Intelligent Public DR Management for Smart Home with Interworking IoT Platform

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Abstract

Smart grid business model is now focused on demand response (DR) for enterprise environment and slowly expanding into Internet of Things (IoT) based smart home that is the microgrid. However, in the smart grid, sensor networks are used for monitoring of the devices and smart power management system through the big sensor data processing with artificial intelligence (AI) technology. Therefore, interworking functions are needed to connect to the smart grid and work with different types of IoT platform at home for the energy management of smart devices, and equipment. In such case, it becomes more challenging to control the energy DR into heterogeneous IoT platform for supporting the energy management to each and individual IoT device into the smart home like environment. To mitigate above-mentioned challenges, in this research work we are introducing interworking IoT platform with AI supported public DR management for heterogeneous IoT device energy control and management. Finally, we have found significantly improve performance gain in our experimental result.

1. Introduction

Smart grid and smart home shall be able to integrate understandably and seamlessly an enormous number of different and heterogeneous IoT sensors and actuators with microcontroller based IoT devices. Furthermore, to manage energy DR for those individual IoT devices, it is necessary to support artificial intelligence (AI) based interworking IoT platform. However, Smart home-IoT and smart city are not including the public DR function for home energy saving and also there is no common message type to communicate between those things [1].

To solve those challenges, in this experiment, we have pr oposed interworking IoT platform architecture and also mo deled intelligent public DR management based on different types of energy load for smart home IoT devices. Finally, we have achieved a higher performance gain compared to t he other models.

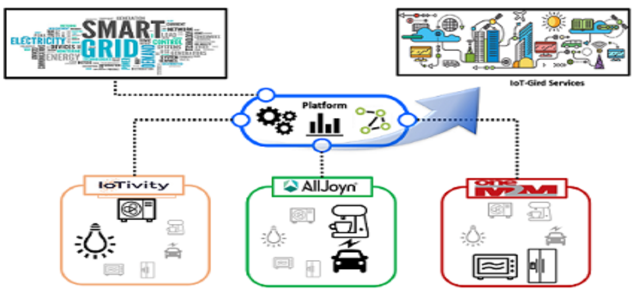

Figure 1: IoT-Grid Interworking platform

Figure 1 shows the heterogeneous IoT devices consider numerous types of IoT platform into a single smart home. However, the energy demand varies based on different types of energy load such as primary load, deferrable loads, and modular load for different IoT devices [2].

2. Interworking IoT Platform

Interworking IoT platform architecture is presented in Figure 2. We have proposed a three-layer architecture and the layers are transport, main framework, and services layer. The bottom layer is the transport layer that is accumulated with different types of IoT protocols such as, Bluetooth, Wifi, Zigbee, LTE, and so on.

The middle layer includes the main framework and it consists of five modules. These are extraction, message management, device management, service connection, and the final one is energy management module.

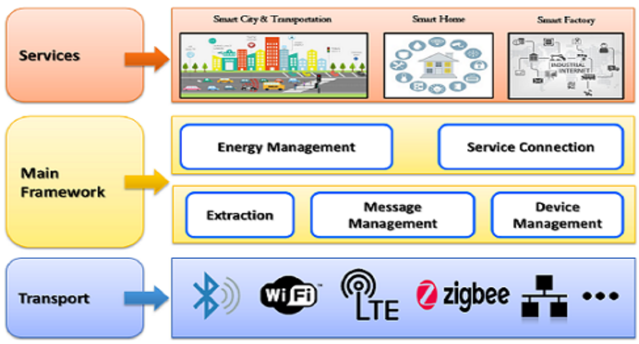

Figure 2: Interworking IoT Platform Architecture

Extraction module extracts the messages from IoT device through the transport protocol to request the task and generate rule message for message management unit. However, for reverse communication, this module extracts the rule message from the message management unit and deliver to the IoT device through the transport layer. The second module is the message management module that is responsible for converting the rule messages into action messages and then send these action messages to the device management module. Furthermore, on opposite side communication, this module receives the action messages from device management then decode these messages into the rule messages and pass these rule messages to the extraction module.

Device management module is the third module into the main framework and the prime duty of this module is to support the task from the device with service connection using the action message command and also it sends the action message to the message management for controlling the device behavior. Service connector is the interface between service layer and main framework to execute the services and also works with the energy demand response management to control the energy consumption of IoT devices. Moreover, the energy management module of the main framework layer compute the energy demand of each device and supply the required energy to devices through the service connection and also manages the energy generation and energy storage based on demand response.

