A wireless sensor application for energy management in home appliances using smart

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Abstract— *Energy is very essential in our day-to-day life as it became a part of our life. We cannot imagine a life without electricity. Due to lack of awareness among the people, they waste the electricity taking it for granted. In our project , we use In-home energy management application (iHEM) to evaluate the performance of home appliances in the role of energy consumption. We are going to utilize the energy efficiently based on the need depending on the time. We try to reduce the contribution of the consumers to the peak load. For this, we prioritize the demand and then shift the demand according to the priority. And we are also calculating the real time price of the electricity charge based on the consumption.*

Keywords— Cost optimization, energy and demand manage- ment, home automation, smart grid, wireless sensor networks.

1. Introduction

In today's ever-growing need for power consumption there is lack of resources to meet the demand which results in inefficiency of the traditional powergrid that is being used in day to day life. After introducing smartgrid by collaborating Information and Communication Technologies (ICT) to the power grid, automation has been increased. Though traditional powergrid meets the demand of large-scale consumers such as industrial plants or commercial buildings, it fails to satisfy the residential units due to lack of communication, sensors, and efficient automation tools.

In previous papers several authors have established automatic controllers and scheduling. Although optimization-based demand scheduling schemes are able to provide energy savings, individual preferences of consumers are not considered in those schemes.

In our previous work, we proposed an iHEM application which employs a wireless sensor home area network (WSHAN), and exploits communications among the appliances and an energy management unit (EMU). In the iHEM application, EMU communicates with the appliances, smart meter, and storage units to determine a convenient time to accommodate the consumer demands. In this paper, we aim to compare the performance of the iHEM application with an optimization-based scheduling technique. For this purpose, we developed the optimization-based residential energy management (OREM) scheme, which aims to minimize the energy expenses of the consumers by scheduling appliances to less expensive hours according to the TOU tariff. We show that the iHEM application decreases the cost of energy consumption and its savings are close to those of the optimal solution.

It also reduces the contribution of the residential consumers to the peak load and the carbon emissions of the household. In this paper, we also elaborated on the use of real-time pricing and priority-based appliance scheduling. Furthermore, we evaluated the performance of the WSHAN in terms of delivery ratio, delay, and jitter. We showed that increasing the packet size of the underlying applications degrades the performance of the WSHAN.

2. Related work

Residential load control (RLC)

A residential load control (RLC) scheme that is suitable for grids with real-time pricing is proposed to predict the price of electricity during the scheduling horizon and schedule appliances to provide an optimum cost and waiting time within that horizon. And the main goal is to reduce the total cost and peak-to-average ratio.

Decision support tool (DST)

A decision-support tool (DST) for smart homes like space heater, water heater, pool pump etc. Then the PV system was scheduled based on various TOU tariffs by using the particle swarm optimization technique, whereas in our scheme the controller and the users communicate through appliance interfaces to schedule the distributed energy resource.

Optimal Consumption schedule (OCS)

Optimal consumption schedule (OCS) is suitable for energy management protocol which allows consumers to set a maximum consumption value and the residential gateway is able to turn off the appliances that are in standby mode. Our iHEM application interacts with the consumers via appliance interfaces, and consumers negotiate with the controller using a three-way handshake protocol.

Micro CHP-Based schedule

Micro CHP Schedule is proposed for micro grids and neural Network-Based prediction approach to predict the day-ahead demand. According to the predicted demand, the schedule of the Micro CHP device in each house is optimized. In addition, local appliances are controlled to optimize electricity import/export of the home. We aim to minimize the cost of electricity based on TOU rates. Moreover, in our paper, we assume that each house makes independent decisions.

Appliance co-ordination scheme

Appliance co-ordination scheme (ACS) supplied with a suggested time when they wish to turn on their appliances. The suggested time is calculated based on TOU rates, generation capacity, stored energy, and concurrent demands. In these schedule to reduce total expenses and peak load, then interacting demand shifting method to be used.

3. Energy management

A residential load control (RLC) scheme that is suitable for grids with real-time pricing is proposed in optimal residential load control with price prediction in real-time electricity pricing environment. The electricity grid is undergoing a major renovation and becoming a smart grid by integrating the advances in Information and Communication Technologies (ICT).

