Smart Expense Management Model for Smart Homes

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Abstract
Smart home technology is the near future necessity that aims to provide comfort and security with a minimal cost by avoiding wasteful expenditure. In this research paper we have focused on the efficient expense management by monitoring its timing and quantum of cash outflow. Our proposed model helps in recording and keeping track of all types of expenses incurred by the household owner. The recorded expenses are categorized to provide an insightful distribution of the total spending. Integration of smart home with expense management system, increases the efficiency and effectiveness in the task of maintaining household budget. In this research paper the significance and need of such a system is discussed that helps in significant savings and future planning by analyzing daily household expenses with available funds.

Keyword
Smart Home, Expense management, Budgeting, Automation

1. Introduction

This section presents the introduction to the terms 'Smart Home' and 'Expense Management', explaining their relationship and how integrating expense management in Smart Home will automate the necessary yet toiling manual task of controlling and keeping track of expenditure.

1.1 Smart Home

Smart Home is an idea sparked more than a few decades ago. Since then this technology has been continuously growing and integrating with new technologies thus improving standard of daily life. This technology of automating household activity introduces idea of forming a network of devices and other tech gears in house, so as to automate manual tasks. As per the Smart Homes Association, the most appropriate understanding of the smart home technology is that it is a system having a centralized controlling of devices and other automated services, which are being controlled by building a network among devices for a better standard of living [1]. The home networking unit facilitates for communication among the devices providing for home security functions and other convenient services of daily life. Networking system also helps in building a system that can collect information and provides for intelligence factor 'Smart' in Smart Home. To assemble a smart home, it requires devices that are integrated with uniform framework resulting in interconnection among these devices. For fulfilment of functionality of a Smart Home requires to map all devices into a well-defined space which provides for computing capabilities with background awareness [2]. For example, a homeowner on vacations away from home can use a smartphone to turn on the home security system, or can control room temperature, lighting inside or outside of home, switch appliances on or off, even if at home he can program a home theater or any other entertainment system for a specific schedule.

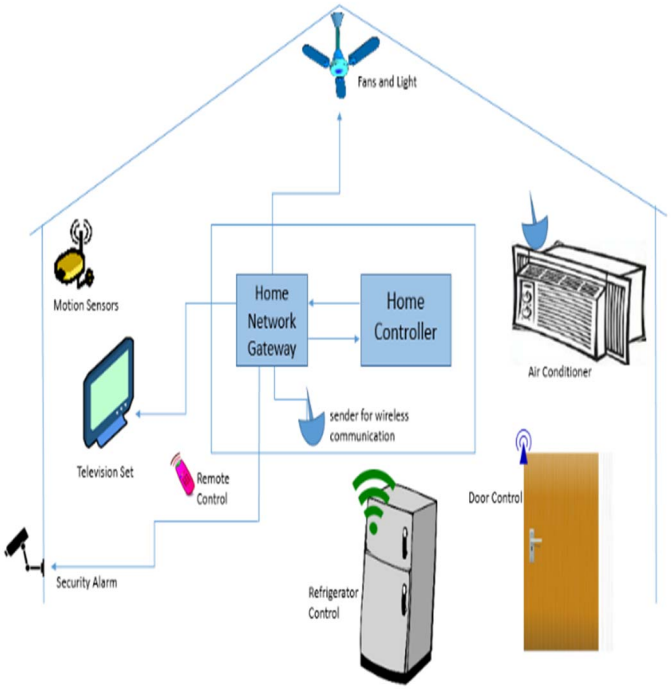

Fig 1: Smart Home

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Smart home architecture has three major components, namely Smart Home Network, Smart Home Controller and Home Automation devices [3]. The Smart Home Network is used for providing a channel for connection among the automated devices and for controlling the devices. Smart Home Network generally are of two types: wired and wireless. The controlling device act as interface between homeowner and the devices. These are also used for centralized controlling and managing of the system. The Home Automation devices are the devices which are used to provide automated control to the physical environment. See Fig 1.

1.1.1 Smart Home Network

Communication between devices and the home controller is established using a Smart Home Network. The network channel used in Smart Homes can be one of the major types, wired or wireless, or can be hybrid of both [4].

