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Infrastructure Control & Automation System (ICAS): An IOT based Home Automation

Danish Raza Rizvi
Department of Computer Engineering
Jamia Millia Islamia
New Delhi, INDIA *drizvi@jmi.ac.in*

Abstract- The Infrastructure Control and Automation System (ICAS) is that solution which is a counterpart of the existing conventional systems for managing the basic amenities of any infrastructure. Be it a home where the system can control any number of appliances using a wireless handheld interface for the whole infrastructure, and also gives an ease to installing any number of new devices/appliances/sensors to the existing structure with simplicity due to its modular and plug and play design. And also now you home will feel alive as each and every small section of it is linked together with an interactive interface that also suggests ways to achieve the proper energy management and also provides results on the basis of real time usage analysis and other information such as faults and inefficiencies.

Keywords: *IOT, ICT, WSN, ICAS, Automation System*.

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I. INTRODUCTION

The aim to develop ICAS as a product under the smart cities and automation sector integrating multiple Internet of Things (IOT) solutions, embedded systems, wireless modules (RF/Wi-Fi), cross platform user interfaces and further development on cloud computing data mining techniques and recommendation systems using trend analysis. Smart cities and automation techniques have considerably gained popularity over the last few years. This has caused an increase in the development of the automation sector including various systems that provide better efficiencies, enhanced quality, performance and better interactivity of various services. This system aims at providing features that enables flexible and easy addition of any number appliances/sensors, better control, accurate and real time monitoring , and implementation of the specified energy usage over the whole infrastructure using a single interactive interface from within and also over the internet.

II. HOME AUTOMATION AND IOT

The goal of building a smart city is to improve quality of life by using technology to improve the efficiency of services and meet residents' needs. Information and communication technology (ICT) and Internet of Things IOT solutions in a secure fashion to manage a city's assets. ICT interact directly with various levels of infrastructures and cities to enable a better quality of life. Through the use of sensors integrated with real-time monitoring systems, data are collected from devices - then processed and analyzed. The information and knowledge gathered are keys to tackling inefficiency.

A. FEATURES

An automation and control system implemented over multiple platforms like Android, Cloud, and Embedded Systems to provide better control and user interface systems.

Easy implementation, deployment and usage over the whole infrastructure, to establish a working system with minimum prerequisite knowledge and tools.

SICAS incorporates different Layers and protocol for each of its functionality to provide automated setup and Error Detection techniques enabling easy and better functionality and control.

SICAS is a Cost Efficient and customer friendly system to establish it as a replacement for various existing conventional mechanisms like the passive switches, hardware locks, non-interactive appliance controls, etc.

SICAS also incorporates Analysis and monitoring techniques like usage trends, pattern of failures, over/under usage, efficiency prediction to give the user the whole knowledge of the infrastructure on real time basis.

SICAS combines the Analysis Mechanisms with the Lower Level Control (appliance control) interfaces, exploiting the true power of Data Mining techniques to enable automation over the whole infrastructure.

Features such as Mood Lighting, Theme selections, Preset selections, planned preset modes (such as welcome mode, night mode), Darkness/Motion based switching and intensity control.

Fig. 1: Energy Consumption block.

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B. CHALLENGES

There are the following three major challenges for the ICAS system development:

a. Cost Efficiency

Adopting mechanisms and techniques that are cost efficient so as to provide a practical and viable replacement over the existing the conventional system. Usage of Low cost processing systems and implementation of cloud computing to provide even more cost reduction.

b. Modular Design

Design to support further developments and supporting major features.

Design incorporating proper protocols to enable proper functionality over each platform (Embedded, UI, Communicating Network)

Maintaining tested and implemented libraries of interface mechanisms.

c. Flexibility And Ease Of Implementation

Automated mechanisms used to provide hassle free setup and error control over multiple platforms. Interfaces and protocols supporting user customizable structure, topologies and other requirements Structure and mechanisms promoting easy user level implementation and explanation of system features Usage of low power embedded systems and wireless communication providing flexibility.

