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SMART LIGHTING SYSTEM WITH LiFi

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Abstract:

Smart lighting systems go far beyond just replacing lamps. These current systems are able to regenerate random bands, colour temperatures, intensities and axis on smart sensors and actuators combining information and communication technologies. This project presents an interoperable smart lighting solution that combines heterogeneous lighting technologies enabling intelligent functions. The proposed system can modify light strength to increase visual comfortand also adding a LiFi technology for down streaming a data through the LED lamp by converting it to a hotspot.

Keywords – Lifi, LED, Intensties, Visual.

1. INTRODUCTION

For many years, home automation (HA) has been considered to be a field with a high potential for development. HA increases quality of our life of residents through using monitoring and remote-controlling devices. Nowadays, the available devices are inexpensive home systems that use wired technology, which is very complex and difficult to install. These wireless technologies introduced into the home environment such as infrared-light for short range applications and wireless local area networks (WLANs), Bluetooth and ZigBee for mid-range applications. However, a WLAN automation system of home can breakdown. The system'ssecurity also vulnerable to intruders because IP addresses are required to connect a wireless home automation (WHA) system to various devices. WHA can be accessed by n number of devices and requires high bandwidthto transfer data. Yet there are delays, jitters in data transmission when too many devices are connected to the wireless system. In addition, existing WLAN HA does not confirm data transmission security. In this project, a ZigBee communication technology system is designed and implemented for use in a smart home wireless sensor network. The primary methodology used separates the entertainment/computing wireless devices from the security/home automation appliances. The former devices use a WLAN and the latter appliances use ZigBee.

All of us have increasingly become dependent on the internet some way or the other. It is impossible to think of a day in our lives, when are not "connected" to the "net". are using the internet for a variety of purposes, chief among them being sharing of data. In scenarios where want to transmit data quickly and efficiently, low internet speeds can be quite annoying. In 2011, Professor Harold Haas from the University of Edinburgh in the UK, suggested an idea called "Data through illumination" . He used fiber optics to send data through LED light bulbs. Light modulation certainly is not a new concept, but Haas is looking to move things forward and enable connectivity through simple LED bulbs. With Li-Fi, can connect to the internet simply by being within range of an LED beam, or could conceivably transmit data using our car headlights. The ramifications of this are huge, especially with the internet of things in full swing and the much mooted spectrum crunch expected to bite increasingly hard in the coming years. LI-FI is a new technology which uses visible light for communication instead of radio waves. It refers to 5G Visible Light Communication systems using Light Emitting Diodes as a medium to high-speed communication in a similar manner as WI-FI. It can help to conserve a large amount of electricity by transmitting data through light bulbs and other such lighting equipments. It can be used in aircrafts without causing any kind of interference. LI-FI uses light as a carrier as opposed to traditional use of radio waves as in WI-FI and this means that it cannot penetrate walls, which the radio waves are able to. It is typically implemented using white LED bulbs at the downlink transmitter . By varying the current through the LED at a very high speed, can vary the output at very high speeds. This is the principle of the LI-FI. The working of the LI-FI is itself very simple—if the LED is ON, the signal transmitted is a digital 1 whereas if it is OFF, the signal transmitted is a digital 0. By varying the rate at which the LEDs flicker and encode various data and transmit it. Li-Fi is no longer a concept or an idea but a proven technology, albeit still at its infancy. Already, several experts in the field of communication have attested that Li-Fi technology would soon become a standard adjunct to Wi-Fi. That is, until its inherent limitations could be overcome. Since it is light-based, its major drawback is that it won't be able to penetrate solid objects such as walls. Though it could also mean privacy for the personal user, it also questions its use for large-scale delivery of data transmissions. But despite its drawbacks, researchers all over the world have been going all-out in further developing this new technology. It is led by Professors Martin Dawson, from the Institute of Photonics, and Harald Haas, from the University of Edinburgh.