In wired network system, the devices communicate through the wires present in the major power supply. The information, in form of data bits, is sent into the power supply which turns the device on or off. There are different types of wires that are being used, for e.g. new wire (twisted pair, optical fiber), Busline, Powerline, etc. The Powerline Carrier Systems (PCS) is a wiring methodology used for sending code embedded signals into a home's prior in-wall electric wiring to the preprogramed circuits or switches. Such signals are used for conveying tasks that imply to locations or "addresses" of those targeted devices. These signals are medium for controlling when and how devices would work. PCS transmitter sends a pulse of data along the common household line, and a receiver connected in that electricity outlet would receive that pulse and would perform the operation on the device attached to it [5]. X10, an open standard protocol for PCS, is used in automation of houses. X10 transfers the binary encoded information via a simple AM (Amplitude Modulation) technique, which transfers the signals, carrying the data, over house wiring to the end points. There are certain issues of X10, such as electrical lines don't account for sure reliability for communication because noise from other lines tend to creep in. X10 devices interprets any incoming electric interference as a task and reacts on those fake commands, due to noise, it might not receive the command at all. Hence, new wireless systems emerge to overcome such limitations of wired network system.

Wireless network system, must have two components, wireless sender and wireless receiver. New generation devices communicate via wireless technology such as Microwaves, Infrared, Wi-Fi, radio frequency, IEEE 802.11 and Bluetooth etc. Wireless systems for smart home available in market are Z-wave and ZigBee which are affordable and reliable solutions. Z-wave uses Radio Frequency (RF) for communication among appliances and controller but ZigBee is more versatile since it can be configured for virtually any short-range wireless task. Both of these solutions are for the mesh networks in which more than one path is available for the command to reach its destination.

Some of standards for a Smart Home, works on a hybrid network of wired and wireless system.

1.1.2 Smart Home Controller

Smart Home Controller is the integrating unit among the residence's home automation systems. Controller performs centralized controlling functions. Communication among the whole systems is carried out via a single home controller, which enables resident with single button control. The examples of the home controllers for smart home are the traditional remote control, or it can be smartphones also, controlling via Short Message Service (SMS) and web browsers. Moreover, computers at large can also be the controlling unit.

1.1.3 Smart Home Automation

A Home Automation System contains a panel of home devices [22]. These are all the electronic devices that perform important time saving functions of the house for the owner thereof, for e.g. gas stoves, washing machines, heaters, refrigerators, room thermometers, light adjustment systems, smoke detectors, TV, gaming consoles and other essential entertainment providers, ventilators, air conditioners, surveillance cameras, motion and sound detectors etc. Their functions can be actuators, sensors or both. More advanced versions of such devices are being developed constantly, like smart furniture (bed and chair) [6].

1.2 Expense Management

Expense Management is an effective way of keeping track on daily expenses. Management of expenses is important because it helps in keeping account of spending and taking control of finances. In comparison to income, control on expenses can be easily exercised. Expense Management creates financial awareness that not only helps in staying financially healthy but also helps in planning for future endeavor.

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Expense Management is a very simple process of balancing the money in and money out. Expense Management starts with understanding the types of expenses that occur in daily life. There are three types of expenses, namely Fixed, Variable and Periodic Expenses [7].

- *Fixed Expenses*: These are those types of expenses that occur after a fixed period for a fixed amount. Cash outflow for these expenses are fixed, for example monthly house rent payment, loan repayments to banks, insurance premium payment, school tuition fees etc. Such expenses are regular up till a specific period and are mostly non-negotiable.

- *Variable Expenses*: These expenses are those types of expenses which have fixed per unit cost and the total expense varies with the quantum of consumption. Such expenses occur on regular basis. Although the amount can vary but these expenses are unavoidable generally. For example electricity bills, food bills, utility bills, entertainment bills etc.

- *Periodic Expenses*: These are those types of expenses that are fixed for a particular period. These periodic expenses can either have fixed or variable cost but they never occur on daily basis. Such expenses are highly negotiable and also avoidable. For example gifts, clothing, accessories, impulse buying etc.