III. FUNCTIONALITY

ICAS system is a collaboration of 3 fields as mentioned below:

A. Embedded Segment

SCUs (Smart Control Unit), CDUs (Configure Device Unit) are embedded devices providing the functionality of physical control over the infrastructure. These units comprise of microcontrollers (AtMega328), interfacing circuits and wireless communication ICs (NRF).It acts as an intermediary to provide the data to be analyzed over to the cloud and implement the processed results back to the infrastructure.

B. Networking Technology

SICAS uses 2.4 GHz RF communication protocol, enabling wireless communication for flexibility.

The RF protocol enables secure and flexible communication protocol, with implemented AES encryption and predefined protocols and commands.

C. Android User Interface

Android development provides an interactive User Interface for various control and monitoring features.

SICAS uses on board features of Android like high resolution Touch-Screens, higher processing power, memory, Wireless support (Wi-Fi), USB-Serial Port, battery backup and easy up gradations.

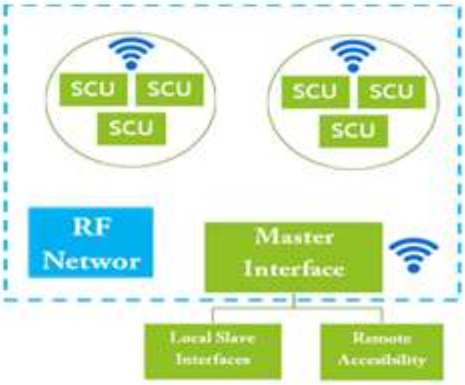

Fig. 2: Functionality

The Embedded systems are the core of ICAS, providing cost efficiency, flexibility and independent control over each appliance and sensor of the whole infrastructure along with providing an intermediate with the user interface and cloud.

The Major segments of ICAS under the Embedded Systems are:

- SCU (Smart Control Units)

Supporting the modular design of ICAS, SCUs are multipurpose smart units that enable flexible and easy control over each appliance and sensors of the infrastructure. SCUs act as the intermediate between the user interface and lower level components of the infrastructure such as electrical appliances, sensors etc. SCUs have flexible design to support multiple interfacing circuits each for digital, analog and sensor control. SCUs also incorporates wireless communication, enabling independent setup and error/breakage free communication, maintaining a better and reliable system

- CDU (Configuring Device Unit)

Supporting the Automated Setup of ICAS, CDUs provide easy one-time initialization for each SCU to be configured to the established SICAS over the infrastructure. Its wireless control and automated setup mechanism requires no prerequisite knowledge or tools to setup a properly functional system.

- ATMEGA

The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

- NRF IC

The nRF24L01 is a chip which provides wireless communication capabilities with stringent requirements on battery lifetime and cost. Thetransceiver operates in the license free worldwide 2.4GHz ISM band and provides a 2 Mbps (Megabits per second) air data rate. It integrates a complete 2.4GHz RF transceiver, an RF synthesizer, full baseband logic including the unique Enhanced Shock burst hardware link layer, advanced power management and a high-speed SPI for the host controller interface.

It provides support for up to 6 bi-directional logical links for 1:6 star network topologies.

