Volume: 07 Issue: 03 Pages: 2736-2740 (2015) ISSN: 0975-0290

Pervasive Computing Based Intelligent Energy Conservation System

Dr. A.Kanagaraj
PG Department of Computer Science, Nehru Arts and Science College, Coimbatore-641105.
Email: a.kanagaraj@gmail.com
Ms S.Sharmila
Department of Computer Science, NGM College, Pollachi, Coimbatore-642001.
Email: mcasharmi2007@gmail.com

ABSTRACT

Most of the HVAC system in home is running based on static control algorithm; based on fixed work schedules. In that old system energy became waste when home contains low or no people occupancy. In this paper we presented new dynamic approach of HVAC system control, by combined with pervasive computing. Pervasive computing can be defined as availability of centralized system and information anywhere and anytime. We achieved our target by using occupancy sensors for collecting home status. Initially our occupancy sensors collect human presence and current HVAC status details and stored in centralized system. Then based on our user defined threshold value the centralized system maintains the building's heating, cooling and air quality conditions by controlling HVAC devices. I.e. this system turned off HVAC systems when a home is unoccupied, or put the system into an energy saving sleep mode when persons are asleep.

Keywords - **HVAC, Pervasive Computing, Humidity Management, Occupancy Sensor, Ventilation Management.**

Date of Submission: Oct 14, 2015 Date of Acceptance: Nov 13, 2015

1. Introduction

The development of low-cost and easy-to-deploy sensing systems to support activity detection in the home has been an important trend in the pervasive computing community [1, 7]. Much of this research has centered on the deployment of a network of inexpensive sensors throughout the home, such as motion detectors or simple contact switches. Although these solutions are cost-effective on an individual sensor basis, they are not without some important drawbacks that limit their desirability as research tools as well as their likelihood of eventual commercial success through broad consumer acceptance [8].

We have developed an approach that provides a whole-house solution for detecting gross movement and room transitions through occupancy sensor by sensing differential air pressure at a single point in the home. Our solution leverages the central heating, ventilation, and air conditioning (HVAC) systems found in many homes. The home forms a closed circuit for air circulation, where the HVAC system provides a centralized airflow source and therefore a convenient single monitoring point for the whole airflow circuit.

Disruptions in home airflow caused by human movement through the house, especially those caused by the blockage of doorways and thresholds, results in static pressure changes in the HVAC air handler unit when the HVAC is operating. Our system detects and records this pressure variation from differential sensors mounted on the air filter and classifies where exactly certain movement events are occurring in the house, such as an adult walking through a particular doorway or the opening and closing of a door. Preliminary results show we can classify unique transition events with up to 75-80% accuracy. We also show how we detect movement events when the HVAC is not operating using occupancy sensor.

The principal advantage of this approach, when compared to installing motion sensors throughout an entire house space, is that it requires the installation of only a single sensing unit that connects to a computer. By observing the opening and closing of doors and the movement of people transitioning from room to room, the location and activity of people in the space can later be inferred. In addition, detecting a series of room transitions can be used for simple occupancy detection or to estimate a person's path in the house to regulate the HVAC system to consume more energy.

Because of the use of a single monitoring point on an existing home infrastructure (the HVAC air handler, in this example) to detect human activity throughout an entire house, we consider our system a member of an important new class of activity monitoring systems that we call infrastructure mediated sensing. In the remainder of this paper, we further define this new category of sensing and solutions to solve this limitation by implementing occupancy sensors are discussed.

2. Literature Review

Shwetak N. Patel, Matthew S. Reynolds et al. [15], We have developed an approach for whole-house gross movement and room transition detection through sensing at only one point in the home. This system considers to be one member of an important new class of human activity monitoring approaches based on what we call infrastructure mediated sensing, or "home bus snooping." This system provides solution which leverages the existing ductwork infrastructure of central heating, ventilation, and air conditioning (HVAC) systems found in many homes. Disruptions in airflow, caused by human inter-room movement, result in static pressure changes in the HVAC air handler unit. This is particularly apparent for room-to-room transitions and door open/close events involving full or partial blockage of doorways and thresholds.

The system detects and records this pressure variation from sensors mounted on the air filter and classify where certain movement events are occurring in the house, such as an adult walking through a particular doorway or the opening and closing of a particular door. In contrast to more complex distributed sensing approaches for motion detection in the home, this method requires the installation of only a single sensing unit (i.e., an instrumented air filter) connected to an embedded or personal computer that performs the classification function. A preliminary result shows the system can able to classify unique transition events with up to 75-80% accuracy.