The best way to control your household finances is by tracking all of them and keeping them in form of tabular records on basis of which weekly, monthly or yearly charts can be prepared. These charts help in analysis of money flowing out and provide an insight for the direction which facilitates in keeping the balance between spending and income.

2. Related Work

The expense management is generally done manually by comparing the income with expenditure incurred at the end of each month. Under this method most of the expenses are not recorded because of their small amount or their fixed nature. Moreover the manual remembering of the dates of payment for services such as maid's salary, car driver salary, society maintenance bills and other utility bills is tedious and sometimes leads to losses because of the double payments. Hence, instead of savings, extra expenditure is incurred. See Fig 2.

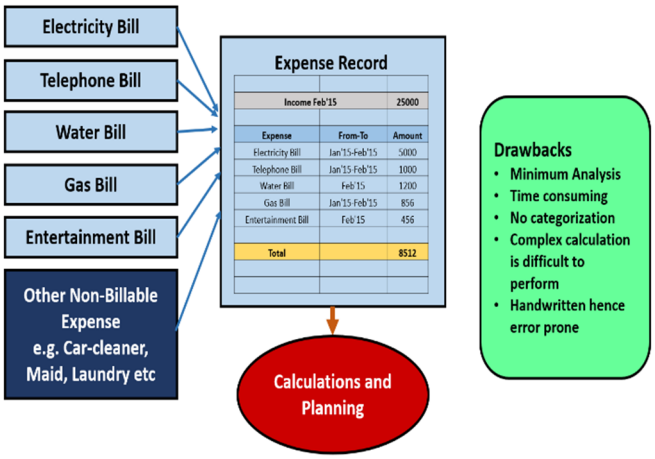

Fig 2: The manual expense management and its drawbacks

In recent years, with increasing use of smartphones, several applications have immerge to automate the process of record tracking of finances. This makes the time consuming task of keeping records easier. But these applications fails to provide the user with proper analysis and utilization pattern of the expenditure. Hence the regular expenses such as electricity bill, water bills, fuel bill, telephone bill etc. which can be reduced by analyzing usage pattern, are not taken care of.

The toiling task of expense management when combined with the Smart Home technology can yield a simple and efficient system of finance management as this model will automatically track the expenses which are otherwise difficult to trace. For example electricity consumed by appliances in standby mode, standby mode of electric chimney, tracking wastage of water etc. As the Smart Home manages the home devices, the analysis of reduction and effective usage can be easily mined.

3. Smart Expense Management Model

In this section the Smart Expense Management Model for Smart Home is proposed. This model is aimed at revolutionizing the way expenses are managed and also states about how inculcating this factor with Smart Home technology can yield in better personalization of technology.

The model aims to track and record the expenses of residents, and then provide with category-wise analysis of their expenditure weekly, monthly and

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yearly basis. This also strive to provide the resident with options of reminding payment dates for fixed services and also provide for savings opportunities that can be achieved by tracking the general expenses. See Fig 3.

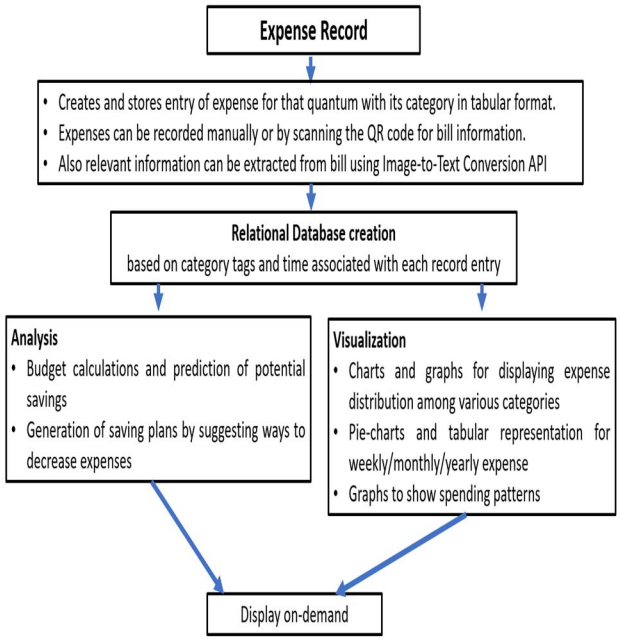

Fig 3: Smart Expense Management Model explained using flowchart.