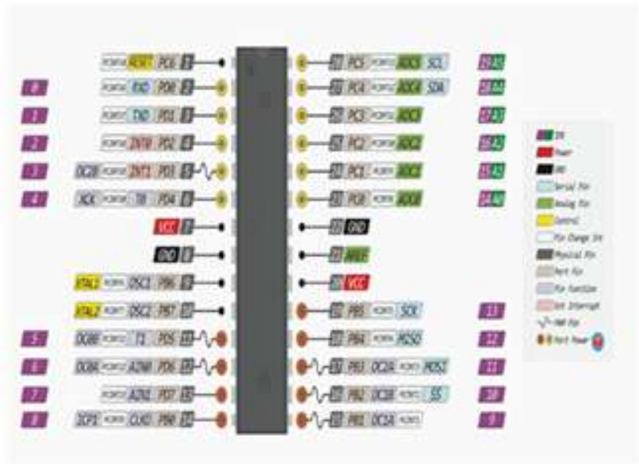

Fig. 3:ATMEGA Pin configuration

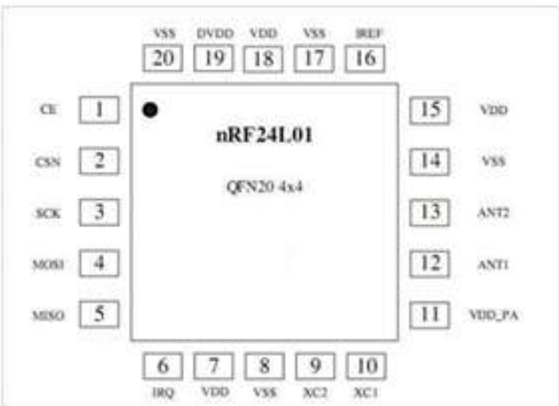

Fig. 4: NRF1C Pin configuration

In conclusion, major embedded segment of SICAS, SCUs, is a collective implementation of majorly 3 categories- Microcontroller (Atmega), Interfacing Circuits and RF Technology.

Network communication, methodology of ICAS is based upon radio frequency which operates in the licence free 2.4GHz ISM band and can provide bandwidth upto 2 Mbps.

RF communication enables better security and coverage area with low power consumption as compared to other wireless systems like wifi and bluetooth. The topology by which all the devices are connected is implemented in the form of a 4 Way Tree over the RF network. The 4 way tree is a very efficient structure which routes the packet with minimum switching at nodes. The packets are designed in the most efficient way with taking care of the limitation of the RF packet size i.e. 32 bytes. The packet include all the necessary fields for forwarding and errorless operation like source, destination, CRC etc.

Due to increasing incidents of hacking and cyber-attacks, it is really necessary to have secured communication so that no third party or intruder can get access to the system.. In order to achieve this the packets are encrypted with AES 128 bit encryption method.

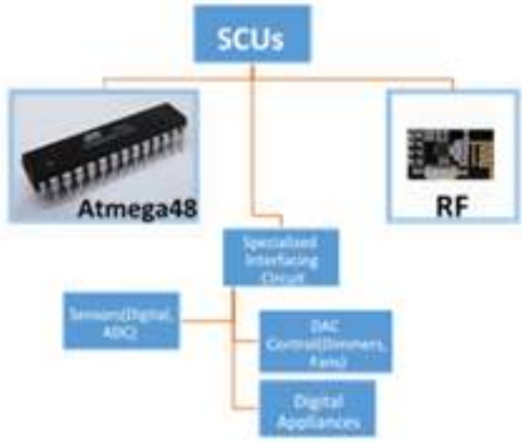

Fig. 5: Embedded Segment

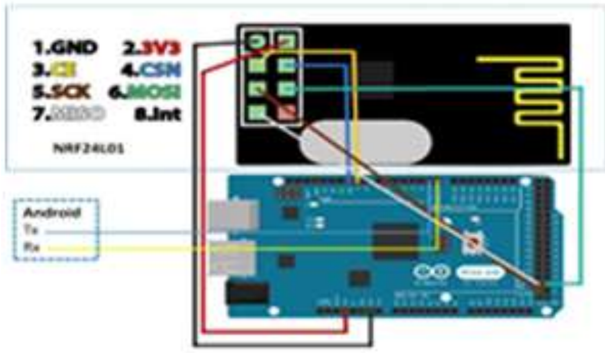

Fig. 6: Connection Diagram

ADDRESSING

In ICAS system, a device have a unique address of 8 bytes integer in which last 1 byte is the port address of the device and 7 byte network address which is unique for each system. Each SICAS system can have maximum of 168 devices.

For each of the device, there are 6 addresses attached to it i.e a device can communicate to the maximum of 6 devices at once .Out of the 6 addresses, 1 address is of the parent, 4 child addresses and 1 configuring address. The addresses of the children and configuring pipe are calculated according to the parent address in the following way:

Address Resolution Algorithm

(max 255 device addresses)

Let Parent Pipe address– p

Child Pipe address – 4p+1,4p+2,4p+3,4p+4

Configuring pipe address – 255-p

Fig.7: Child & configuration pipe address calculation

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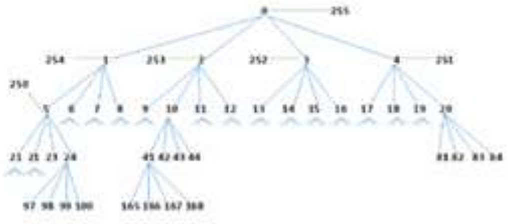
Packet Routing Algorithm
While(1) {
If (Destination address = Address of the child) {
Send packet to the that pipe.
Break; }
Else {
Destination address = Destination address – 1;
Destination address = Destination address/4; }
}
4- WAY TREE STRUCTURE



