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Research Article

Intelligent Building Automation using DALI-WSN Integration

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Abstract

Intelligent buildings prominently aims to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as lighting, heating and power for equipment. Integration of Digital Addressable Lighting Interface(DALI) devices with wireless sensor networks is focused in this paper for encouraging the Smart building concept. Heating ventilation and air conditioning, lighting control , different kinds of alarms ,etc. are aspects of building automation. Building automation (BA) system(BAS) is developed for monitoring and control of building services. The need of centralized monitoring control centre makes necessary the integration of all BA applications. DALI is considered as stepping stone for more complete and more capable building equipment automation system. This paper is focused on prototype used in wireless sensor network(WSN) which integrates DALI protocol. Main purpose is to give end consumer with an economical fully centralized system in which home appliances are managed by IEEE802.15.4 based on WSN. So initial investment, maintenance and energy consumption cost are considered.

Keywords: *DALI, BAS, WSN, Lighting Automation, IEEE802.15.4, Wireless ZIGBEE.*

1. Introduction

Building automation (BA) system (BAS) were initially developed to control heating, ventilation and air conditioning (HVAC) systems. There are many kinds of controllers, e.g. analog circuits, pneumatics, microprocessors, etc from few years. From start the purpose of BA was the comfort of consumers and later (early 1970s) energy efficiency criteria was also considered. BAS deals with monitoring and control of building services, such as HVAC, lighting, alarms, etc. HVAC and lighting control can be obtained by more efficient and natural ways not only limited to operate in HVAC appliances and lamps.

Building services are usually controlled separately by making BA the set of communication technologies and control which links such different subsystems and also operates from a centralized monitoring and control centre . Costs reduction is the main purpose of having a single control point which provides access to all building services. Quick detection of failing devices without needing long searches and wasting personal time is achieved by Remote Monitoring. The continuous monitoring facilitates a preventive or predictive maintenance, which results in operational and maintenance costs reduction. As it is projected that the operational cost of a building is about eight times the initial investment, considering the global life-cycle an additional initial cost worth the effort.

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The requirement of a centralized monitoring control centre makes necessary the integration of all BA applications. The number of proprietary solutions has increased from the rise of BA, now there are several open standards (DALI , BACnet, KNX, ZigBee, LonWorks) which makes the integration process easy.

This paper focuses on the making of a prototype to be used in a wireless sensor network (WSN) integrated with DALI protocol. it is very easy to find DALI compliant devices as DALI is a well-established standard majorly adopted by electronic ballasts' suppliers. The building automation system (BAS) had received the huge amount of focus in past years. To monitor the parameters defining working conditions within a building, and control its electrical equipment are implemented by BAS. Other home systems like lighting, security should also use automation, and are installed in a different system than HVAC. The end consumer cost is increased because of such division of the two subsystems and due to additional investment in communication software and hardware for integrating lighting in a single control point and HVAC. However, the connectivity of devices within the building for the purpose of building automation increases the new and exciting opportunities but remains largely unexploited. A solution for centralization of building automation services can be provided by WSN-DALI. The digital addressing capability of the DALI is used.

DALI is also adapted to other applications inspite of its design for lighting control, such as proximity alarms, motor or fan controllers, etc. Integration of DALI devices as a part of the WSN is allowed by adapting standard to a WSN. Expanding the traditional DALI bus and removing wires (DALI devices require a dedicated bus for data transmission), results in a reduction of installation costs. A WSN as part of a home automation system is also called a wireless home automation network, it allows monitoring and control applications for home end user and energy efficiency.

2. Hardware Overview

2.1. Nodes

DALI-WSN integration is considered for two nodes. Each node having two sensor controls.

2.2. Micro Controller

Here MSP430 microcontroller is considered and is the control unit of the whole project. The **MSP430** is a mixed-signal microcontroller family from Texas Instruments. Built around a 16-bit CPU, the MSP430 is designed for low cost and, specifically, low power consumption embedded applications.

The MSP430 can be used for low powered embedded devices. The electric current drawn in idle mode can be less than 1 μA. The top CPU speed is 25 MHz. It can be throttled back for lower power consumption. The MSP430 also uses six different low-power modes, which can disable unneeded clocks and CPU. Additionally, the MSP430 is capable of wake-up times below 1 microsecond, allowing the microcontroller to stay in sleep mode longer, minimizing its average current consumption.

2.3. Sensors

In this paper two sensors on each node is considered. Sensors considered are PIR sensors for intrusion detection and light sensor on first node, temperature sensor and light sensor on second node.

2.4. ZIGBEE

ZIGBEE is a latest wireless technology which is guided by the IEEE 802.15.4 Personal Area Networks standard. At the beginning it was designed for the wide ranging automation applications and to replace the existing non-standard technologies. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250Kbps.