3.1 Tracking and Recording Expenses

For effective management of money, the system needs to analyze the expenses monthly by maintaining tabular records. This information is collected from the user and stored in a proper format, as columns having the amount the user would like to pay for each category. The system will have some initial categories of expenses such as Fixed, Variable and Periodic based on the definition stated earlier. These categories can be further extended by the resident as per his wishes in order to track that particular category for expense monitor. Further each category can have multiple tags for further detailing of the expense. For example a category named home and utilities can have tags such as electricity, water, telephone etc.

The category-wise expenses are stored in the table with the respective dates on which each expense is made. As the table gets its initial values, the system starts preparing with weekly, monthly and yearly charts having the data of the spending pattern followed by the user. This data can be represented in several formats taking care for easier understanding of resident such as graphs, percentage comparisons, straight figure analysis etc. See Fig 4.

As the system records for expenses, it also saves the payment dates and other important information such as advance payments, due dates for agreement renewal etc. This information not only helps in better planning but also saves the resident from the payment of late fee as a wasteful expense. Smart Home technology caters for home and hence this information will be accessible to all of the members of home to achieve optimum expense management. [10, 15]

View: Annually

Category	Amount Spend	Spending Limit	%age Comparison	Previous Budget %age Comparison
Home & Utilities	45,456 ₹	50,000 ₹	9.09% save	1.24% save
Insurance & Financial	13,900 ₹	20,000 ₹	30.50% save	3.45% save
Groceries	19,877 ₹	20,000 ₹	0.62% save	1.56% extra
Personal & Medical	5,678 ₹	4,000 ₹	41.95% extra	56.81% extra
Entertainment & Eat-out	13,457 ₹	10,000 ₹	34.57% extra	6.23% save
Transport & auto	22,344 ₹	30,000 ₹	25.52% save	4.76% extra
Children	45,687 ₹	50,000 ₹	8.63% save	6.56% save
Summary	1,66,399 ₹	1,84,000 ₹	9.57% save	0.02% extra

Fig 4: Tabular Format for tracking expenses categorically with track of extra spending and savings being compared to set goals and previously saved budget, providing the better insight about the domain where the savings can be easily increased. Colour coding to every category is provided for easier understandings of flow of money.

3.2 Entering Bills and Assigning Categories

The resident enters the bill record with a tag in the system which automatically assigns it with the respective category. Each record can be easily keyed in manually on the system with touch assistance. But this also may become the tedious task when the number of records are numerous. To make the system more user friendly, saving time and increasing efficiency, the bills can be scanned for the bar codes or QR codes to store the required information.

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This scanning and extracting information from a bill automatically is achieved by using APIs. There is API for image to text conversion. This API will scan the bill and extract the selective text from the scanned image. Irrespective of the platform, existing systems can easily inculcate theses APIs.

This OCR (Optical Character Reorganization) API takes machine encoded texts from types, printed or hand written text and then using electronic conversion to convert it into a machine-encoded text. There are several vendors available that provide for this API, one such is the Google Web API, more information on this can be found from link: http://googlesystem.blogspot.in/2009/09/google-docs-ocr.html. See Fig 5.

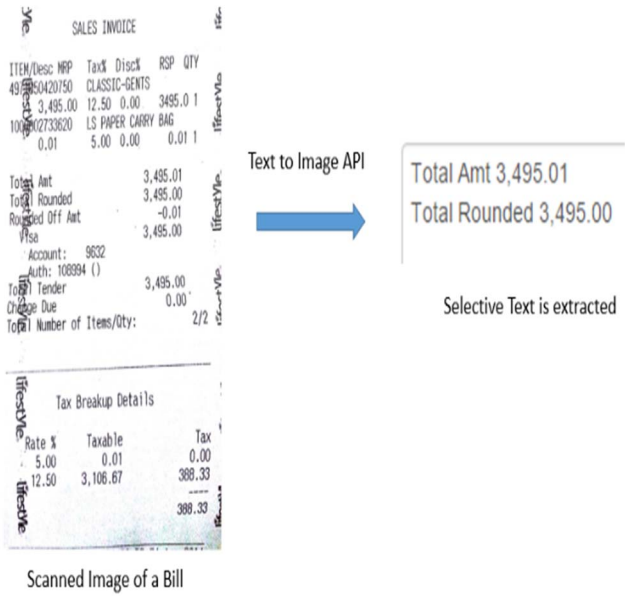

Fig 5: The OCR API converts the scanned image of bill into text which is filtered out.

