

Research Article

ALL ASPECTS OF A SMART HOME: THE STUDY OF OVERVIEW

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ABSTRACT

Smart homes offer a potential benefit for individuals who want to lead independent lives at home and for loved ones who want to be assured of their safety. We have designed algorithms to detect anomalies and predict events based on sensor data collected in a smart environment. Demand response applications within smart grid provide excellent opportunities for peak demand reduction through demand side load management. In the context of a smart grid, renewable energy resources are getting immensely popular as many homeowners are now opting for renewable energy systems at their residence. This paper proposes a method for improved energy management in smart homes by means of resource allocation. For this purpose, a Banker's algorithm based strategy has been developed. It is used to control the system and decide which of the given processes should be provided with resources at the time. Constraints such as due time of a process, limit of electrical energy consumption and use of preferable resources are taken into account.

Keywords: *Potential, Algorithm, HEM Systems, MavHome*

INTRODUCTION

We propose one such framework to derive temporal rules from a time series representation of observed inhabitant activities in a smart home, and validate the algorithm using both synthetic datasets and real data collected from the MavHome smart environment. This framework is based on Allen's temporal logic (Allen and Ferguson, 1994).

Allen suggested that it is more common to describe scenarios by time intervals rather than by time points, and listed thirteen relations formulating a temporal logic (before, after, meets, meet-by, overlaps, overlapped-by, starts, started-by, finishes, finished-by, during, contains, and equals). These temporal relations play a major role in identifying temporal Activities which occur in a smart home. Consider, as an example, a case where an elderly person takes pills after eating food.

We notice that these two activities, taking pills and eating, share the temporal relation "after" between them. When this relationship is violated, the relationship type is updated to "meets" and an anomaly in activity is noted. Morchen argued that Allen's temporal patterns are not robust and small differences in boundaries lead to different patterns for similar situations (Mörchen, 2006).

As a possible solution, Morchen presented a Time Series Knowledge Representation, which expresses the temporal concepts of coincidence and partial order. Although this method appears feasible, it does not suit our smart home application due to the granularity of the time intervals in smart homes datasets. His approach does handle noise elimination, which is a problem with the large datasets generated by smart home sensors (Gottfried *et al.*, 2006).

Also reason that space and time play essential roles in everyday lives. They offer qualitative approaches for spatiotemporal reasoning in smart homes which are not yet presented in an implementation. Residential demand response (DR) programs can be implemented in the form of home energy management (HEM) systems. Recent research topics are related to designing HEM systems with Renewable energy (RE) integration (Guo *et al.*, 2012; WI *et al.*, 2013).

Authors in (Gottfried *et al.*, 2006; Papavasiliou and Oren, 2014) consider this problem as a stochastic optimization problem to minimize energy costs based on dynamic pricing and stochastic nature of renewable energy output. In (Liu *et al.*, 2012; Byun *et al.*, 2012) DR programs are proposed that use a dynamic priority based appliance scheduling based on forecast of RE capability. Authors in (Squartini *et al.*, 2013) address the use of battery, discussing dependence of HEM algorithms on battery characteristics.

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Definitions

Smart Home

In our setup, a smart home is a system that controls processes by means of providing them with resources they request to complete tasks given by a user. To be completed, every process requires a certain amount of resources. The developed algorithm decides on the schedule of assigning each process by requested resources. For illustration of a smart home setup, the considered processes and resources and their interconnection are depicted in Figure 1.

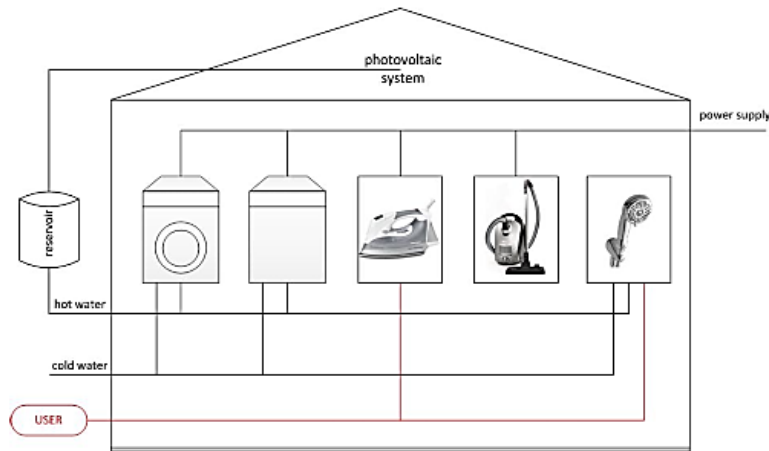


Figure 1: Smart home

Set of Resources Electricity

Electricity is split into two different resources: low cost, and expensive electricity, because of daily changes of electricity prices in certain countries (TMC, 2011). Electrical energy is cheaper by night because of the smaller demand at that time of a day. In the setup, the expensive tariff is chosen to last from 8 a.m. till 10 p.m., while the low-cost lasts from 10 p.m. till 8 a.m. There are two parameters that describe the resources of electricity: the maximal reserved power, and the limit power. The maximal reserved (allocated) power is the maximal amount of electric power that can be provided to a household. The limit power is defined by a user and it is the amount of electricity defined as the maximal power that can be drawn from the grid. That amount should never be reached in the normal working conditions.

