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Internet of Things for Energy Efficiency and Personalization

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Abstract. The present work presents a home energy management system (HEMS) that based on an Internet of Things will allow appliances to be turned on or off by remote commands. This approach is essential for a sustainable planet with the fast growing implementation of intermittent renewable energy sources, like wind and solar. This renewable energy sources have an intermittent behavior, so one solution to this problem is an EMS that tries to fit production to energy consumption. In this research work we propose a solution based on the standard OpenADR and a network of sensors to handle this problem, creating a platform based on internet-of-things capable to turn-on or off electrical devices based on a central decision process that meets the requirements of energy producers and consumers. Producers can provide energy according to the consumer's requirements and take part of energy production and costs fluctuations. Based on an OpenADR standard for energy data exchange and a central cloud server, a list of services are provided to handle these transactions, with georeferenced information to minimize energy losses in the distribution process. Furthermore, mobile devices can passive collect user mobility data to optimize energy efficiency, heating or cooling the house before users return home, thus, generating energy personalized services.

Keywords. Sensor networks, Smart-cities, Energy efficiency, OpenADR, Decision Process, Smart Grid, Distributed Energy Sources and Home Energy Management System

1. Introduction

Home appliances such as air conditioners (ACs), cooking devices, battery energy storage systems (BESSs), electric vehicles (EVs), and heat-pump water heaters (HPWHs) are being introduced into homes. Due to the increase of intermittent energy resources it is important to create user consumption flexibility and users must consider intelligent ways of energy consumption. To handle this problem, we propose a home energy management system (HEMS) based on an internet of things where it is possible to turn off appliances remotely to balance the supply-and-demand relationship, which will control electricity consumption. This HEMS tries to perform matching between production and consumption, reduce system losses and improve the voltage profile while serving the primary goal of demand supply [1]. This is what is called Demand Response (DR), where consumers play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. Thus, this can be achieved by an HEMS that change electricity consumption patterns by offering the flexible electricity consumption based on remote OpenADR signals are sent to houses appliances. Consequently, HEMS will play an important role by automatically adjusting consumption.

Personalization is achieved by user different approaches because it is difficult to determine an appropriate priority adaptively under various environments because the optimal operation for one user will be different from that of other users depending on the user's subjective comfort and convenience. This HEMS can solve this problem by learning the habitual operation of home appliances and thus control home appliances automatically using information about user home arrive and preferences like temperature not bellow certain value. Similar ideas have been discussed in recent studies. For example, an algorithm for controlling home appliances under restrictions on electricity consumption based on a pre-fixed priority was proposed by Pisapattanasomporn et al.[2] HEMS for residential load control based on price prediction was proposed by Ren et al.[3] A method for analyzing and predicting hot water usage was proposed by Hu et al.[4]

Rabl et al. [5] studies the application of DR simulation models in commercial buildings and develops a data-driven-based dynamic model to simulate the effect of different thermostat control strategies to reduce peak demand. Morris et al. [6] investigates two optimal dynamic building control strategies in a representative room in a large office building. Xu et al. [7] shows the potential for reducing peak electrical demand in moderate-sized commercial buildings by modifying heating, ventilation and air conditioning (HVAC) system control. Peak-load reduction strategy modeling studies by Yin et al. [8] developed and calibrated simulation models of 11 commercial buildings for evaluating the effect of different thermostat control strategies.

Demand Response Architectures have been developed is being developed based on a two-way communication infrastructure between home appliances and a central management infrastructure, example of these are: (1) OpenADR (Open Automated DR) [9] is an open specification of communications data models designed to provide interoperable DR signals to building and industrial control systems (e.g., BACnet) that are pre-programmed to take automatic action based on the signals, see next section; (2) Whirlpool Smart Device Network [10] is a Home Area Network (HAN) architecture. It is a collection of web services providing interfaces some of which similar to OpenADR's. The Smart Device Controller hosts a set of proprietary load management algorithms called the in-home energy management system; (3) The Australian HAN guideline [11] specifies that a HAN can have two partitions: a Utility Private HAN and a Customer HAN, bridged by a Premise EMS (Energy Management System). The Utility Private HAN includes the smart meter and HAN devices registered with the utility and (4) PowerMatcher [12] is a multi-agent architecture explicitly designed for supply and demand matching. An agent residing in every device bids and buys (or sells if the device is a producer) in the electricity market. We choose OpenADR based on market penetration and standardization issues.