Tamim Sookoor, Brian Holben et al. [16], demonstrated in their paper, how to use cheap, off-the-shelf sensors and actuators to retrofit a centralized HVAC system and enable rooms to be heated or cooled individually, in order to reduce waste caused by conditioning unoccupied rooms. They named this approach as room-level zoning.

Vic Callaghan, Graham Clarke et al. [17], in their paper they seeks to use their experience as computer scientists to advance debates by considering issues arising from their research related to intelligent buildings and environments, such as the deployment of autonomous intelligent agents.

K.F. Fong a, V.I. [5], presented the robust evolutionary algorithm (REA) to tackle the nature of HVAC simulation models. REA is based on one of the paradigms of evolutionary algorithm, evolution strategy, which is a stochastic population based searching technique emphasized on mutation. The REA, which incorporates the Cauchy deterministic mutation, tournament selection and arithmetic recombination, would provide a synergetic effect for optimal search. The REA is effective to cope with the complex simulation models, as well as those represented by explicit mathematical expressions of HVAC engineering optimization problems [18].

3. Limitations of HVAC

HVAC here stands for Heating, Ventilation and Air Conditioning. Thus, a HVAC control system applies regulation to a heating and/or air conditioning system [19]. Usually a sensing device is used to compare the actual state (e.g., temperature) with a target state. Then the control system draws a conclusion what action has to be taken (e.g., start/stop the blower).

To implement temperature limits and a variety of control strategies based on the available control system technologies currently in place in home facilities, in order to reduce the consumption of energy [3, 4]. This plan shall include, but not be limited to temperature comfort ranges (limits), building schedule controls (occupied versus unoccupied), various control strategies and system upgrades and standardization of full DDC systems with occupancy sensors for all future facilities and renovations. The current system regulates the HVAC system based on static control algorithm. Where as in the paper we introduced dynamic system, so that we can consume more energy compare to static system.

4. Pervasive Computing

Pervasive computing envisions a world with users interacting naturally with device-rich environments to perform various kinds of tasks. These environments must, thus, be self-managing and autonomic systems, receiving only high-level guidance from users. However, these environments are also highly dynamic - the context and resources available in these environments can change rapidly. They are also prone to failures - one or more entities can fail due to a variety of reasons. The dynamic and fault-prone nature of these environments poses major challenges to their autonomic operation.

Pervasive computing advocates the construction of large distributed systems that feature a number of devices and services [12]. These devices and services are meant to help users perform various tasks more easily and efficiently. Besides, these devices are supposed to disappear into the surroundings and not intrude on the user's consciousness. This requires pervasive computing environments to be self-managing and autonomic, requiring minimal user intervention. At the same time, these environments are also highly dynamic and fault-prone. New kinds of entities can enter these environments at any time. Existing entities may fail or leave the environment. The context of these environments can also change.

Pervasive computing aims at availability and invisibility [14]. On the one hand, pervasive computing can be defined as availability of software applications and information anywhere and anytime. On the other hand, pervasive computing also means that computers are hidden in numerous so-called information appliances that we use in our day-to-day lives. Personal digital assistants (PDAs) and cell phones are the first widely available and used pervasive computing devices.

Several pervasive computing devices and users are wireless and mobile. Devices and applications are continuously running and always available. From an architectural point of view, applications are non-monolithic, but rather made of collaborating parts spread

Volume: 07 Issue: 03 Pages: 2736-2740 (2015) ISSN: 0975-0290

over the network nodes [9, 13]. Pervasive computing is characterized by a high degree of heterogeneity: devices and distributed components are from different vendors and sources. Support of mobility and distribution in such a context requires open distributed computing architectures and open protocols.

The intelligent system uses occupancy sensors to automatically turn off the HVAC system when the occupants are sleeping or away from home. The intelligent system uses these sensors to infer when occupants are away, active, or sleeping and turns the HVAC system off as much as possible without sacrificing occupant comfort [6, 10].

The first main challenge of this approach is to quickly and reliably determine when occupants leave the home or go to sleep. Motion sensors are notoriously poor occupancy sensors and have long been a source of frustration for users of occupancy-based lighting systems, which often turn the lights off when a room is still occupied. For the intelligent system, these mistakes would lead to more than just user frustration: frequently turning off and on the HVAC system can cause uncomfortable temperature swings, shorten the lifetime of the equipment, and even cause energy waste due to frequent equipment cycling. Furthermore, a longer time-out period is not an adequate solution because it would waste energy by conditioning unoccupied spaces; the intelligent system requires occupancy monitoring that is both quick and reliable. To address this problem, we use occupancy sensors to detect human presence in home, and based on that our intelligent system quickly recognize leave and sleep events, dynamically allowing the system to respond without increasing false detection rates.