Finally, the top layer of interworking IoT platform architecture is the service layer and some of the services are smart city, smart transportation, smart home, smart factory, and so on.

3. Intelligent Public DR Management

Energy management module at main framework layer is responsible for public DR management and we have modeled long short-term memory network (LSTM) which is the one of the optimized version of recurrent neuron network (RNN) and also it is capable to deal with the vanishing gradient problem and Figure 3 presents the LSTM model [3].

$$m_t = \sigma_o(M_m X_t + V_m h_{t-1} + v_m) \quad (1)$$
$$I_t = \sigma_o(M_I X_t + V_I h_{t-1} + v_I) \quad (2)$$
$$O_t = \sigma_o(M_O X_t + V_O h_{t-1} + v_O) \quad (3)$$
$$G_t = \phi_E(M_E X_t + V_E h_{t-1} + v_E) \quad (4)$$
$$E_t = m_t \odot E_{t-1} + I_t \odot G_t \quad (5)$$
$$h_t = O_t \odot \phi_h(E_t) \quad (6)$$

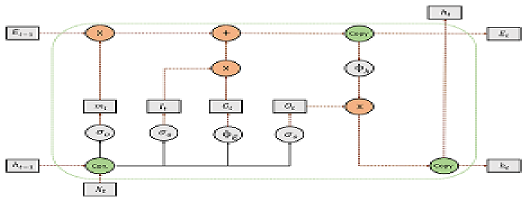

Figure 3: LSTM Model

4. Performance Evaluation

In this experiment, we have implemented our intelligent public DR management into energy management module using the python platform. We have used openei residential dataset [4] for performance analysis and also, we divide the energy demand based on primary load, deferrable load, and modular load for different IoT devices.

Figure 4 shows the higher performance gain of LSTM model compared with the linear regression and ARIMA for hourly demand prediction. Figure 5 depicts the root-mean-square error (RMSE) is rigorously reduced than other two models. Finally, the Figure 6 proofs that proposed model can provide better performance for different types of energy loads such as, a primary load, deferrable load, and modular load for different IoT devices.

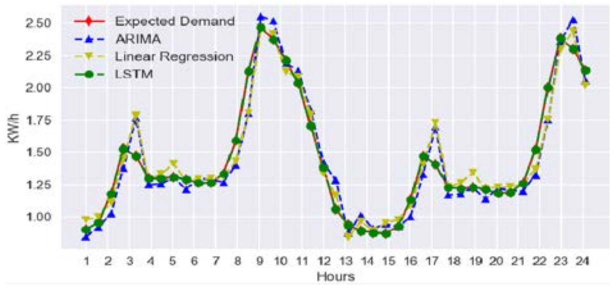

Figure 4: Public DR Forecasting

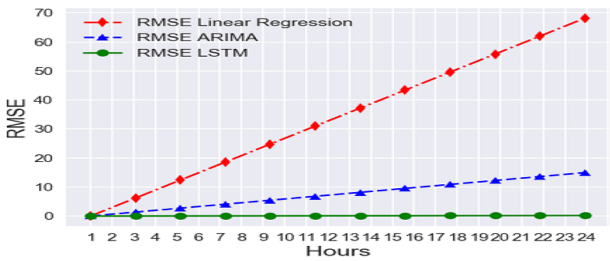

Figure 5: RMSE Result

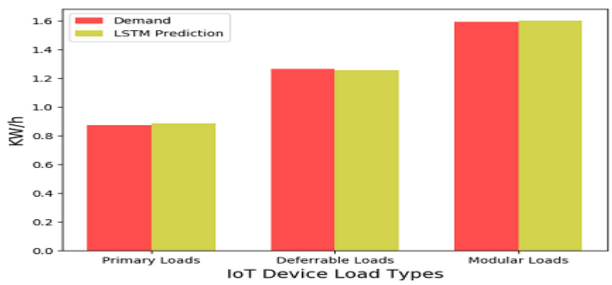

Figure 6: Load Types Prediction Result

5. Conclusion

Smart home intelligent public DR management and interworking IoT platform for the smart grid is a novel approach that ensures the energy management of each and individual IoT device. The proposed model substantially helps to reduce the risk of energy demand and supply. This method will significantly gain the performance of energy demand prediction in heterogeneous IoT environment.

Acknowledgement

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