2. OpenADR

Automated Demand Response (ADR) describes a web-based control system that triggers DR events automatically by signaling other pre-programmed control systems and with the available production resources. OpenADR2.0, an open communication protocol specifically designed for DR, is gaining momentum in the U.S., Asia and Europe. Initially developed by Lawrence Berkeley Nat. Lab OpenADR2.0 is now supported by an influential Alliance while more and more vendors integrate it into their technical products. Some vendors acting in the building energy management business start implementing OpenADR2.0 from design phases. OpenADR is certified by OASIS and has recently been approved as a Publicly Available Specification (PAS) by the International Electrotechnical Commission (IEC). A working group is also working on a harmonization between OpenADR2.0 and Common Information Model (CIM) [13].

The OpenADR protocol is a communication IP network to handle energy consumption requests based on production availability. Based on the Demand Response we centralize all transitions process between Virtual Top Node (VTN, identifies the entity that manage VENs) and Virtual End Node (VEN, client energy consumer or producer). Based on the graph of distribution network, a hierarchical relation is performed between VTN and VEN, see Figure 2. VTN performs the role of Virtual Power Plant (VPP) manager. A VPP consists of an aggregation of Distributed Energy Resources (DERs). The VPP Manager centralizes transitions from VEN with load resources that they interact and performed decision about loads ON/OFF based on distribution distance, previously calculated in georeferenced graph. This VPP receives information about production resource available and based on the demand response try to fit the resources do VEN needs with the goal of minimization power losses and non-supplied energy. All local Micro Generation (MG) can be handled as a VEN with a report service based on a metric device.

2.1. Functionalities available for stakeholders interaction

OpenADR 2.0 supports the following services from OASIS EI Version 1.0 standard or subset thereof. Extensions to these services are included to meet the DR stakeholder and market requirements. A list of central available services is described at OpenADR (http://www.openadr.org), like logical request-response services. We create a new service, the distance distribution calculation, which output is the distance of VEN to other energy resource based on a georeference graph for the electrical DN. The main problem of this approach is the work involved in the identification of georeference of each of these points on the DN. Having collected this information any geographic database can easily handle the problem. Main idea for decision process of electrical distribution is the real distance on the DN. The area with the distribution of the electrical network is manually transformed in a graph (see Figure. 1), where it is added geographic information and power limitations between the nodes. Each node is identified the distance and the distance is calculated between geographic coordinates of VTN and VEN matching to this nodes. Figure 1 shows this distribution network transformed to a georeferenced graph with dependencies. When a VEN is registed a distance calculation is performed to other VEN. For that we need all distribution nodes georeference.

2.2. Security

For all message exchanges in OpenADR, use of Transport Layer Security (TLS) with client authentication is mandated for mutual authentication as well as message integrity and confidentiality protection. The OpenADR 2.0 specification requires all nodes (both VTNs and VENs) to be equipped with public/private key pairs and digital certificates issued by a trusted Certificate Authority (CA), which implies that vendors have to pay nominal per-device cost for issuance and management of certificates. Communicating peers are required to authenticate each other by using the digital certificates.

Regarding authentication of VENs, the OpenADR specification requires to use the identifier of the VEN (venID) and some unique information derived from the VEN's digital certificate, e.g., a SHA fingerprint of the certificate. In order for a VTN to verify that a sender of an incoming message is actually the VEN whose venID is claimed in the payload, the VTN should perform validation of a one-to-one mapping between the venID and the digital certificate.