The second main challenge of this approach is to decide when to turn the HVAC system back on. Preheating the house could waste energy if the system is activated too early. On the other hand, heating only in response to occupant arrival could also waste energy because, at that point, the house must be heated very quickly; many multi-stage HVAC systems have a highly efficient heat pump that can be used for slowly preheating, but a lower efficiency furnace or electric heating coils must be used to heat the house quickly. Since the intelligent system uses static control algorithm, it cannot predict exactly when occupants will arrive, it is difficult to decide which approach will be more efficient on any given day. Instead, the system uses a hybrid approach which uses occupancy sensors that minimizes the long-term expected energy usage based on the occupancy patterns of the house [11].

The collected parameters including people number, light luminance, temperature. CO2, power used, and humidity which would influence the dynamic running of the system, and the collected parameters would be sent to centralized system decide the feedback control parameters. The sensors of temperature, CO2, luminance, humidity, power used in this energy-saving system were design with modules to meet with different situations of power consumption such as power system, lights luminance, air conditioning, official affairs machines and facilities, and the information stream was used large number of technology of Wireless Sensor Network (WSN) so as to construct an active & intelligent energy-saving system [2].

5. Infrastructure

Occupancy sensors play a significant role in the performance of the intelligent system. We deploy X10 motion sensors and door sensors in 4 homes to collect occupancy and sleep information. These homes include both single-person and multi-person residences, and the people living in the home include students, professionals and homemakers. For example, one home includes a graduate student couple along with an elderly resident, two other homes include young working professionals, and another home includes three graduate students. The duration of the sensor deployments varies from one to two weeks. In general, we deploy one occupancy sensor in each room and one motion sensor on each entryway to the home, and some inner doors. However, we do not instrument rooms or entryways that are very infrequently used. This system analyzes the leave, return, wake, and sleep times from two publicly-available data sets that contain home occupancy information. These data sets are collected by manually labeling activities such as sleeping, eating, and bathing, and leaving home.

6. An Automated System Design & its Operations

Relationship between collected parameters in space and energy-saving system was described as follow:

6.1 Humidity Management

The various WSN sensor modules with ZigBee data transmission interface for sensing temperature and number of people are well-designed. Those environmental parameters would be detected and sent to the server computer as judged factors to be determined whether the system should proceed feedback control based on the proposed intelligent system. These WSN modules are placed at proper location to match up the condition of environment.

6.2 Ventilation Management

We would first calculate the area of a space and decide the maximum number of people, after then we detected the real people number and the luminance parameters and sent back to centralized system to feedback control how many lights in the space should be turn off and the luminance still meet with the regular luminance 550Lux, the decisive procedure could be in two ways, one is calculated the factor which was maximum entered people divided by entered people, and used this factor to multiply the total lights number, so we got the desired turned on lights, and then we used the detected light luminance to decide whether the luminance was enough or not, and then feedback control the lights according the judge of intelligent agent system built in centralized system. We could directly and dynamically decide the lights turned on or off according to the luminance sensor signals.

6.3 Air-Conditioning Management

The CO2 density would decide whether the people inner the space were comfortable or not, if the density was over the standard and made people not feel well then the air-conditioning would proceed to winding function rather than cooling to release the condition. If there were no people in the space, then the air-conditioning would be turned off. If the number of people was more than threshold we set, then the air-conditioning would be turned on. If the temperature was higher than threshold, then the cooling function would be turned on. As for central control air-conditioning with cool-water machines, which consumption the most electricity power, our system dynamically turns OFF/ON the system based on air quality data's received from occupancy sensors. This system overcomes the debate of static system followed by old HVAC system, and consumes more energy.

7. Conclusion

To automate the HVAC devices and for reducing of the energy consumed in a home, we need to create a system which works by sensing human presence in home, it is necessary to create a system which includes different scenarios of using of the energy and also to provide users with solutions to reduce the energy usage and automate HVAC devices. This paper introduced pervasive computing based; HVAC control system to control energy consumption. As a result, the system can be used to provide information and suggestions on questions such as: how to avoid running HVAC devices or how to avoid energy consumption if nobody occupied in home; how much energy has to be reduced if occupants are in asleep; and finally how to automate the system in dynamic manner based on systems demand.

References

[1] Anand Ranganathan, "*Autonomic Pervasive Computing based on Planning*", University of Illinois, Urbana-Champaign.