The goal of the consortium is to eventually make every illuminated device, such as televisions, lamps, road signs, and commercial ad boxes, transmit data to gadgets such as mobile phones. Dubbed micro-LED or micron-sized LEDs, these newer models are merely 1µm 2 (square micrometers) in size. This means that 1,000 more lights could be fit into the same space as a typical LED. In addition to its size, microLEDs can flicker 1,000 times faster than commercial LED. Thus, in theory, a bank of 1,000 micro-LEDs flashing 1,000 times faster could transmit data a million times faster than that of an average LED. At the moment, the potential advantage of micro-LEDs for Li-Fi use is staggering. While Li-Fi technology by itself is already incredible, having increased its data transfer speed that is comparable to fiber optics is what makes this new technology a major issue. Imagine having a light source that not only provides light but also networking capability at astonishing speeds. Or a home television that communicates with every other gadget around, including the ability to project your smart phone's display onto it for easy presentation to large groups. Or highways lighted by Li-Fi, providing motorists with real-time traffic and weather news as well as internet access to all devices inside. The possibilities seem endless, and the potential is much broader than at first thought. With all the support pouring in, it won't be long now before Li-Fi becomes an everyday technology. Professor Haas has founded a company called Pure LIFI to carry on work in the field of this new technology.

The company's mission statement is: "Pure LiFi seeks to resolve the global struggle for diminishing wireless capacity by developing and delivering technology for secure, reliable, high speed communication networks that seamlessly integrate data and lighting utility infrastructures and significantly reduce energy consumption." Li-Fi signals are confined to narrowly-focused 'beams' that do not travel through walls.

Moreover, LED lights are natural beam-formers, which makes it easier to create separate uplink and downlink channels, which essentially means more secure internet browsing, given that both channels have to be 'intercepted' if someone did manage to coerce their way into the same room as us. The LI-FI allows us to network via a desktop photosensitive unit that works in tandem with an off-the-shelf, unmodified light fixture. The desktop unit has infrared LEDs to communicate in the uplink channel. The LI-FI delivers a capacity of 5Mbps in the uplink and downlink channels, covering a range of up to three meters. It is worth noting here that it has been shown that speeds of upto 10Gbps has been proven with LI-FI too.

2. RELATED WORK

Saving energy has become one of the most important issues these days. The most waste of energy is caused by the inefficient use of the consumer electronics. Particularly, a light accounts for a great part of the total energy consumption. Various light control systems are introduced in current markets, because the installed lighting systems are outdated and energy-inefficient. However, due to architectural limitations, the existing light control systems cannot be successfully applied to home and office buildings.
A LED control system is presented. The brightness and color temperature of the lamp are adjustable. The system composition and design of hardware and software are given. The infrared signal is sent by an infrared remote controller. A STC-MCU is used to process the infrared information and generate PWM signals which can adjust the brightness of the white LED and yellow LED respectively. It proves that the system is convenient, reliable and practical, and suitable for indoor illumination.

Smart Grid refers to the next generation power grid in which the electricity distribution and management are upgraded by incorporating advanced communications and capabilities for improved control, efficiency, reliability and safety. Among all fields covered by the term Smart Grid such as renewable energies, smart metering, electric vehicles, etc. lighting control in home and building facilities is one of the Smart Grid aspects which is still using very inefficient technologies. The energy consumption in lighting can be heavily decreased by applying the new information and communication technologies. This project focuses on the development of a lighting management system making use of wireless sensor networks and implemented using commercial electronic ballast with DALI communication protocol.

As the era of the ubiquitous computing is ushered in, consumers have been primed for a variety of automation applications. Active RFIDs can be used for a number of automation applications because it may also have other sensors to extend its applications. An active RFID instinctively focuses on a long communication range. Nevertheless, active RFIDs cannot be applied to a large-scale area due to their limited radio communication and obstacles. This project introduces a large-scale active RFID system based on multi-hop deployment utilizing dual radio frequency to overcome radio shadow areas that do not reach signals from the RFID reader.

The sensor tag consists of a commercial tag front end and a newly developed baseband. The baseband is implemented using 0.13-μm CMOS technology and the functionality is verified on an field-programmable gate array platform. A combination of a finite state machine, microcontroller, and firmware is adopted in the baseband architecture in order to lower the cost and at the same time to attain high flexibility. The power consumption of the sensor tag baseband is 18 μW at 1.28-MHz clock frequency and 1.2 V power supply. The area of a sensor tag baseband increases ~20% comparing with a RFID tag without sensor supports.