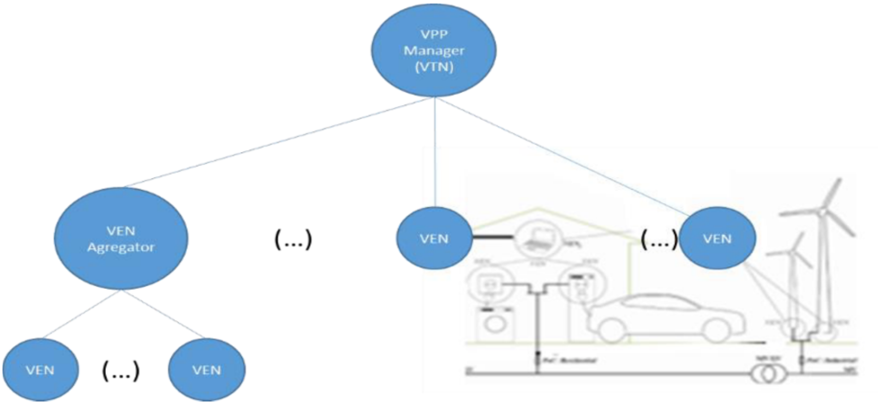


Figure 1. VEN and VTN interaction with georeferenced position. VTN centralize information in a hierarchical process.

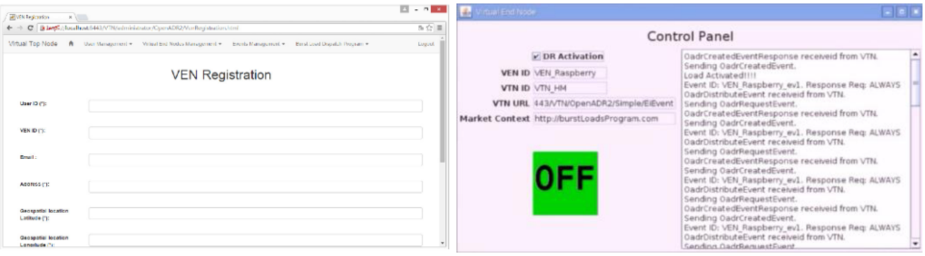
2.3. VEN - Virtual End Node

The VEN has operational control of a set of resources/processes and is able to control the electrical energy demand of these in response to an understood set of messages (i.e., DR signals). The VEN is able to communicate (2-way) with a VPP receiving and transmitting messages that relate to power grid situations, conditions, or events.

Consumers define the number and type of electrical appliances of the house from a pre-defined list. Tree main operation classes are defined based on operation's needs:

- Class 1: Schedule-Based Appliances – Concerns with the electrical appliances time periods of operation. Since in the houses there are appliances with flexible operation time, like washing machines, dryers and dishwashers, users can define their operation time according to the best options in terms of energy availability.
- Class 2: Range Temperature Based Appliances – For equipment with temperature range, like refrigerators, heating systems or air conditioners, users can define the ranges, and the VPP manager will try to fit it based on energy availability.
- Class 3: Battery-Assisted Smart Appliances – The electric vehicle charging processes can be scheduled and controlled to adapt to energy availability.

VENs can also be energy producers that integrate a diversity of players: conventional electricity producers, renewable energy producers and home users with MG. The main sources of energy in a MG are wind and the sun, and the electrical energy is obtained through micro wind turbines and solar photovoltaic panels. These sources of energy are the most common and the easier to implement in the MG. Presently, this produced energy is provided to the electrical power grid without any concern about the Energy Market (EM) or the electrical power grid capability to receive energy.



VEN Registration

User ID (*):

VEN ID (*):

Email :

Address (*):

Geospatial location Latitude (*):

Geospatial location Longitude (*):

Control Panel

☑ DR Activation

VEN ID: VEN_Raspberry

VTN ID: VTN_HM

VTN URL: 443/VTN/OpenADR2/Simple/EiEvent

Market Context: http://burstLoadsProgram.com

```
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Load Activated!!!!
Event ID: VEN_Raspberry_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_Raspberry_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
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OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_Raspberry_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
```

Figure 2. Example of a web interface for VEN registration processes and VEN Web client interface where all information about this VEN transaction is displayed.