[2] Chun-Liang Hsu, Sheng-Yuan Yang, "*Design of Sensor Modules of Active & Intelligent Energy-saving System*", IEEE, pp.2096-2099, 2011.

[3] Friedemann Mattern, Thorsten Staake, et al., "*ICT for Green – How Computers Can Help Us to Conserve Energy*", e-Energy 2010, April 13-15, 2010.

[4] Giuseppe Loseto, "*A Semantic-based Pervasive Computing Approach for Smart Building Automation*", Politecnico di Bari, via Re David 200, I-70125, Bari, Italy.

[5] K.F. Fong, V.I. Hanby et al., "*System optimization for HVAC energy management using the robust evolutionary algorithm*", Elsevier, Applied Thermal Engineering, pp.2327-2334, 29-2009.

[6] Magnus Boman, Paul Davidsson, et al., "*Energy Saving and Added Customer Value in Intelligent Buildings*", ISES, sub-project #9: Robust Distributed Decision Islands.

[7] Markus Weiss, Wilhelm Kleiminger, "*Smart Residential Energy Systems – How Pervasive Computing can be used to conserve energy*", Institute for Pervasive Computing, 8092 Zurich, Switzerland.

[8] Matthias Kranz and Albrecht Schmidt, "*Restriction, Modification and Extension of Consumer Devices for Prototyping Ubiquitous Computing Environments*", Research Group Embedded Interaction, 80333 Munich, Germany.

[9] N. A. Malik and A. Tomlinson., "*Web-Services Architecture for Pervasive Computing Environment*", Information Security Group, Surrey, UK.

[10] Nikitas Liogkas, Blair MacIntyre, et al., "*Automatic Partitioning: A Promising Approach to Prototyping Ubiquitous Computing Application*s", IEEE Pervasive Computing, March 2004.

[11] Radu Balan, Sergiu Stan et al., "*Advanced Control Algorithms For Energy Efficiency And Comfort Inside A House*", 13th World Congress in Mechanism and Machine Science, Guanajuato, Mexico, 19-25 June, 2011.

[12] Robert Grimm, Janet Davis, et al., "*Systems Directions for Pervasive Computing*", University of Washington.

[13] Roy Campbell, Jalal Al-Muhtadi, et al., *"Towards Security and Privacy for Pervasive Computing*", University of Illinois at Urbana Champaign, Urbana, IL 61801.

[14] Sachin Singh, Sushil Puradkar, et al., "*Ubiquitous Computing: Connecting Pervasive Computing through Semantic Web*", School of Computing and Engineering, University of Missouri, MO 64110, USA.

[15] Shwetak N. Patel, "*Exploring WideSpread Deployment Through Infrastructure-Mediated Sensing*", Computer Science & Engineering, University of Washington.

Volume: 07 Issue: 03 Pages: 2736-2740 (2015) ISSN: 0975-0290

[16] Tamim Sookoor, Brian Holben et al., "*Feasibility of Retrofitting Centralized HVAC Systems for Room-Level Zoning*", IEEE, University of Virginia Charlottesville, VA, 2012.

[17] Vic Callaghan, Graham Clarke, et al., "*Some Socio-Technical Aspects of Intelligent Buildings and Pervasive Computing Research*", In Intelligent Buildings International Journal, Earthscan Journals, Vol 1 No 1, Jan 2009.

[18] Victor M. Zavala, "*Real Time Optimization Strategies for Building Systems*", Argonne National Laboratory, IL 60439, USA.

[19] Yuvraj Agarwal, Bharathan Balaji et al., "*Duty-Cycling Buildings Aggressively The Next Frontier in HVAC Control*", ACM, IPSN'11, April 12–14, 2011.

Short Biographies

Dr. A. Kanagaraj MCA., MSc., M.Phil., PhD., DIR., is a teaching professional living in Tamilnadu, India. Currently he is working as an Assistant Professor in Nehru Arts and Science College, Coimbatore, India. He has around two years of Industrial Experience and 5 years of Research Experience as Project Fellow. He has experience in handling UGC - Major Research Projects. He has published many papers in National / International Journals and Conferences. He published 2 books. He is a life member of the Indian Science Congress. His Interested areas are Data mining and Pervasive Computing.

Ms S.Sharmila MCA., M.Phil., is a teaching professional living in Tamilnadu, India. Currently she is working as an Assistant Professor in NGM College, Pollachi, Coimbatore, India. She has more than four years of teaching experience. She has published many papers in National / International Journals and Conferences. Her interested areas are Data mining, Software Testing and Software Engineering.