Cold Water

The resource of cold water comes from the water supply line.

Hot Water

Solar energy is used only to heat the water that is necessary for some processes. It is possible to lower the use of electricity and reduce total costs by using the hot water instead of cold one. Considered smart house is equipped by photovoltaic system to heat the cold water tanks. In this setup, the water tanks are designed as separated tanks to ease the calculation of the amount of heated water.

Set of Processes

Set of processes consists of five elements: ironing, showering, washing the dishes (dishwasher), doing the laundry (washing machine), and vacuum cleaning (done by a robot). This set could be separated into two parts: first group consists of processes that require user's involvement, e.g. ironing or showering, while the second group consists of processes that, once they have been started, are able to get completed without human presence, e.g. dishwashing, washing machine, robot vacuum cleaner. First group of processes is included to increase the generality and to simulate user's interference which can be seen as a disturbance of the smart home system and developed algorithm. When assigning, each process is given following values:

1. Start time - the time instance at which a process has been started
2. Due time - by that time instance a process has to be done, at any cost

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Banker's Algorithm

Banker's Algorithm (Dijkstra, 1977) is used for allocating resources and avoiding deadlocks. Although the algorithm itself is intuitively clear and easy to implement, its application is limited because of certain assumptions of the algorithm. These assumptions are listed below:

1. The number of processes must be predefined and constant.
2. The number of resources must be predefined and constant.
3. All processes announce in advance how much of every resource each of them needs.
4. After completing, each process returns all the allocated resources, so they can be reused by assigning to some other process (es).
5. Each process is completed in a finite time.

In addition, to obtain better energy management, the considered system should satisfy several additional constraints:

1. The use of sustainable energy resources such as hot water and low-cost electricity.
2. Completion of given tasks before the deadline (respecting the due times).
3. Keeping the power below a specified threshold (the limit power).

Smart Home Technology

All the appliances and devices are receivers, and the means of controlling the system, such as remote controls or keypads, are transmitters. If you want to turn off a lamp in another room, the transmitter will issue a message in numerical code that includes the following:

1. An alert to the system that it's issuing a command,
2. An identifying unit number for the device that should receive the command and
3. A code that contains the actual command, such as "turn off."

All of this is designed to happen in less than a second, but X10 does have some limitations. Communicating over electrical lines is not always reliable because the lines get "noisy" from powering other devices. An X10 device could interpret electronic interference as a command and react, or it might not receive the command at all. While X10 devices are still around, other technologies have emerged to compete for your home networking dollar. Instead of going through the power lines, some systems use radio waves to communicate, which is also how Wi-Fi and cell phone signals operate. However, home automation networks don't need all the juice of a Wi-Fi network because automation commands are short messages. The two most prominent radio networks in home automation are ZigBee and Z-Wave. Both of these technologies are mesh networks, meaning there's more than one way for the message to get to its destination.

Z -Wave

Z-Wave uses a Source Routing Algorithm to determine the fastest route for messages. Each Z-Wave device is embedded with a code, and when the device is plugged into the system, the network controller recognizes the code, determines its location and adds it to the network. When a command comes through, the controller uses the algorithm to determine how the message should be sent. Because this routing can take up a lot of memory on a network, Z-Wave has developed a hierarchy between devices: Some controllers initiate messages, and some are "slaves," which means they can only carry and respond to messages.

Zig Bee

Zig Bee's name illustrates the mesh networking concept because messages from the transmitter zigzag like bees, looking for the best path to the receiver. While Z-Wave uses a proprietary technology for operating its system, ZigBee's platform is based on the standard set by the Institute for Electrical and Electronics Engineers (IEEE) for wireless personal networks. This means any company can build a ZigBee-compatible product without paying licensing fees for the technology behind it, which may eventually give ZigBee an advantage in the marketplace. Like Z-Wave, ZigBee has fully functional devices (or those that route the message) and reduced function devices (or those that don't).

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Smart Home Advantages

Smart homes obviously have the ability to make life easier and more convenient. Home networking can also provide peace of mind. Whether you're at work or on vacation, the smart home will alert you to what's going on, and security systems can be built to provide an immense amount of help in an emergency. For example, not only would a resident be woken with notification of a fire alarm, the smart home would also unlock doors, dial the fire department and light the path to safety.