Another way of getting the bill record into the system is by QR code scanning. Quick Response Code (QR code) is the hallmark for matrix barcode (or 2-D barcode). A barcode is read by machine as optical label which has all the information of the item to which it is attached. Kanji, alphanumeric, Byte/Binary, numeric are some encoding modes standardized to be used for QR code for efficient storage of data. The QR Code system is popular due to its large storing capacity and faster readability. The API for QR code scanning is also available and makes the whole process much faster.

The important information such as last payment date of fixed expense can be stored manually or can be automatically captured on the payment of bills for the expenses. Advance payment made is automatically set off against the said bills and excess or shortfall (in case late fee or delayed payment considered separately) is recorded. This can also be set off manually. Once the bill payment is made, the reminder automatically terminates after adjustment of the said short or excess of payment.

3.3 Analysis of the Expenses

As the records are entered, the system performs analysis on the data about how the expenses are made. See Fig 6.

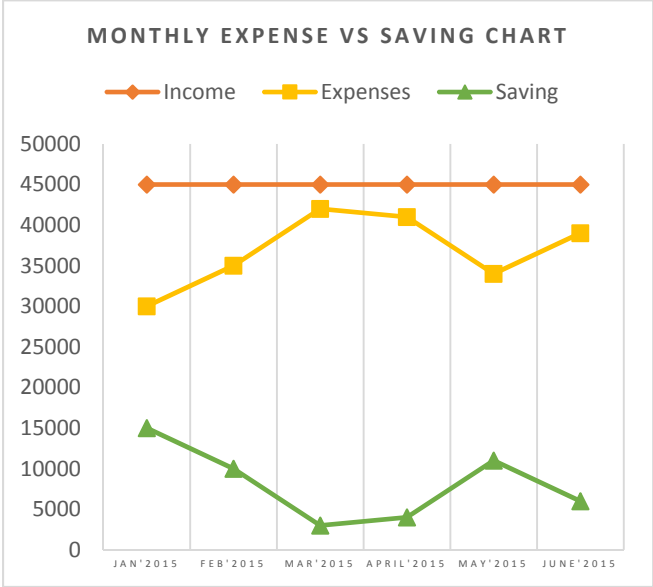

Fig 6: Analysis of expenditure and savings curve monthly from the Database.

This categorization of expenses from analysis point of view is important because this provides for the right way of spending on the subjects which matters the most to the resident.

The system prioritize the categories according to user into the Needs and Wants Expenses. See Fig 7.

The Needs are the very basic necessities, the expenses that have to be paid in order to live. Such as rent or loan repayment, food and groceries, health care, gas and electricity, transport etc.

The Wants can be further divided in Goals and Extras. The Goals are those expense that are not necessary but increase the standard of lifestyle and are the part of future planning for the residents. Extras are those expense that can be easily reduced, such as entertainment expenses.

Fig 7*: User based prioritization of expense flow.

Prioritizing the expenses gives the system a ways to help the resident in providing for the switching and saving options.

3.3.1 The Saving Option

The system analyses the records and expenses done in each category as they are performed. As per the goals and limit set by the resident, the system prepares for finding paths for more savings.

The options for saving are reported by the system to the resident by percentage comparisons of the expenses and also by tracking the consumption details of the necessities of the house such as electricity and providing with the devices information that consumes the most units.

3.3.1.1 Reducing Standby Consumption

The system can be integrated with trackers that keep the record of the units consumed by the devices. The electricity consumed by the devices when used cannot be decreased by the system, but when the devices are kept in standby mode they are no more in use. Hence the electricity though that part can be easily cut. This can substantially decrease expenses and thus increase in savings and also helps to conserve electricity. See Table 1 and Fig 8.