2.4. VTN - Virtual Top Node

Nodes in these networks are divided into two groups: nodes that publish and transmit information about events to other nodes (e.g., utilities), and nodes that receive the communications respond to that information (e.g., end-users). The upstream nodes that publish information about upcoming events are called Virtual Top Nodes (VTNs); the downstream nodes that receive this information are called Virtual End Nodes (VENs). In this context, the VTN manage the VEN's resources based on geographic location of the generations resources look for nearest loads resources (based on electrical distribution distance) and activate loads consumption. Due to proximity between generation resources and loads we have less loss in transmission process.

The VENs with generation resources, send information about energy availability to VPP manager and establish communication between pre-defined VEN (main condition is the distribution distance). The OpenADR signals are transported via standards-based Internet Protocols (IP) such as Hyper Text Transfer Protocol (HTTP) or XML Messaging and Presence Protocol (XMPP).

2.5. Electric Vehicle as a UPS

Electric Vehicles (EVs) also represent an increase in energy consumption that could be used to capture renewable energy generation and help to balance generation with demand, theoretically making electricity marginally cheaper and cleaner. Vehicle-Grid-Integration (VGI) technologies encompass this approach. At the University of Minho was developed a new operation mode that consists in the detection of a power outage in the power grid and the change of the EV battery charger control to operate as an off-line UPS [14]. This charging system with the introduction of VEN concept since the EV can handle more electric power. At user home, the EV can be charge with different profiles from the power grid of 240V-15A. There is already a diversity of EV, such as Nissan Leaf with a 24kWh battery pack and autonomy of 160 km (value considering a careful drive style). Volt's has a battery pack of 16 kWh. Once there is a diversity of EV with different battery power, we assume that in average we have 15kWh available and in a for the energy market. Also there is a diversity of hybrid vehicle with low batteries capacities so we will assume the value of 10kWh with a market penetration of 10%. So our simulation handles a local VPP of 300 end-users with 30 EVs, each of them with 10kWh. With the EV market penetration, the goal of flat power consumption is possible to be achieved at night periods (when the majority of EVs are at home plugged in at charging process). Consumption variations, as well as intermittent production due to renewable sources, can be dealt by the central control process, with production excess being used in the charging of EVs, and during production deficit the energy can be taken from EVs (operation in V2G – Vehicle-to-Grid mode). EVs can act as controlled load or generation resource, using a smart charging process, as explained and exemplified in [15, 16].

2.6. Geo-Reference Graph for the Electric Distribution Network

One important approach introduced in this work is the Geo-Reference Graph for the electrical distribution network. This allows computational data manipulation, such as distance calculation, identification of power limitation, and identification of user communities. The area with the distribution of the electrical network is manually transformed in a graph (Figure 3), where we add geographic information and power constraint between the nodes. Figure 3 shows different nodes with different apparent power capabilities (these nodes represent six T4 houses and two buildings with two and three floors). The main node (node zero) represents the power transformer responsible to supply the others eight nodes. Regarding to the consumer's behavior several assumptions were considered: (1) consumers define their house and family (number of house divisions and number of persons); (2) they define the number and type of electrical appliances from a pre-defined list; and (3) they also define their usual routine (e.g. arrival and departure times). Every consumer has its own behavior, and changes or unexpected behavior are randomly generated at the beginning of the experiment. Each consumer is represented by an agent who knows contractual power limitation and also the distribution.

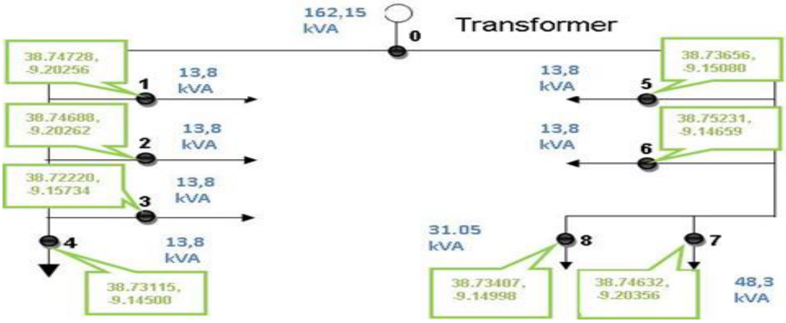


Figure 3. Geo-reference electrical distribution network.