The use of TEDS to store information concerning patient clinical history and diagnostic criteria in order to project learned and patient-adapting devices. In this way, the sensing system uses the built-in information to optimize the data processing by adapting the diagnostic algorithm to the specific patient. Such a new approach in designing biomedical sensors allows to improve reliability and accuracy of final diagnosis. Three application cases are proposed and discussed to guide designers and developers in projecting smart biomedical sensors.

The lighting industry has been going through fundamental digital revolution: with light sources going for LED, drivers going digital, and control going networked. This revolution creates the flush of energy-efficient and modern-designed home lights, and also frees up the way of using lights together with the proliferation of smart devices, sensors, and internet of things. The control of lights becomes fast and rich-flavored, going beyond on/off, dimming, to color (or color temperature) change and scene setting, with intelligence to react to human mood and activity, and adapt to environments. To fully explore the benefits of the new generation lights, the last hop (x10 meters) connectivity is key. ZigBee Light Link (ZLL) [1] gives the lighting industry a global communication standard for interoperable and very easy-to-use consumer lighting and control products. It allows consumers to gain wireless control over all their LED fixtures, light bulbs, timers, remotes and switches. Products using this standard will let consumers change lighting remotely to reflect ambiance, task or season, all while managing energy use and making their homes greener.

3. SYSTEM MODEL

SMART lighting is a buzzword that defines heterogeneous lighting technologies: High-intensity discharge lamps (HID), fluorescent, solid state LED and OLED luminaires, composed of numerous smart sensors and actuators, and with the possibility of incorporating a wide set of capabilities and connectivity interfaces. The most important intelligent features are related to enabling advanced functions such as adjustable spectral reproduction , and adaptive dimming , combining energy efficiency with the real needs of the illuminated space taking into account available natural lighting. With the rise in digital connectivity options, smart lighting systems have different wired and wireless interfaces oriented to increment the connectivity in smart grid systems and Building ManagementSystems.

These systems allow us to control and monitor modern and heterogeneous electrical equipments such as ventilation and lighting devices. The main interfaces conceived for wired lighting systems are Digital Addressable Lighting Interface, Power Line Communications (PLC), Digital Multiplex and KNX for intelligence buildings. The most important wireless physical interfaces for distributed intelligent devices are WiFi, Bluetooth, ZigBee, WPAN, Wireless HART, MiWi) and RFID compatible for automation applications. Now modern smart lighting systems contain wired and wireless interfaces, and they can be harmonized in a set of ISO standards . This harmonization covers Transducer Electronic Datasheets (TEDS) formats.

TEDS are different electronic data sheets stored in a non volatile flash memory. These formats define node capabilities and transducer channel configuration. In addition, ISO/IEC/IEEE 21451 standard covers standard syntactic messages, and logical transducer function services to be implemented in the Network Capable Application module (NCAP) and/or the Transducer Interface Module (TIM). More formally, each NCAP performs the task of coordinator node while the TIM module will be integrated in the luminaries or in different smart sensors. Both can be organized as a Wireless Sensor and Actuator Network (WSAN). The IEEE 21451 reference model enables the coexistence of heterogeneous smart lighting systems and also allows interoperability through web services. In addition, allow us to exchange data among diverse networks that support the new wave of human centric lighting applications .An interoperable smart lighting system that implements the IEEE 802.15.4 physical layer and ZigBee Light Link (ZLL), plus application layer, has been implemented in this study as a practical solution for communication between wireless lighting devices, occupancy detectors and illuminance sensors. In order to demonstrate the use of Fuzzy Logic theories in smart lighting systems, a predictive algorithm adjusts the dimming level based on the occupancy level, work schedule and natural lighting available. A graphical user interface was designed in Matlab to run the fuzzy algorithm. Finally, all information is encapsulated in standard message structures to interact with the Representational State Transfer (REST) web service architecture. The web service runs on a free platform that contains an open API intended to control intelligent devices for the Internet of Things (IoT).