As the system process the expenses, it can also offer standby cuts and their impact on saving. There are several ways by which the system can decide which device circuit to cut. Some of the ways are:

- Cut the supply of the products that are rarely used. For example is the TV and AC in the guest room.

*Fig 7 reference: https://www.moneysmart.gov.au

Appliance	When On (Watts)	Standby (Watts)
Stereo	22	12
Television	100	10
Video Recorder	13	1
DVD Recorder	12	7
Digital Set-Top Box	6	5
Computer+ peripherals	130	15
Computer Monitor	70	11
Laptop	29	2
Broadband Modem	14	14
Answering Machine	3	3
Battery charger	14	1
Mobile Charger	5	2
Total	418	83

Table 1: This table highlights how much energy in watts (on average) most common household appliances uses when it is on and when it is on standby.

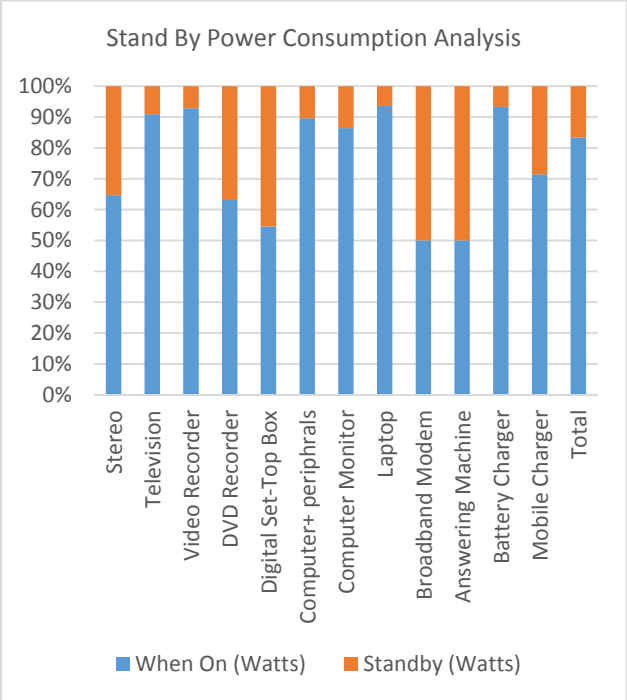

Fig 8: Shows the percentage ratio of the power consumed when devise is on to the power consumed on standby, based on the Table 1

- Use a common power controller with a switch to control clusters of products that are likely to be used together. Example of such clusters are computer clusters (Desktop, speakers, modem, WebCam, printer, scanner etc.), audio clusters (receiver, amplifier, CD players, etc.) video clusters (Television, home theater, DVD/Blu-ray player, game consoles, etc.

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- Use sensors to detect room presence. If no one is in the room keep the circuit of that room on cut. Whenever the presence is detected more than few minutes or the remotes are used, turn on the cut.

4. Conclusion and Future Work

The inculcation of the expense management system with the smart home technology provides the resident for a personalized automated finance handling system which not only helps managing the money but also provides with the ways of saving money. This kind of automated system not only track the consumption details in terms of money but also provided for the solution by analyzing the motion and presence sensors and keeping their records. This model of Smart Expense Management is compatible with both wireless and wired form of smart home technology.

The proposed model is not only flexible but can be included with other different technologies for further refinement of the model and progress towards achieving user personalized technology.

The model presented here only perform analysis on the data provided by the user. On inculcation of system with internet capability the system can help the resident in providing much more advance analysis on the financial front, such as by indicating the variation in the consumption of energy among the resident's appliances and appliances with the same qualification available in market. Similarly the consumption and usage pattern of water and telephone can also be tracked with the system for reduction of the expense and conserving scared resources.

Moreover, with more advanced feature, the Smart Home Management system can provide an automated bill payments using implementations of e-wallets.

References

[1] http://www.shaba.eu/

[2] Xiaohang Wang, Jinsong Dong, ChungyauChin, Sanka Ravipriya Hettiaraehehi; Semantie Space: an Infrastructure for Smart Spaces;Pervasive computing IEEE; 2004.4

[3] Li Jiang, Da-You Liu and Bo Yang, "Smart Home Research", 2004, Proceedings of the Third International Conference on Machine Learning and Cybernetics, August26-29, Shanghai, pp. 659-663.