3. Implementation of an OpenADR Infrustructure with RaspberryPi(s) towards Internet of Things

Since most fabricants do not provide an OpenADR yet or because the existence of old equipment, we developed a cheap solution around $25. Figure 4, shows the product developed to create the VEN for a load or MG. RaspberryPi was configured to act as a VEN. In the Figure 4, we simulated on/off operation through a LED but in real VEN operation this command is used to put on/off equipment or to slow\increase heat or cooling process. Also this can be used as a VEN with a generation resource where we add metering capability, display information is optional because information is stored as local EMS and can be presented through a web application. Since most electrical appliances are not compliant with OpenADR a VEN of Figure 5 should be integrated. All resources send information to local EMS that was developed for VENs configuration interfaces and visualization of energy exchanges. Based on VENs definition a consumption profile is created where we add non OpenADR consumptions. This is basically a web interface application that interacts with local VENs. This consumption profile are important information to apply in a future work data mining approach to extract knowledge related with energy consumption.

Since is not easy to have a real scenario for testing, we simulated our approach creating several VENs and multiply the effect to have impact in electricity consumption. Regarding production we use real data from 3 days (28 a 30 Abril 1015) from Portuguese REN [17]. Also consumption patterns were available and a dynamic approach were performed to match production to consumption based on a central commands performed remotely at the VEN. We introduce a small scale VEN (ten) distributed geographic.

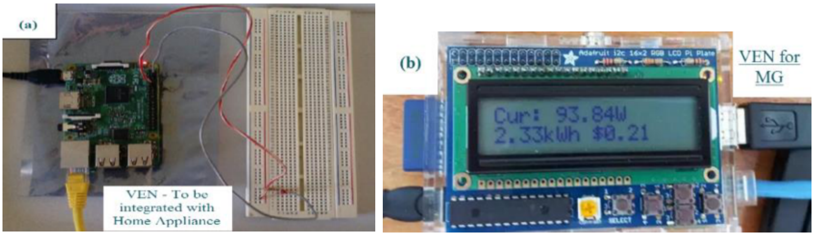
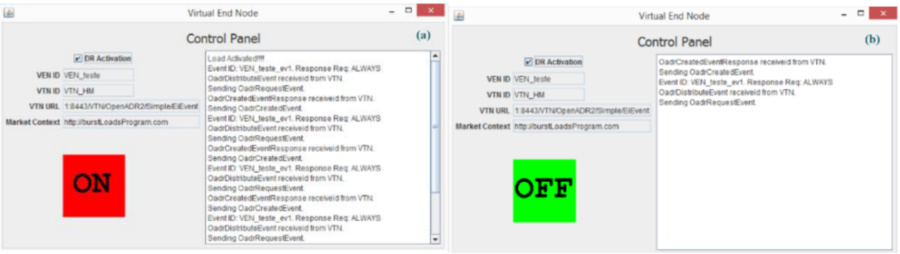


Figure 4. Developed RasberryPi VEN (a) and VTN for MG (b).



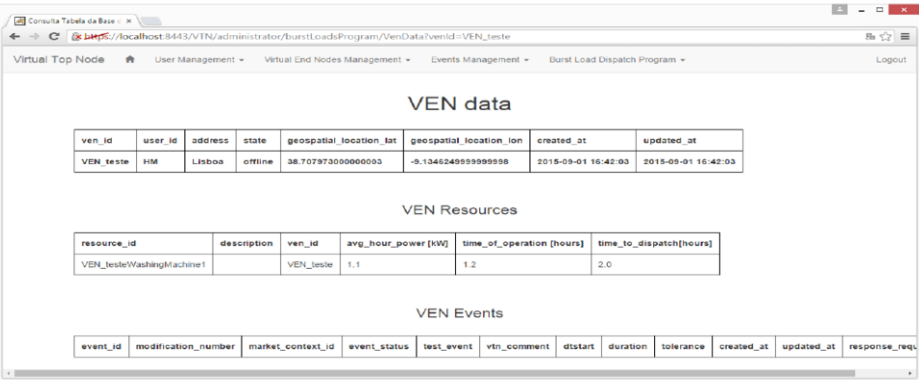
VEN ID VEN_teste
VTN ID VTN_HM
VTN URL 1:8443/VTN/OpenADR2/Simple/EiEvent
Market Context http://burstLoadsProgram.com

```
Load Activated!!!!
Event ID: VEN_teste_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_teste_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_teste_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_teste_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
```