4. ISO/IEC/IEEE 21451 REFERENCE MODEL

The family of ISO/IEC/IEEE 21451 (formerly IEEE 1451) aims to expand the syntactic interoperability through a standardized message format implemented using heterogeneous smart sensors and actuators. Several Transducer Interface Modules (TIM) work in cooperation with the Network Capable Application module (NCAP) operating as a coordinator node entity. The NCAP architecture is shown in Figure 1.

See Figure 2. Each TIM is an embedded physical device that implements a reduced set of logical services. The typical TIM hardware architecture contains an ultra low power microprocessor unit (MCU) and a non-volatile memory to store the node configuration in an electronic datasheet (TEDS). The IEEE 21451reference model defines different standardized TEDS formats corresponding to the type of transducer. The IEEE 21451-4 standard defines a physical transducer channel in a mixed mode interface while the IEEE 21451-2 standard define TEDS formats for serial interfaces, and both standards are oriented for operation in wired networks. However, the IEEE 21451-7 standard covers syntactic interoperability based on standardized TEDS formats for RFID devices. In addition, the IEEE 21451.5 standard covers different standardized TEDS formats for transducers (sensors and actuators) working in a Wireless Sensor Network (WSN).**LIFI**

Li-Fi is a visible light communication which is used for high speed communication. The name Li-Fi is due to the similarity of the working of Wi-Fi except light source instead of radio waves. The Li-Fi technology was first proposed by Harald Hass a German physicist, number of industry group sand companies combined form the Li-Fi association to promote the high speed wireless communication using VLC technique to overcome the shortage in spectrum distribution for the purpose of high speed wireless communication. The technology is demonstrated for the first time in los Vegas using a pair of smart phones up to the distance range of 10 meters. The data is send in the way of light rays that has been generated using LED light source the intensity of the light source as been increased by reducing the amplitude of the digital data that as to be transmitted.

This signal treatment service attempts to adjust lightinglevels by synthesizing a set of linguistic control rulesobtained from information collected during experimentalmeasurements. The computational algorithm adjusts lightingcomfort levels in compliance with UNE 12464-2012 [25]. Theinput variables in the Fuzzy model are occupancy, daylightlevel on the work plane, the position of the blinds, theschedule of work in the office and the daylight indexes whichhave been calculated from simulations with the ray tracing software Daysim [26]. Each input variable passes through aMamdani Fuzzy process [27], using a logistic sigmoid function and is represented in a fuzzification process. In this case,each variable is coded as a fuzzy function and is evaluated by using certain rules of inference as shown in Table I.The rules must be combined in some manner in order to make a decision. The algorithm uses inference rulesthrough boolean logic and aggregation methods of the type(IF-OR-NOT-AND) for quantifying the input variables. The output values must be defuzzified in order to resolve a singleoutput value from the input dataset. The final desired output is the expected artificial illuminance organized as a metadatastandard syntactic structure. Table II shows the syntactic message structure.

The application layer where run the fuzzy logic algorithmwas initially designed as a Matlab function, the NCAP sent acommand to read illuminance and TIM response with a smallmessage of 13 bytes. Then, the NCAP merged illuminancevalues and estimated optimized dimming values. When theoutput of the fuzzy algorithm obtained a response, the NCAPcompared current dimming values before sending a requestto change the dimming value in the TIM smart luminaire.
A second fuzzy logic algorithm runs internally in a TIMmote as an additional internal IEEE 21451 service. In thiscase, the final Matlab Fuzzy logic FIS file is converted toa C function by using the FIST: MATLAB Fuzzy InferenceSystem C Converter [30], and overall firmware code is portedinitially from Arduino toward TinyOS 2.1. The compiledC-code occupies 220 bytes of RAM and 21568 bytes of ROMin the TIM nodes based on the MSP430 16-bit microcontroller.

For human centric lighting studies several autonomoussensors to measure illuminance were developed. All of them contain a photovoltaic harvester based on organic solar cellsfor indoor operation. Figure 4 shows the hardware architecture.Each node contains an energy harvesting sub-module and aTIM unit. The energy harvesting unit contains organic andflexible solar cells, a direct current (DC/DC) micro-powerregulator, super-capacitors and an ON/OFF switch to enablethe device. The main TIM components are the MSP430CPU, the external wireless transceiver and the flash memory tostore the TEDS configuration. The nodes were located in theoffice near the windows and the walls to measure illuminancevalues at the height of the working plane.The autonomous TIM wakes up when the harvestercaptures energy from the DSSC solar module due to an increase in daylight or artificial lighting levels.