2.5. Driver Circuit

A driver is an electrical circuit or other electronic component used to control another circuit or other component, such as a high-power transistor. They are usually used to regulate current flowing through a circuit or is used to control the other factors such as other components, some devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. An amplifier can also be considered a driver for loudspeakers, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages.

Typically the driver stage(s) of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier, typically the driver circuit requires current gain, often the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

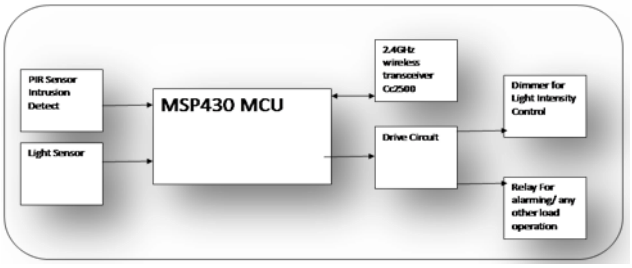

Fig.1 Node1

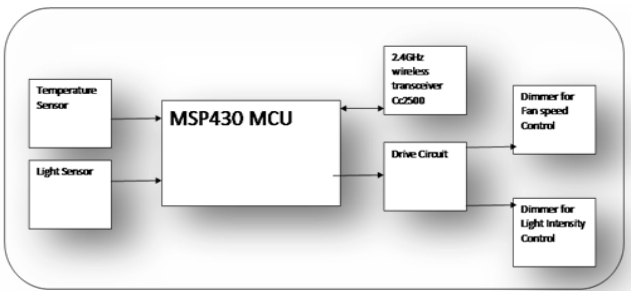

Fig.2 Node2

3. Hardware Design

Monitoring and control of building services, such as Fan, light, alarms, LED etc is the main motive of building lighting automation. Without the use of electrical conductors or wires the transfer of information over a distance is done through wireless communication. The distances may be short (few meters in television remote control) or long (thousands or millions of kilometres for radio communications).It encloses several types of cellular telephones , mobile, and portable two-way radios, wireless networking ,and personal digital assistants(PDAs). Here ZIGBEE networks is tested in various environmental conditions by using four node star networks for industrial applications such as direction and speed control of D.C motor, Illumination control of incandescent lamp through light sensor, intrusion detect through PIR sensors and fan speed for

temperature control. It was seen that error free proper communication was established between the processing unit and monitoring unit.

In future other ZIGBEE Networks can be tested for proper wireless data communication. Here a wireless technology for data acquisition of parameters like lighting control, temperature control and intrusion detect etc in a building are developed. In this system the data for Temperature, light present and intrusion detect in a Building are monitored, and here a GUI is also used to control the parameters through laptop. ZIGBEE transceiver Cc2400 is used for transmission of data through microcontroller MSP430. This data is received by ZIGBEE receiver and displays on laptop in the monitoring section which will be with a person in that building. Using this data the operator can control the devices by giving the necessary commands, this commands are received by control devices in the processing unit and performs the operations. If any fault occurs the sensors detects the error and makes the alarm to ring. Simultaneously it also sends a message on laptop. This message is received by the Cc2400 and then to GUI and performs the operations in emergency conditions like any fault occurs or in normal conditions, like to switch on the fan (or) a bulb

4. Features of ZIGBEE on board

The specification of ZIGBEE is a combination of Home RF Late and the specification 802.15.4. The operating frequency of specification in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and many other devices. It has the capability of connecting 255 devices per network. The data transmission is supported by specification rates of up to 250 Kbps at a range of up to 30 meters. Even though ZIGBEE's is slower than Bluetooth (1Mbps) and 802.11b (11 Mbps), but ZIGBEE spends considerably less power.

802.15.4 (ZIGBEE) is a latest standard exclusively designed for low rate wireless personal area networks. It aims low data rate, low cost wireless networking and low power consumption, and its aim is to provide a physical-layer along with MAC-layer standard for these networks. when compared with wired networks Wireless networks offers advantages in cost, size, deployment and distributed intelligence. This ZIGBEE (802.15.4) lets users to set up a network quickly and allows them to set up networks where wire cables can't. Wireless networks are cost-efficient than wired networks.

The first well-known wireless standard is Bluetooth (802.15.1) used in a low data rate applications. The efforts of Bluetooth technology to reach in more applications and deliver service quality has led to its deviation from the design objective of simplicity, making it expensive and inappropriate for few simple applications which needs low cost and power consumption. This new standard is focused on such kind of applications. There is relevance in Bluetooth and ZIGBEE, because sometimes they are seen as competitors, to show their dissimilarities for clarifying for which real time applications suits one of them.

The data transfer capabilities are considerably greater in Bluetooth, capable of transmitting audio, graphics and pictures over small networks, and also fits well for file transfers. On the other side ZIGBEE is very well suitable for transferring smaller packets over large networks; mostly static networks with many, uncommonly used devices, just like home automation, remote controls, toys, etc. When the performance of both is compared Bluetooth network loses connection for more than 8 devices, where ZIGBEE networks can handle 65000+ devices.