The existing grid does not provide sufficient mechanisms to manage the residential electricity consumption. However, interconnecting consumer devices with the home area networks and at the same time, communicating with the utility networks through a home gateway facilitate residential energy management in smart grids.

4. System Description

A. PROPOSED SYSTEM

Our optimization based solution is different, in our scheme, consumers can choose an upper limit for the waiting time at the setup time and we make use of TOU rates and exploit communication. In our scheme, the controller and the users communicate through appliance interfaces. We assume that each house makes independent decisions unlike a set of houses being controlled by a steering signal from a global controller.

Our iHEM application interacts with the consumers via appliance interfaces and consumers negotiate with the controller using a three-way handshake protocol.

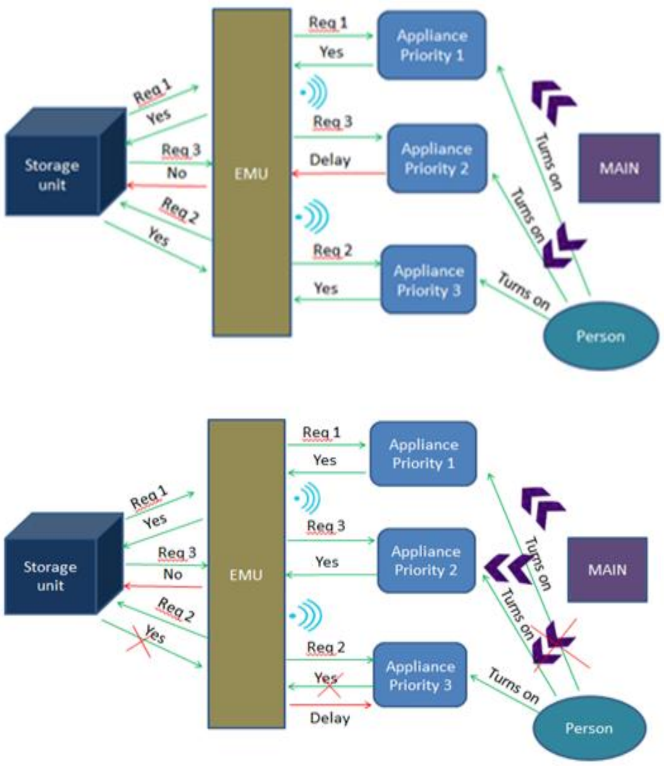

Fig: Overall architecture of the project

B. Scheduling at the EMU

When a consumer turns on an appliance, the appliance sends a request to the EMU. Upon receiving the request, the EMU communicates with the storage unit to retrieve the amount of the available energy. EMU communicates with the storage unit when a demand arrives. The storage unit replies the amount of available energy to the EMU. After receiving the available energy, EMU determines the convenient starting time of the appliance by using algorithm.

Use Case Diagram: Use cases are scenarios for understanding system requirements. Use case provides a clear picture of how actors interact with the system. A use case is an interaction between users and system. Use case is a collection of related success andfailure scenarios that describes an actor using a system to support a goal. Use cases are functional or behavioural requirements. Use cases emphasize the user goals and perspectives.

Class Diagram: The UML class diagram (object modelling) is the main static analysi Diagram . A class diagram is a collection of static modelling elements such as classes and their relationships connected as a graph to each other and to their contents. The class diagram can be used to visualize a domain model in conceptual perspective. The class diagram is also used in a software or design perspective.

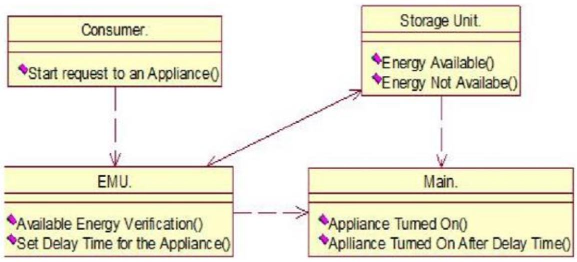

Fig: Class Diagram of scheduling at the EMU

Priority and Shifting the Demand

We give priority to a subset of the appliances. High priority appliances are turned on as soon as the request is received by the EMU regardless of the peak hours. This scenario corresponds to a case where users have either preconfigured a subset of their appliances as high priority appliances or several appliances are not able to communicate with the EMU.