The first state is the initialization step (init) that occursafter an event related to power on or reset, at that time,TEDS configuration is loaded into the RAM memory. Thesecond state is the active mode. In this

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mode, TIM polls eachphysical transducer channel and is already able to send or receive short messages. The third state is a sleep-mode thatis used to reduce energy consumption. In this sleep state, thenode waits for the expiration of a timer to wake up. The NCAPrequests commands and the TIM responds with short messages corresponding to the command type.

After the initialization takes place, each TIM reads theTEDS calibration values for the physical channels. Oncethe program checks all the values, it saves the measureddata in the RAM memory. The main loop runs once everyfive minutes. One loop runs the IEEE 21451 commands and sorts all arrays using standardized metadata formats. Afterthe sorting procedure takes place, the program goes to active mode and starts the transceiver to send or receive messages.

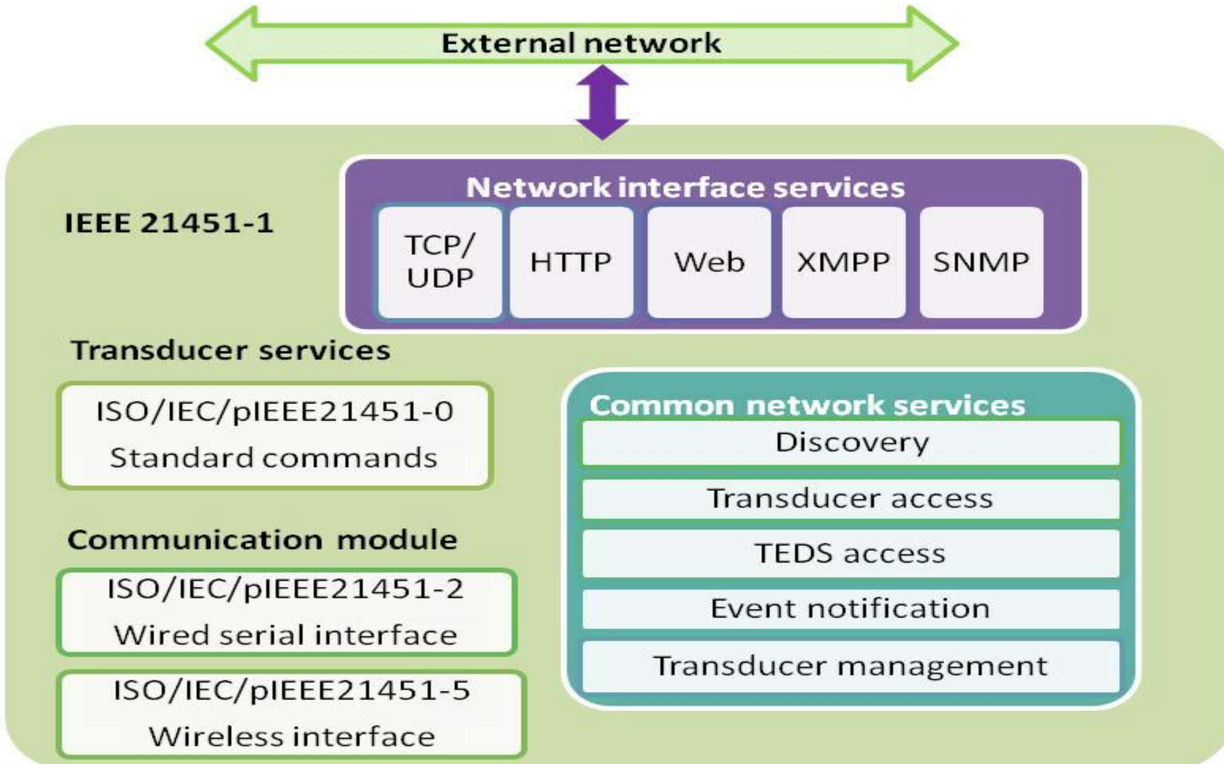

Fig:1 NCAP architecture.