Smart homes also provide some energy efficiency savings. Because systems like Z-Wave and ZigBee put some devices at a reduced level of functionality, they can go to "sleep" and wake up when commands are given. Electric bills go down when lights are automatically turned off when a person leaves the room, and rooms can be heated or cooled based on who's there at any given moment. One smart homeowner boasted her heating bill was about one third less than a same-sized normal home. Some devices can track how much energy each appliance is using and command it to use less.

Smart home technology promises tremendous benefits for an elderly person living alone. Smart homes could notify the resident when it was time to take medicine, alert the hospital if the resident fell and track how much the resident was eating.

If the elderly person was a little forgetful, the smart home would perform tasks such as shutting off the water before a tub overflowed or turning off the oven if the cook had wandered away. It also allows adult children who might live elsewhere to participate in the care of their aging parent. Easy to control automated systems would provide similar benefits to those with disabilities or a limited range of movement.

Smart Home Appliances for Physically Challenged Individuals

If an individual has difficulty moving around effectively, they are often forced to depend on others for care. With the implementation of smart home appliances, such as an effective security system, those with physical challenges are often able to live on their own. A smart home security system allows the homeowner to remotely view visitors on a camera, and speak to them via microphone and speakers. If the visitor is welcome, the security system unlocks and opens the door to allow the visitor access to the home. Smart home security systems can also learn which visitors are always allowed, and what areas they may have access to (Nicks, 2009).

Automatic Vehicle Parking System

The Parking System works like the following scenario, the vehicle has to be driven to the gate of the parking garage. The driver draws a parking ticket, and then drives the vehicle to search an available parking space for parking. The automatic vehicle parking system has to be designed to be smart and easily managed. Vehicles can search parking space and park themselves in correct spaces automatically (Chou *et al.*, 2007).

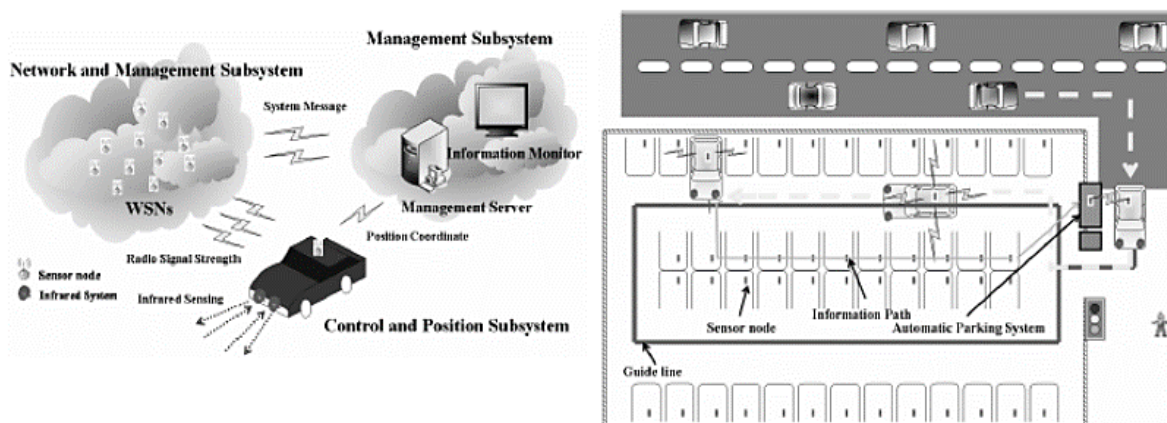


Figure 2: Architecture and the operation procedure of the automatic vehicle parking system

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The major work of the parking management subsystem is to supply user interface, and to display system status and information. The control and positioning subsystem is embedded on the vehicle, and is able to control the behavior of the mobile vehicle and compute its current position according to the received signals (Figure 2). The WSN network and management subsystem is deployed in the parking garage. It is responsible for monitoring the status of the vehicle, and transmitting commands and data between the parking management subsystem and the control and positioning subsystem.

Sensor nodes are equipped with the parking spaces for the purposes of positioning and communications. A guide line is painted on the road surface. The infrared detector embedded on the vehicle can detect the guide line and report to the control and positioning subsystem. The vehicle thus can avoid deviation from the guide line, due to the inaccuracy of the Position estimated. In the automatic vehicle parking system, the driver just takes a parking ticket and leaves the vehicle on the Gate. The parking management system will communicate with the control and positioning subsystem on vehicle, and command the vehicle to move to and park on an assigned available parking space. The WSN management system will keep monitoring the parking space for the reason of security. As long as the driver wants to take back the vehicle, he just pays the parking fees and the vehicle will automatically move to the exit gate (Chou *et al.*, 2007).

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