Consider an example in which there are four appliances, such as coffee maker, dish washer, heater and washing machine. Each of these appliances is assigned apriority value. If the demand arrives for an appliance of high priority then the appliance is turned on immediately in spite of peak hours. If the demand arrives for an appliance of less priority then the start of the appliance is delayed until the computed waiting time.

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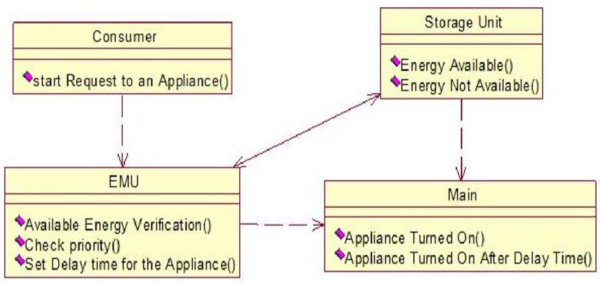

Fig: Class Diagram of priority and shifting demand

Real Time Pricing

In the smart grid, it is also possible to have real-time (dynamic) pricing. Dynamic pricing reflects the actual price of the electricity in the market to the Consumer bills. In this subsection, we analyse the performance of iHEM for real-time for pricing. We present the contribution of the appliances for the regular iHEM scheme and iHEM for real-time pricing. iHEM for real-time pricing introduces savings. Scheduling under real-time pricing may require demand prediction in order to increase the performance of scheduling.

We define a maximum limit for consumption of energy. If that limit is exceeded then the consumer is given an alert message indicating the excess consumption of energy. Bill is also calculated periodically by multiplying the energy consumed with the cost per unit of energy.

Cost = Energy Consumption * per unit of current

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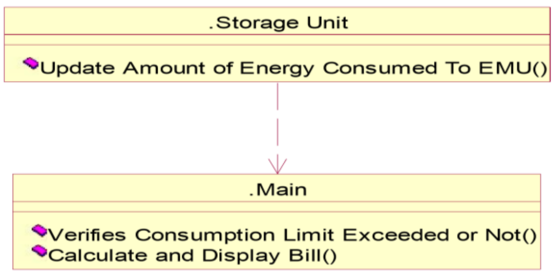

Fig: Class Diagram of Real Time Pricing

5. Performance Anallysis

Simulation Result

Overall output of our project is that all the appliance are working according to the time allotted in the priority schedule in a cyclic manner.

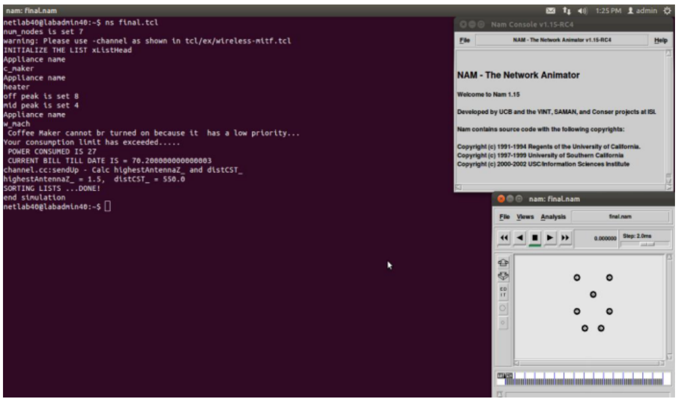

Fig: Terminal Where Inputs are given

The code is executed using the command "ns filename.tcl". Appliance name is taken as the input which the consumer wants to turn on. After all the inputs are given, the energy consumed is calculated and displayed along with the current bill if the consumption limit is exceeded. Then the nam file and trace file are displayed.

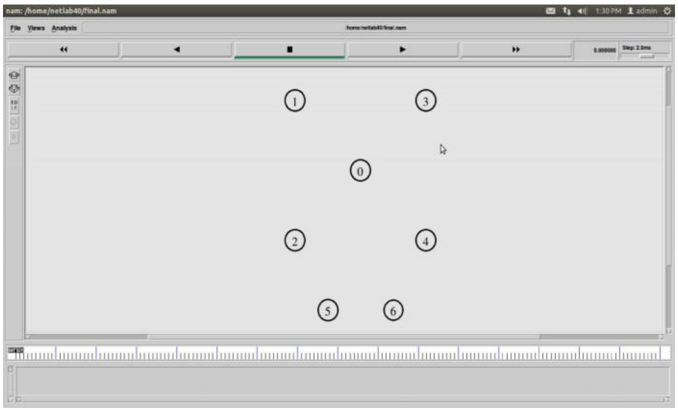

Fig: Initial Node Position

After executing the trace file, the nodes are displayed in the name file in their respective positions. These node positions are already given in the code. These positions of the node can be either fixed or the nodes can move. In our case, the nodes are in a fixed position