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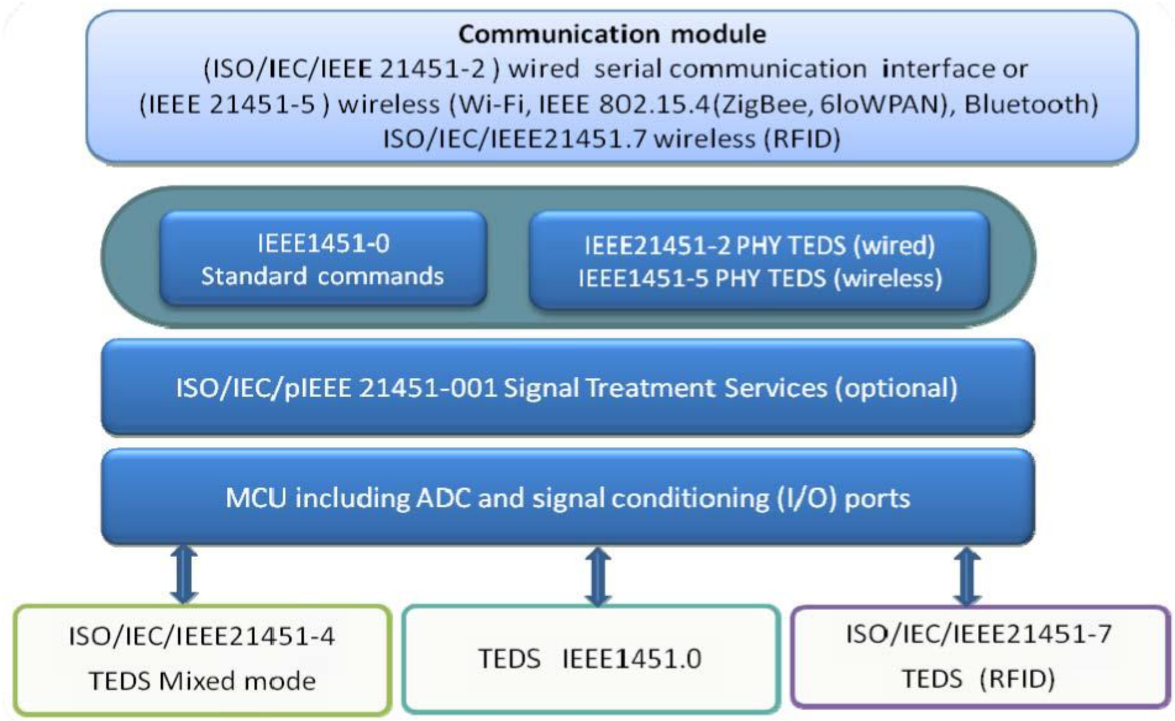

Fig: 2 TIM architecture.

