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Home Automation in Energy Management Intelligent Control System

S.Pratyusha[1] & N.Chandrashekhar[2]

[1]M-Tech Dept of ECE, Khammam Institute of Technology and Science, khammam,TS

[2]Associate Professor & HOD Dept of ECE, Khammam Institute of Technology and Science, & TS

Abstract

The design and development of a smartmonitoring and controlling system for household electricalappliances in real time has been reported in this pap er. Thesystem principally monitors electrical parameters ofhousehold appliances such as voltage and current andsubsequently calculates the power consumed. The noveltyof this system is the implementation of the controllingmechanism of appliances in different ways. The developedsystem is a low-cost and flexible in operation and thus cansave electricity expense of the consumers. The prototypehas been extensively tested in real-life situations andexperimental results are very encouraging.

Keywords: Energy Management, Home Automation, Intelligent Control System, Wireless Sensor Network.

1. Introduction

It is foreseen that service and personal care wirelessmechatronic systems will become more and moreubiquitous at home in the near future and will be veryuseful in assistive healthcare particularly for the elderlyand disabled people [2]. Wireless mechatronic systemsconsist of numerous spatially distributed sensors withlimited data collection and processing capability to monitorthe environmental situation. Wireless sensor networks(WSNs) have become increasingly important because oftheir ability to monitor and manage situational informationfor various intelligent services. Due to those advantages,WSNs has been applied in many fields, such as themilitary, industry, environmental monitoring, andhealthcare [3]–[5]. The WSNs are increasingly being usedin the home for energy controlling services. Regularhousehold appliances are monitored and controlled byWSNs installed in the home [6]. New technologies includecutting-edge advancements in information technology,sensors, metering, transmission, distribution, and electricitystorage technology, as well as providing new informationand flexibility to both consumers and providers ofelectricity. The Zig-Bee Alliance, wireless communicationplatform is presently examining Japan’s new smart home wireless system implication by having a new initiative with
Japan’s Government that will evaluate use of the forthcomingZig-Bee, Internet Protocol (IP) specification, and the IEEE802.15.4g standard

to help Japan to create smart homes thatimprove energy management and efficiency [7].It is expected that 65 million households will equip withsmart meters by 2015 in the United States, and it is a realisticestimate of the size of the home energy management market[8]. There are several proposals to interconnect variousdomestic appliances by wireless networks to monitor andcontrol such as provided in [9], [10]. But the prototypes areverified using test bed scenarios. Also, smart meter systemslike [10]–[12] have been designed to specific usagesparticularly related to geographical usages and are limited tospecific places. Different information and communicationtechnologies integrating with smart meter devices have beenproposed and tested at different flats in a residential area foroptimal power utilization, but individual controlling of thedevices are limited to specific houses. There has been designand developments of smart meters predicting the usage ofpower consumption [10]. However, a low-cost, flexible, androbust system to continuously monitor and control based onconsumer requirements is at the early stages of development.In this study, we have designed and implemented a Zig-Beebased intelligent home energy management and controlservice. We used the Zig-Bee (the IEEE 802.15.4 standard)technology for networking and communication, because it haslow-power and low-cost characteristics, which enable it to bewidely used in home and building environments [11].The paper focuses on human-friendly technical solutions formonitoring and easy control of household appliances. Theinhabitant's comfort will be increased and better assistancecan be provided. This paper emphasizes the realization ofmonitoring and controlling of electrical appliances in manyways. The developed system has the following distinctfeatures.

1. Use of Traic with opt isolated driver for controlling electrical appliances: Household appliances are controlled either remotely or automatically with the help of fabricated smart sensing unit consisting of triac – BT138.
2. No microprocessor/microcontroller: The design of smart sensing unit does not require a processing unit at the sensing end
3. Flexibility in controlling the appliances: Depending on the user requirements, appliances can be monitored and controlled in different ways discusses about the various options of controlling the devices.

2. Related Work

2.1 LIGHTING CONTROL SYSTEM OVERVIEW:

Lighting control systems provide workspace illumination,ambience and security, shown in Fig1. They directlyinfluence workplace productivity and occupant safety, butare often one of the largest consumers of electricity in abuilding. These systems utilize fluorescent, incandescentand Light Emitting Diode (LED) lamps, but we will focusonly on fluorescent lamp based systems.

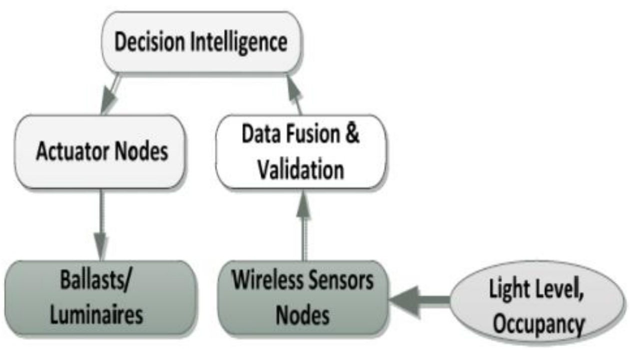

Fig.1. an Intelligent Lighting Control System.