[4] Manfred Huber, 2006, "Smart Home Technologies" [Online], Available: http://ranger.uta.edu/~huber/cse4392_SmartHome [2012, October 18].

[5] Rosslin John Robles and Tai-hoon Kim (2010) "Applications, Systems and Methods in Smart Home Technology: A Review", International Journal of Advanced Science and Technology Vol. 15, February, 2010

[6] W. rong Jih, J. Y. jen Hsu, C.-L. Wu, C.-F. Liao, and S. you Cheng. A multi-agent service framework for context-aware elder care. In AAMAS-06 Workshop on Service-Oriented Computing and Agent-Based Engineering (SOCABE'2006), pages 61{75, Future

[7] Molly Edmonds, "How Smart Homes Work" [Online], Available: http://home.howstuffworks.com/smart-home4.htm [2012,October 19]

[8] University, Hakodate, Hokkaido, Japan, 2006.http://www.advantageccs.org/blog/tracking-your-expenses-daily-is-very-important

[9] http://www.sustainable-girton.org.uk/articles/standby.html

[10] Yongquan Yang, Zhiqiang Wei, Dongning Jia, Yanping Cong, Ruobing Shan, A Cloud Architecture Based on Smart Home", Second International Workshop on Education Technology and Computer Science, 2010.

[11] S. Abras, S. Pesty, S. Ploix, and M. Jacomino. Advantages of mas for the resolution of a power management problem in smart homes. In Y. Demazeau, F. Dignum, J. M. Corchado, and J. Bajo, editors, Advances in Practical Applications of Agents and Multiagent Systems, 8th International Conference on Practical Applications of Agents and Multiagent Systems, PAAMS 2010, volume 70 of Advances in Soft Computing, pages 269{278. Springer, 2010.

[12] Sharma, Sugam, et al. "Wrenching: transient migration from commonality to variability in product line engineering of smart homes." Toward Useful Services for Elderly and People with Disabilities. Springer Berlin Heidelberg, 2011. 230-235.

[13] F. K. Aldrich. Smart homes: Past, present and future. In R. E. Harper, editor, Inside the Smart Home, pages 17{39. Springer, 2003.

[14] D. Bonino, E. Castellina, and F. Corno. The dog gateway: enabling ontology-based intelligent domotic environments. IEEE Transactions on Consumer Electronics, 54(4):1656{1664, November 2008.

[15] Sharma, Sugam, et al. "Bidirectional migration between variability and commonality in product line engineering of smart homes." International Journal of System Assurance Engineering and Management 4.1 (2013): 1-12.

[16] D. Bonino and F. Corno. Rule-based intelligence for domotic environments. Automation in Construction, 19(2):183{196, 2010.

[17] Y. Rahal, H. Pigot, and P. Mabilleau, Location Estimation in a Smart Home: System Implementation and Evaluation Using Experimental Data, International Journal of Telemedicine and Applications, Vol. 2008.

[18] http://www.smarthome.com

[19] M. Merabti, P. Fergus, O. Abuelma'atti, H. Yu, C. Judice, "Managing Distributed Networked Appliances in Home Networks", Proceedings of the IEEE, Vol. 96, Issue 1, pp.166-185, 2008.

[20] I. W. Lee, H. J. Park, K. R. Park, S. H. Kim, "Developments and Performance Evaluation of Digital-Home Service Delivery & Management Systems," Networking, International Conference on Systems and International Conference on Mobile Communications and Learning, pp. 23-26, 2006.

[21] Yu Hua Zhang, Jian Zhang, Wei Hua Zhang, "Discussion Of A Smart House Solution basing Cloud Computing", International Conference on Communications and Intelligence Information Security, 2010.

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[22] Sharma, Sugam, et al. "Wrenching: transient migration from commonality to variability in product line engineering of smart homes." Toward Useful Services for Elderly and People with Disabilities. Springer Berlin Heidelberg, 2011. 230-235.

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