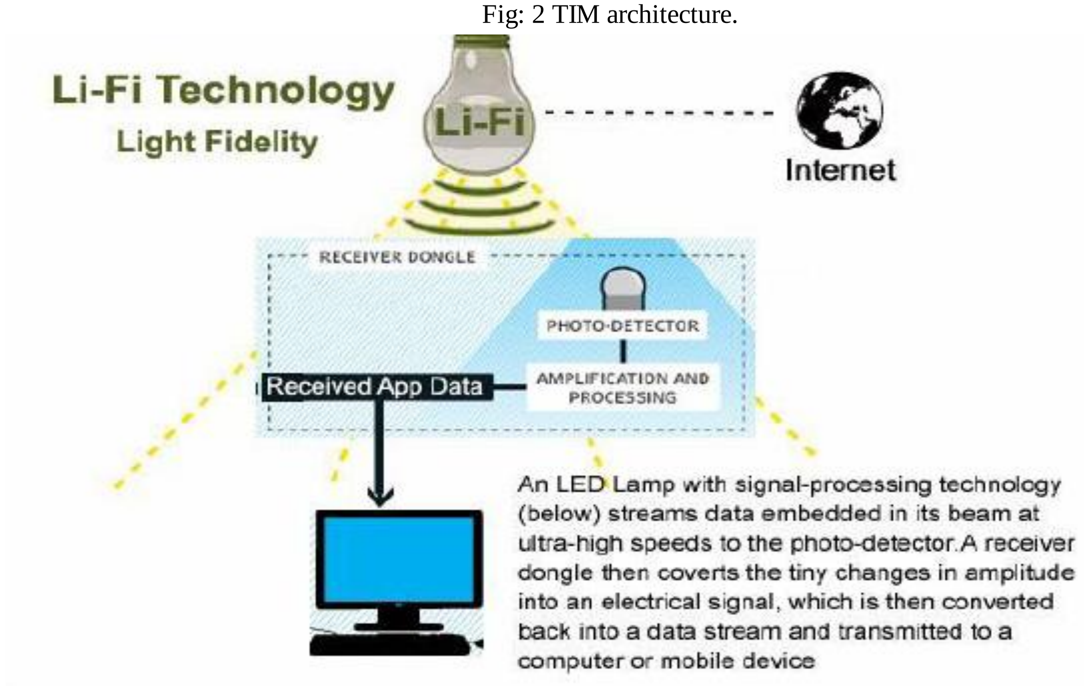

Fig:3 li-fi technology

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Although there are a lot of advantages of LI-FI, there are still certain challenges which need to be overcome. LI-FI requires Line of Sight. If the apparatus is set up outdoors, it would need to deal with changing weather conditions. If the apparatus is set up indoors, one would not be able to shift the receiver. The problem of how the receiver will transmit back to the transmitter still persists. Light waves can easily be blocked and cannot penetrate thick walls like the radio waves can. become dependent on the light source for internet access. If the light source malfunctions, lose access to the internet. SPEED 100 times faster than Wi-Max 100 times faster than WI-FI RANGE 10 meters 30-100 meters FREQUENCY BAND 100 times of THz 2-11 GHz TECHNOLOGY USED Light Fidelity Microwave NETWORK TOPOLOGY Point-to-Point Point-to-Multi Point SPECTRUM RANGE 10000 times than WI-FI 10-66 GHz.

5. FUZZY LOGIC ALGORITHM

Lighting control systems have been defined historically to minimize power consumption and/or increase visual comfort. Traditionally, these strategies are divided into four different approaches. The first one involves updating thelighting system with energy-efficient luminaires. The second approach, introduces occupancy sensors in the lighting system. The third, the lighting system contains daylight harvesting and control. Finally the fourth approach, a lighting system further includes motorized blinds. However, in our lighting control system prototype, attempt to cover these different approaches by considering a heuristic model to determine control actions based on user experience and with the support of smart sensors and actuators. Several heuristic models, considering artificial intelligence techniques have been reported during the last years . In some cases, these heuristic models seek to solve problems that traditional methods cannot work out. These solutions are often based on innovative strategies, rules or principles of data fusion. For this reason, chose a Fuzzy logic algorithm to determine light levels required on the work plane during a working day in an office.

- The objectives are This new lighting system is able to achieve energy savings
- Too reduce unnecessary electricity consumption
- To design smart lighting system which compatibilty and scalability with other commercial product and automation system,which might include more than lighting
- lighting system
- To use as a data down streaming terminal
- Efficient usage of light source LED

The energy savings have been calculated over a time periodof eight months. With the new system savings between 13.4 %and 43 % were achieved and at the same time user satisfactionincreased due to the use of a smart lighting contol system.

CONCLUSION

In this project, a smart lighting system that takes into accountuser preferences and includes smart sensors and actuators based on IEEE 21451 is proposed. Autonomous TIM nodes provided with energy harvesting techniques were designed. A reduced set of functions that cover the core of thenew IEEE 21451 standard were also implemented.This new lighting system is able to achieve energy savingsbetween 13% and 43% compared to the old fluorescent office lighting installation. As shown in the presented quantitative survey indicators, experimental results show a reduction inoperational energy costs and a clear increase in visual comfortfor the occupants from 75% to 86.5%.An additional IEEE 21451 Fuzzy logic service wasimplemented as a Matlab function to optimize control strategies directly in the NCAP. In addition, a secondIEEE 21451 fuzzy service within the TIM firmwarecontinuously adapts dimming values to guarantee optimalvisual comfort at point-of-measurement.

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