A. Lighting Control System Components

Lighting control systems consist of luminaries, sensorsand controls.

1. Ballasts/Luminaries

Luminaries are complete lighting fixtures comprising of alamp, ballast, reflectors and an enclosure for all the lightingunit components. Ballasts are used to provide the startingvoltages required for lamp ignition and to regulate thecurrent flow within the lamp in order to guarantee optimaloperation. They can be either magnetic or electronic (solidstate) types, with newer installations tending towardselectronic bal-lasts due to their superior performance interms of noise and flicker. Newer ballasts also enablefluorescent fixture dimming between 1-100%, utilizingeither analog or digital dimming. Analog dimming utilizesa control voltage ranging between 0-10V to signal thepercentage of dimming required. Due to its low cost andsimplicity, analog dimming is the most widely deployeddimming scheme. Digital dimming offers greater controlgranularity, as well as the ability to individually address andnet-work ballasts, and is therefore gaining more acceptances.

2. Sensors

Sensors serving as the eyes and ears of the intelligentlighting control system allow the system to detect and respondto events in its environment. The most commonly usedsensors are occupancy and photo sensors, although somesystems incorporate the use of smart tags to detect and trackoccupants. These smart tag based schemes are yet to gainwide-spread acceptance due to privacy concerns. Occupancysensors are used in detecting room occupancy. They areutilized in locations with irregular or unpredictable usagepatterns such as conference rooms, toilets, hallways or storageareas. The primary technologies used in occupancy sensorsare ultrasonic and Passive Infra-red (PIR) sensors. Newersensors incorporate both technologies to pro-vide improveddetection, at the expense of increased cost. Photo sensorsdetect the amount of ambient light, which can be used todetermine the amount of artificial lighting required tomaintain total ambient lighting at a defined value.

Therefore,photo sensors are an integral component of daylightharvesting systems.

3. Lighting Controls

These are the various mechanisms used for lamp actuation.They can be simple devices such as basic on/off wallswitches, time clock switches for scheduled lighting actuation,or dimmer switches. More complex lighting controls includelighting automation panels and Building Automation Systems.

B. Lighting Tasks

A variety of control strategies are available for lightingcontrol, depending on the function of the room or location inquestion. The simplest and most basic form of lighting controlis on/off control, which is often achieved by means of a wallswitch. It can be combined with scheduling, occupancydetection or demand response to achieve greater energysavings. Another basic control is dimming, where the level oflamp luminance is altered to compensate for user preferences,achieve energy savings, or in response to demand responsesignals from the utility. More complex controls are discussedbelow.

1. Scheduling

This is the most prevalent control scheme after on/offcontrol. Lights are turned on/off according to a predeterminedschedule, and this control method is most appropriate inbuildings and areas such as shops or large offices, which havepredictable usage patterns.

2. Daylight Harvesting

Also known as day lighting, this technique involvesharnessing available daylight to minimize the amount ofartificial lighting generated. Photo sensors are utilized todetect ambient light levels and dimmers are used to dimfixtures to maintain defined lighting levels.

3. Demand Response

Demand Response is the ability to respond to signals from the power utility company to reduce power us-age due to high system loads. This is primarily achieved by dimming or switching off non-essential loads. Demand responsive dimming is usually un-noticeable to building occupants due to the limited sensitivity of the eye to minor variations in lighting intensity.

C. Task Tuning

The amount of light output is adjusted to suit the taskbeing performed or the current function of the workspace.This allows occupants to personalize their workspacelighting in accordance with their current work task oroptimal comfort level. It is also used for aesthetic purposessuch as the adjustment of lighting in order to accentuateitems on display, or to create additional ambience in lobbyareas. Task tuning prevents energy waste from overlighting and can be achieved via on/off control or dimming.

3. Implementation

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3.1 SYSTEM SETUP AND PROBLEM STATEMENT:

A. Intelligent Agents:

An agent is an independent hardware/software cooperation unit with the following characteristics: goal oriented, adaptive, mobile, social and self-reconfigurable. Each agent is capable of understanding its situation and adapts to changing environments through self configuration, as shown in Fig. 2a.