VEN ID VEN_teste
VTN ID VTN_HM
VTN URL 1:8443/VTN/OpenADR2/Simple/EiEvent
Market Context http://burstLoadsProgram.com

```
OadrCreatedEventResponse receiveid from VTN.
Sending OadrCreatedEvent.
Event ID: VEN_teste_ev1. Response Req: ALWAYS
OadrDistributeEvent receiveid from VTN.
Sending OadrRequestEvent.
```

Figure 5. VEN interface and associated transactions: (a) Turned on; (b) Turned off.



~~https~~://localhost:8443/VTN/administrator/burstLoadsProgram/VenData?venId=VEN_teste

VEN data

ven_id	user_id	address	state	geospatial_location_lat	geospatial_location_lon	created_at	updated_at
VEN_teste	HM	Lisboa	offline	38.707973000000003	-9.1346249999999998	2015-09-01 16:42:03	2015-09-01 16:42:03

VEN Resources

resource_id	description	ven_id	avg_hour_power [kW]	time_of_operation [hours]	time_to_dispatch[hours]
VEN_testeWashingMachine1		VEN_teste	1.1	1.2	2.0

VEN Events

event_id	modification_number	market_context_id	event_status	test_event	vtn_comment	dtstart	duration	tolerance	created_at	updated_at	response_requ

Figure 6. VEN's available reports with information stored at local VPP.

The first step is the VEN registration through a web application (Figure 5(a)). In this register process the user defines the VEN class, working hours, consumption and geographic position. The simulation tool loads a request from the local VPP server, using the production and consumption data. If the consumption is above a predefined value, then an off remote command is performed, and if the production is high enough a remote on command is given. We perform small scale tests, with ten VEN, and with a simulation of production and consumption based on historical data. From these tests, several procedures of remote turn on/off of VEN were performed. We also have tested with success the decision of VEN on/off based on distribution distance of the VEN to the energy source and priority VEN class (see section 2.3). The case of class 2 (for example, range temperature in a heating system), when temperatures goes down the value defined by the user, it assumes maximum priority, were also tested. Figure 6 shows the VEN interface and associated transactions when it is turned on and when it is remotely turned off, because there was no need to take electricity production excess. Figure. 6 shows a web interface to local HEMS, where the user can check all actions and consumption performed by the VEN that he is the owner.

For MG, owners register the VEN, defining the renewable capacity, geographic localization and the report service poll interval with the energy produced and/or average power. Local device informs about the MG production that was not consumed. In our test environment we simulated VPP manager (VTN) based on historical energy production available from [17]. All the energy production is collected at central VPP manager for main producers and local MG production. Based on this information, the VPP manager takes the decision for the VEN being on/off, or for the VEN increasing or decreasing the power consumption. This decision is based on VEN class and distribution distance between VEN´s generation resources and VEN's loads resources. So, based on production data and consumption data available from [17], a simulation process was taken.

It is possible to check the power consumption per house. Figure 7 shows an example where, at 12 hour, one of the houses is not taking the energy produced (blue line), and therefore, this energy is delivered to the power grid. In this case, a nearest VEN with a load in off position was turned on automatically in order to consume energy. Also, it can be seen that at 15 hour the consumption is negative (the house is injecting energy in the grid). This information is send to a local VPP manager, and a decision process takes place in other that a VEN or a set of VENs need to be turned on.

