE 2018 : International Conference on Applied Energy

**Conference Location :** Tokyo, Japan

**Conference Dates :** April 05-06, 2018