4.1. GUI- Graphical User Interface

It is a type of interface that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, as opposed to text-based interfaces, typed command labels or text navigation. GUIs were introduced in reaction to the perceived steep learning curve of command-line interfaces (CLIs), which require commands to be typed on the keyboard.

The actions in a GUI are usually performed through direct manipulation of the graphical elements. In addition to computers, GUIs can be found in hand-held devices such as MP3 players, portable media players, gaming devices and smaller household, office and industry equipment. 6510/7The term "GUI" tends not to be applied to other low-resolution types of interfaces with display resolutions, such as video games , or not restricted to flat screens because the term is restricted to the scope of two-dimensional display screens able to describe generic information, in the tradition of the computer science research at the PARC (Palo Alto Research Centre).

Designing the visual composition and temporal behaviour of a GUI is an important part of software application programming in the area of human-computer interaction. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline known as usability. Methods of user-centred design are used to ensure that the visual language introduced in the design is well tailored to the tasks.

Typically, the user interacts with information by manipulating visual widgets that allow for interactions appropriate to the kind of data they hold. The widgets of a well-designed interface are selected to support the actions necessary to achieve the goals of the user. A model-view-controller allows for a flexible structure in which the interface is independent from and indirectly linked to application functionality, so the GUI can be easily customized. This allows the user to select or design a different skin at will, and eases the designer's work to change the interface as the user needs evolve. Good user interface design relates to the user, not the system architecture.

Large widgets, such as windows, usually provide a frame or container for the main presentation content such as a web page, email message or drawing. Smaller ones usually act as a user-input tool.

4.2. Temperature Sensor- The LM35

The LM35 is an integrated circuit sensor which could be used for measuring the temperature with an electrical output proportional to the temperature (in ^{o}C).

The LM35 - An Integrated Circuit Temperature Sensor

- You can measure temperature more accurately than a using a thermistor.
- The sensor circuitry is sealed and not subject to oxidation, etc.
- The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

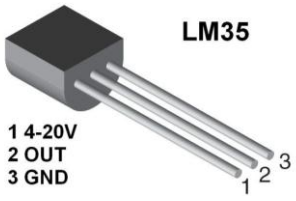

Fig.3. Temperature sensor

1) Working system of LM35

1. The scale factor is .01V/^{o}C
2. It has an output voltage that is proportional to the Celsius temperature.
3. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 ^{o}C at room temperature and +/- 0.8 ^{o}C over a range of 0 ^{o}C to +100 ^{o}C.
4. Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1 oC temperature rise in still air.

The LM35 comes in many different packages, including the following.

- T0-46 metal can transistor-like package.
- TO-92 plastic transistor-like package.
- 8-lead surface mount SO-8 small outline package.
- TO-202 package. (Shown in the picture above).

4.3. PIR Sensors

A passive infrared sensor used to detect motion. The passive infrared (PIR) motion detector is one of the most common sensors found in household and small business environments. It offers affordable and reliable functionality. The term passive refers to the fact that the detector does not generate or radiate its own energy; it works entirely by detecting the heat energy given off by other objects.

PIR sensors do not detect motion; rather, they detect abrupt changes in temperature at a given point. As an intruder walks in front of the sensor, the temperature at that point will rise from room temperature to body temperature, and then back again. This quick change triggers the detection.

PIR sensors may be designed to be wall or ceiling mounted, and come in various fields of view, from narrow "point" detectors to 360 degree fields. PIRs require a power supply in addition to the detection signalling circuit.

Conclusions

As a step towards Smart Buildings DALI was initially introduced for lighting control alone for the purpose of building automation but the capability that it can also be adapted to other equipment & applications, such as motor or fan controllers, power consuming equipment, proximity alarms, etc.. Under this expanding the traditional DALI bus and removing wires, results in a significant reduction of installation costs. Adapting a standard wireless sensor network allows integrating DALI devices as a part of the WSN .Hence opted the IEEE 802.15.4 wireless sensor network.

DALI is based upon the master-slave principle. Implementing a DALI master controller is using an IEEE 802.15.4-based wireless sensor network. Nodes which compose the wireless sensor network have a microcontroller unit (MCU) and IEEE 802.15.4-compliant transceiver. DALI-WSN integration is done through the digital addressing of devices. The utility of digital addressing capability of DALI makes the integration of blocks together and for the purpose of centralized building automation. Direct comparison with digital address of the devices enables the centralized integration of building automation. Besides the lighting control, the heating ventilation and air-conditioning (HVAC) and security systems are also being included for the purpose of centralized building automation. **Future scope** of it can a approach towards **Green Building** Automation

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