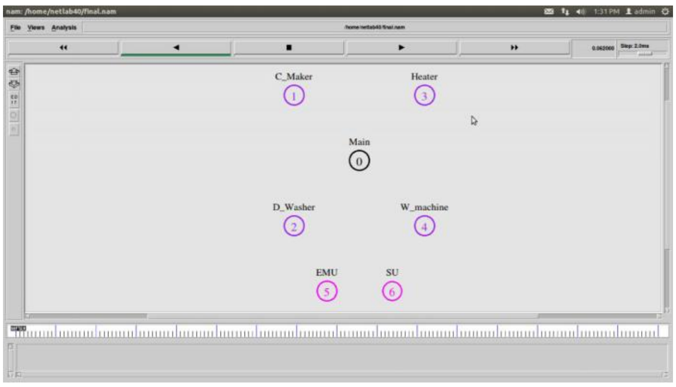

Fig: Labelling and colour of the nodes

The labels for the nodes and the colour for every node have been defined in the code. And also the time at which the labels should be displayed and the change of colours of the nodes are defined in the code. In our scenario, the label and colour changes at 0.0millisecond.

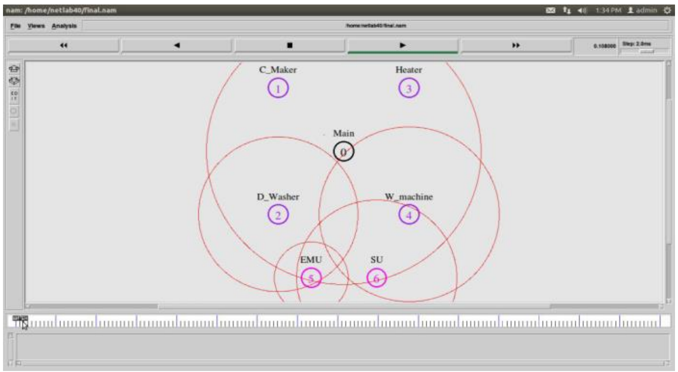

Fig: Start of Appliance

When the input is given as appliance1the EMU checks for the available energy for that particular appliance. The energy is available and so the EMU instructs the main to supply the power to appliance1. The main starts supplying the power immediately.

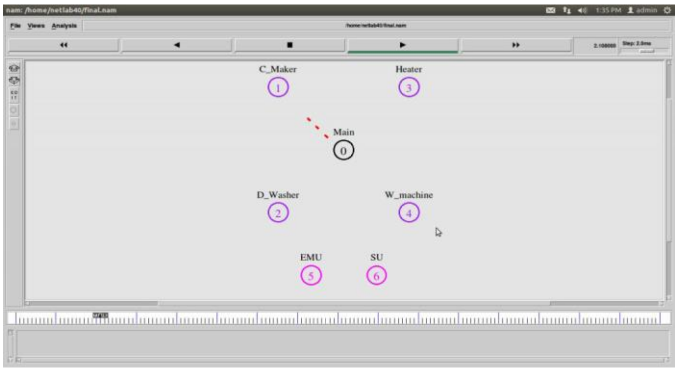

Fig: Supplying power from main to appliance

In our case, the appliance1 we have considered is coffee maker. The main continues to supply power to coffee maker until the coffee maker completes its work.