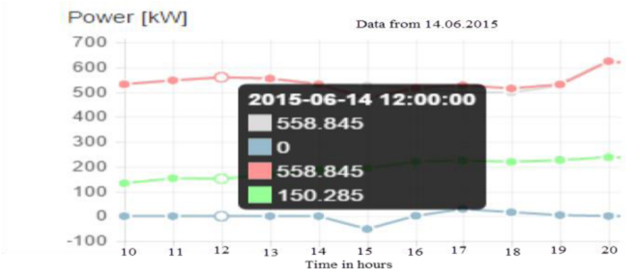
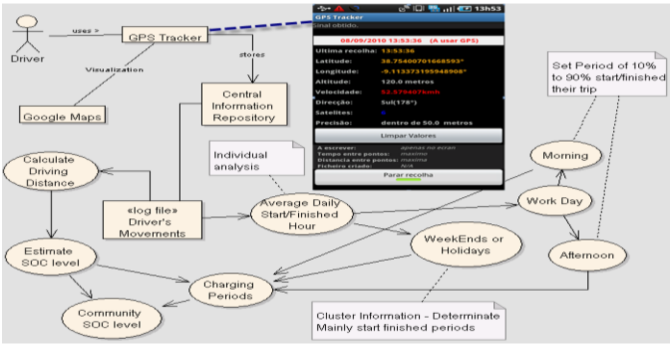


Figure 7. Home consumption stored at local VPP with graphic web interface for user presentation, each line represents different power consumption.

4. Personalization based on Tracking System in ‘Offline’ Mode Drive

We have developed a tracking application to run in an offline mode (to avoid communication costs) in a mobile device with GPS device. This project was developed in an academic final year project at ISEL, described at [16], and its high level vision is showed in Figure 8. This tracking application mainly stores times, GPS coordinates and user identifications. From the GPS coordinates it is easy to calculate travel distances. Using Google Maps API we can represent the drive route and obtain the travel distance. From the travelled distance and the EV efficiency we can estimate the remaining energy stored in the batteries of each EV (SOC – State-of-Charge level), as well as the community SOC level (sum of all individual community SOC levels). The studied population (from the city of Lisbon area), with 50 cases, contains a mixture of university students and their parents. The application designated as GPS Tracker was developed to be used in mobile devices, like PDA, on top of Android. The purpose of this application is to create GPX files with the recording of the GPS data (namely: latitude, longitude and instantaneous speed) related to the travels of the user. The user has yet the possibility of observing, in real time, the collected data.



GPS Tracker
Sinal obtido.
08/09/2010 13:53:36 (A usar GPS)
Ultima recolha: 13:53:36
Latitude: 38.75400701668593°
Longitude: -9.113373195948908°
Altitude: 120.0 metros
Velocidade: 52.579407kmh
Direcção: Sul(178°)
Satelites:
Precisão: dentro de 50.0 metros
A escrever: apenas no ecran
Tempo entre pontos: maximo
Distancia entre pontos: maxima
Ficheiro criado: N/A

Figure 8. GPS Tracking Application and main functionalities.

The system allows seeing statistics on the route taken, including: travel duration time; total distance traveled; average speed; and others that can be obtain by data manipulation (e.g., trip cost).The system can also provide all the above parameters for all the paths of the user, thus obtaining the total average values. The presentation of statistical results for one route or for all the paths of the user is done via GPS ReportView. The purpose of this application is to allow viewing all the statistical data corresponding to journeys made by the user (and owner). This application provides a list of all journeys made to the user menus and two more with statistics and a course with the average values of all paths. The GPS Tracker allows the user to see the GPS data on its position, direction, and speed, as showed in Figure 8. This application allows personalization of home appliance turn on/off by the determination of arrival times, in case of EV the energy needed to perform daily travels.