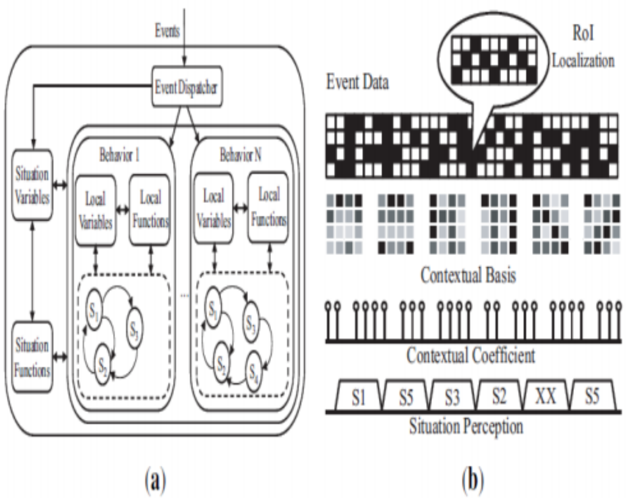

Fig 2. Illustration of (a) agent architecture; (b) situationperception from event sequences.

The situation perception is achieved through learningand contextual modeling of event data, as shown in Fig. 2b.After a set of contextual bases are learned from the high dimensional event data, different scenarios can berepresented by the clustered contextual coefficients. Theagents are then able to percept the situation and localizeregions of interest (RoIs) through identified scenarios.Each agent has a behavior state machine and a behaviorlibrary; it chooses a certain behavior according toindividual goals and other agents' behaviors.

B. Multi-Agent Interactions and Collaborations

Multi-agent-based smart house technology aims at providingenvironmental control, security, and entertainment andhealthcare services for users with high energy efficiency. Thesystem consists of four major types of agents: sensing, action,decision and database as shown in Fig.3. Such a multi-agentarchitecture will enable efficient, distributed informationcollection and processing, as well as system adaptation. Eachagent has a set of beliefs, desires and intentions. All agentsshare beliefs through inter-agent communication. Given a setof beliefs, each agent can plan its short-time behavior,according to its understanding of the situation and recentevents, to achieve the desired goal. The multi-agent platformprovides an agent execution engine, as well as other relatedservices, such as communication, naming, timer and resourcemanagement. There is a library for communication protocols,collaboration mechanisms and resource management schemes.Given a regulation policy and the user's goal, acommunication protocol, a collaboration scheme and aresource management policy will be selected from the library.

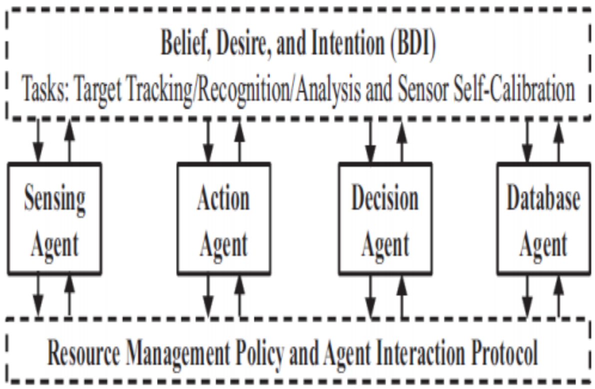

Fig.3. Illustration of multi-agent collaboration.

B. User Interface and Event Dispatching

The user interface has two functions: (1) convert user'sgoal and environment and human context into a set of beliefs,desires and intentions for each agent; and (2) select acommunication protocol, a collaboration mechanism and aresource management scheme based on the regulation policyprovided by the user. For example, goal: house security;constraints: one month with an operation of 100 mW powerconsumption; tasks: measuring the gait biometrics of subjectsinside the house. These inputs will be converted intoselections of sensor modalities,

algorithms/protocols,context/behavior templates and a resource managementpolicy. There are two types of events: (1) external and (2)internal. External events represent different states of theenvironment and human subjects' behavior. Internal eventsrepresent different states of agents' behavior. These eventswill be dispatched to operating agents, and in each agent,events will trigger behaviors under certain situations.

D. Problem Statement

The goal of this study is to develop a MAS framework with aset of design tools for smart house and home automationapplications, which can:

1. Design and control individual agent behaviors based ona belief, desire and intention model;
2. Design and control multi-agent group behaviors basedon a regulation policy; and
3. Evaluate system performance and optimize designparameters based on a set of metrics.

The system diagram is illustrated in Fig.4. It can be seenthat the operation of the whole system relies on theinteraction and collaboration among various agents:sensing, action, decision and database. The individual andgroup behaviors of these agents are formulated by agentmodels and regulation policies. The design of agent modelsand regulation policies should be a strict procedure insteadof an ad hoc one. Therefore, it is an important issue todevelop a set of mathematical models that can describe theindividual and group behaviors of agents. Based on thesemathematical models, the collaboration performance ofagents can be analyzed, and design parameters for thewhole system can be optimized.