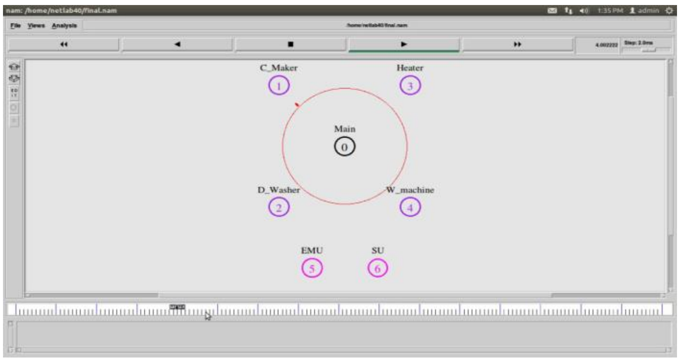

Fig: Turning on the next Appliance

Currently Appliance1 is running, in the meantime the consumer wants to turn on the appliance3, so the EMU again enquires the availability of energy in storage unit. The energy is not available and so the EMU sets the delay time for appliance3 as 4 milliseconds. At the 4th millisecond, the main starts to supply power to appliance3.The appliance3 here is Heater.

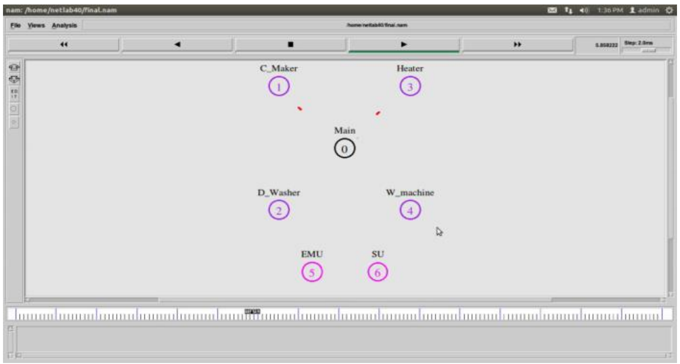

Fig: Supplies power to both appliance1 and appliance3

Currently both the appliances (Coffee maker and Heater) are running. The main supplies power to both the appliances. The appliances terminate only when their respective work is completed.

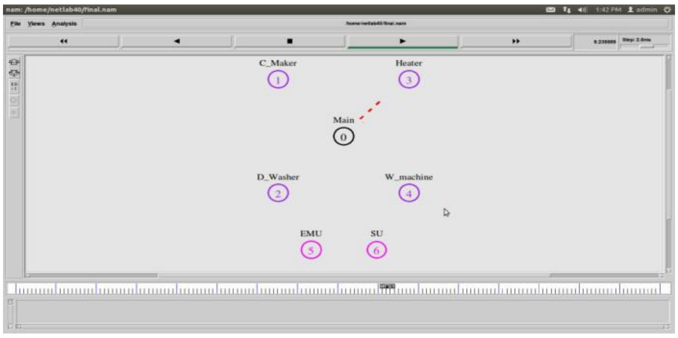

Fig: Termination of appliance1

The running time for appliance1 (Coffee maker) is 8 milliseconds. As the running time for coffee maker is over, the main terminates appliance1. In other words, the main stops supplying power to Coffee maker. And currently appliance3 (Heater) alone is running.

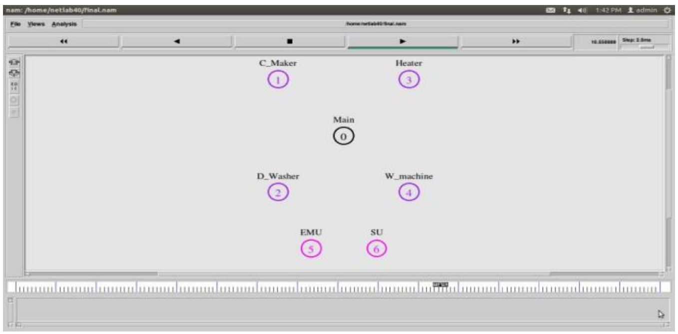

Fig: Termination of appliance3

Running time of appliance3 (Heater) is 6 milliseconds. The Heater starts to run at 4th millisecond. Hence the Heater tends to terminate at 10th millisecond. As soon as the time reaches 10 milliseconds, the main stops supplying power to the Heater.

Conclusion and Future work

In our project we have successfully included automatic priority scheduling of appliances and have managed to reduce the peak load which is the main objective of the project. Furthermore, we elaborated on the performance of the WSHAN in terms of packet delivery ratio and delay.

To enhance performance of the network we have used simulation to decrease the packet size which results in decreasing the delay ratio and increasing the delivery ratio. Finally, we propose to fuse artificial intelligence (AI) with system to make it user-friendly.

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