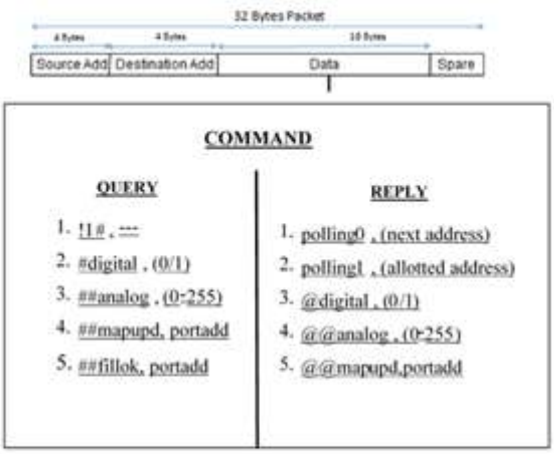


Fig. 8: Packet & Command format

•!1#, (polling0,---) and (polling1,---) commands are used for setup.
•(#digital,(0/1)) and(@digital,(0/1)) commands are used for controlling digital devices.
•(##analog,(0-255)) and (@@analog,(0-255)) commands are used for controlling analog devices.
•(##fillok,portadd) is used for confirming the add of a new device.
•(##mapupd,portadd)and(@@mapupd,portadd) commands are used for scanning the structure.

IV. *USER INTERFACE*

The User Interface for controlling the infrastructure is based on android. Android provides the complete system which is fully customizable and have support for all the components like camera, sensors etc.

There are lot of advantages of android which makes it apt for our system ICAS. Some are:

- It is open source.
- It have on-board components like touch screen, Wi-Fi, USB-Serial Port, battery backup and got high processing power which allow us to develop application which can communicate to the hardware and provide the real time analysis of the infrastructure.

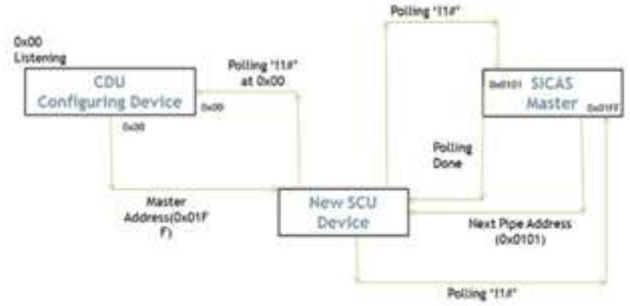


Fig. 9: System Setup

V. CONCLUSION & FUTURE WORK

ICAS system successfully overcomes the major challenges of cost efficiency, modular design, and flexibility in implementation over any infrastructures. SICAS is a viable and yet a smart replacement over the existing the conventional systems such as passive switch boards, hardware locks, non – intelligent appliance controllers.

SICAS is implemented over the infrastructure through the independent smart units (SCUs) which are based on wireless communication protocols to enable easy installation and error/breakage free, fully functional system.

SICAS exploits the true power of data mining as the system itself provides the live data from each appliance to be analyzed, and the processed results are directly implemented over the whole infrastructure at real time basis. The future work includes:

•The implementation of the system established locally, over the cloud with enabled big data. support (Hadoop) for data storage and IOT services support.
•The addition of interfacing mechanisms for various digital and analog appliances over 220 Volts
•The finalizing of prediction algorithms over the collected structured data over the cloud,
•Prediction of better efficiencies and providing alerts and notifications of under/over usage outliers on real time basis.
•Implementation of Recommendation systems, Mood Lighting, Theme selections, Preset selections, planned preset modes (such as welcome mode, night mode), Darkness/Motion based switching and intensity control.
•Enabling cloud control of an implemented SICAS system to its user from over the internet.
•Improvising user interface over platforms like Android/IOS/Web Based with features like energy consumption monitoring, usage trends and area analysis for power failures, cuts, etc.

VI.REFERENCES

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