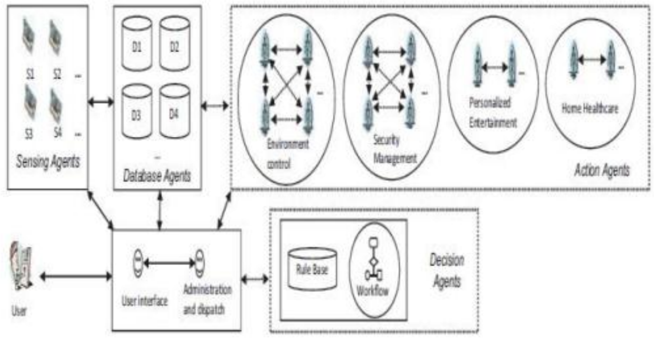

Fig.4.The proposed multi-agent system (MAS) architecture for smart house technology.

4. Experimental Work

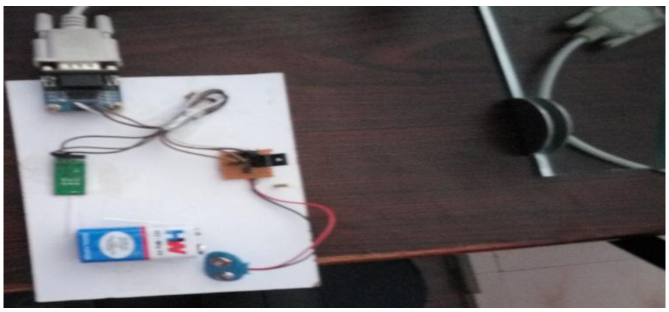

Fig 5: Experimental Resultt-1.

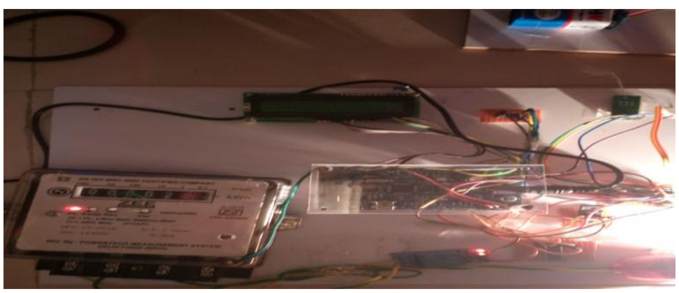

Fig 6: Experimental Resultt-2.

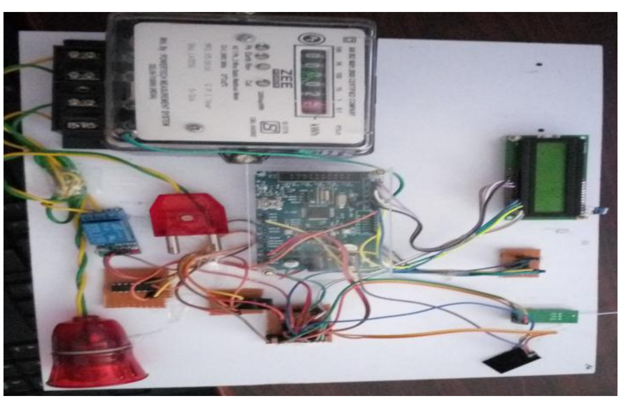

Fig 7: Experimental Resultt-3.

5. Conclusion

A smart power monitoring and control system has beendesigned and developed toward the implementation of anintelligent building. The developed system effectivelymonitors and controls the electrical appliance usages at anelderly home. Thus, the real-time monitoring of the electricalappliances can be viewed through a website. The system canbe extended for monitoring the whole intelligent building. Weaim to determine the areas of daily peak hours of electricityusage levels and come with a solution by which we can lowerthe consumption and enhance better utilization of alreadylimited resources during peak hours. The sensor networks areprogrammed with various user interfaces suitable for users ofvarying ability and for expert users such that the system canbe maintained easily and interacted with very simply. Thisstudy also aims to assess consumer's response towardperceptions of smart grid technologies, their advantages anddisadvantages, possible concerns, and overall perceivedutility. The developed system is robust and flexible inoperation. For the last three months, the system was able toperform the remote monitoring and control of applianceseffectively. Local and remote user interfaces are easy tohandle by a novice consumer and are efficient in handling theoperations. In future, the system will be integrated with cosystems like smart home inhabitant behavior recognitionssystems to determine the wellness of the inhabitant in terms ofenergy consumption.

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Authors Profile

S.Pratyusha completed B-Tech in Electronics communication engineering with 67.81% of marks in Sbit College in Khammam in 2014. Now Pursing M.TECH with embedded system In khammam institute of technology and science

N.Chandra Shekhar completed his M.tech with electronics and communication engineering. He has published more than five international journals. Currently he is a research Scholar in JNTU, Hyderabad and working as Associate Professor & Head of the department for ECE in Khammam Institute of Technology and Science.