5. Conclusions

We proposed an HEMS framework based on, allowing consumption events based on external events, like production availability, that is reflected in energy price. The system is designed to be personalized for the user and provide appropriate appliance operations according to priorities learned from the user’s lifestyle. The HEMS framework enables us to control energy appliances automatically by considering the user's lifestyle when electricity is liberalized and when electricity consumption is limited. We develop a collaborative process based on energy production information, starting/stopping electrical appliances that do not have an obligatory time constrain

It is important to verify this framework with real-world data; therefore, we will experimentally evaluate the framework based on data sets generated from real-world human behavior in a future work. Also OpenADR is a promising standard, as Navigant Research forecasts that global spending on ADR will grow from $13 million in 2014 to more than $185 million in 2023 [18]. The upcoming reality of Smart Grids will need to join efforts from different fields of knowledge. In this research work we have joined two groups with different expertise, one at ISEL in Informatics and Telecommunication, and the other at the University of Minho in Energy and Power Electronics, with previous works on power quality, renewable energy and electric vehicle charging systems.

References

[1] US Energy Information Administration, International Energy Outlook 2014, Washington, DC.

[2] M. Pisapattanasomporn, M. Kuzlu, S. Rahman. An algorithm for intelligent home energy management and demand response analysis. IEEE Trans. Smart Grid. 2012;3:2166–2173

[3] Ren D, Li H, Ji Y. Home energy management system for the residential load control based on the price prediction. IEEE Online Conf. Green Commun. 2011; New York, NY.

[4] Hu Q, Li F. Hardware design of smart home energy management system with dynamic price response. IEEE Trans. Smart Grid. 2013;4:1878–1887.

[5] A. Rabl, L. Norford. Peak load reduction by preconditioning buildings at night. Int J Energy Res, 15 (1991), pp. 781–798

[6] F. Morris, J.E. Braun, S. Treado. Experimental and simulated performance of optimal control of building thermal storage. ASHRAE Trans, 100 (1994), pp. 402–414

[7] Xu P, Haves P, Piette MA, Braun J. Peak demand reduction from pre-cooling with zone temperature reset in an office building. In: ACEEE summer study of energy efficiency in buildings; 2004

[8] R. Yin, P. Xu, M.A. Piette, S. Kiliccote. Study on auto-DR and pre-cooling of commercial buildings with thermal mass in California. Energy Buildings, 42 (2010), pp. 967–975

[9] M. A. Piette, G. Ghatikar, S. Kiliccote, E. Koch, D. Hennage, P. Palensky, and C. McParland, "Open automated demand response communications specification (version 1.0)," California Energy Commission, PIER Program CEC5002009063, Apr. 2009.

[10] T. Lui, W. Stirling, and H. Marcy, "Get smart," IEEE Power and Energy Magazine, vol. 8, no. 3, pp. 66–78, May-June 2010.

[11] Advanced Metering Infrastructure Home Area Network (HAN) Functionary Guideline, Dept. of Primary Industries, Nov. 2008, ver. 0.5.

[12] J. K. Kok, C. J. Warmer, and I. G. Kamphuis, "PowerMatcher: multiagent control in the electricity infrastructure," in Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems, ser. AAMAS '05. ACM, 2005, pp. 75–82

[13] http://cimug.ucaiug.org/Projects/CIM-OpenADR/default.aspx

[14] Vítor Monteiro, Bruno Exposto, J. G. Pinto, Raul Almeida, João C. Ferreira, Andrés A. Nogueiras Meléndez, João L. Afonso, "On-Board Electric Vehicle Battery Charger with Enhanced V2H Operation Mode", IEEE IECON Industrial Electronics Conference, pp.1636-1642, Dallas Texas USA, Oct. 2014.

[15] V.Monteiro, J. C. Ferreira, G. Pinto, D. Pedrosa, J. L.Afonso: iV2G Charging Platform. IEEE-ITSC, 13th International IEEE Conference on Intelligent Transportation Systems, pp.409-414, September, (2010).

[16] João C. Ferreira, Alberto Silva and João L. Afonso: Agent based approaches for Smart charging strategy for Electric Vehicle. EVTEC 11, 17-19 May 2011, in Yokohama, Japan.

[17] Ren WebSite - http://www.centrodeinformacao.ren.pt/PT/Paginas/CIHomePage.aspx

[18] Navigant Report about OpenADR - https://www.navigantresearch.com/research/automated-demand-response