Grenze International Journal of Engineering and Technology, Special issue

Occupancy based Activity Sensing and Wi-Fi Enabled IoT Devices for Smart Buildings

Kalaivanan.S[1], Joemoan Tom.A[2] and Karthikeyan.S[3]
[1]Assistant Professor, Kongunadu College of Engineering and Technology/Department of Information Technology, Trichy, India
Email: kalaivanan3@gmail.com
[2-3]Kongunadu College of Engineering and Technology / Department of Information Technology, Trichy, India
Email: {tomjoe358, karthisekar.kk}@gmail.com

***Abstract*—Intelligent occupancy sensing is becoming a vital foundation for various emerging applications in smart buildings, such as home application, security observation and human behavior analysis. In this project presenting a novel real-time, device and privacy-preserving Wi-Fi-enabled IoT platform for occupancy sensing, which can promote a countless of emerging applications. It is designed to achieve an optimal trade-off between presentation and scalability. Our system empowers Wi-Fi device to collect Channel State Information (CSI) measurements and provides an efficient client server for computing via a lightweight communication protocol. To exhibit the usefulness of our platform, an occupancy detection system is developed by exploiting the CSI curve of human presence. Furthermore, we also design an innovative occupancy activity sensing and voice through control the appliance system based on our platform and machine learning techniques (ML) with high accessibility and extensibility.**

***Index Terms*— IoT (Internet of Things), Channel State Information (CSI), Machine Learning Techniques (MLT).**

I. INTRODUCTION

The IoT, is a system of interconnected computing devices that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Home automation or domestics is building automation for a home, called a smart home or smart house. A home automation system will control lighting, climate, entertainment systems, and appliances. It may also include home security such as access control and alarm systems [2]. When connected with the Internet, home devices are an important ingredient of the Internet of Things. A home automation system typically connects controlled devices to a central "hub" or "gateway". The user interface for control of the system uses wall-mounted terminals, tablet or desktop computers, a mobile phone application, or a Web interface, that may also be accessible off-site through the Internet. While there are many competing vendors, there are very few worldwide accepted industry standards and the smart home space is heavily fragmented [4]. Manufacturers often prevent independent implementations by withholding documentation and by litigation. By 2012, in the United States, according to ABI Research, 1.5 million home automation systems were installed [9]. As per research firm Statists more than 45 million smart home devices will be installed in U.S. homes by the end of the year 2018.
According to Li et al. (2016) there are three generations of home automation:

Grenze ID: 01.GIJET.5.1.51

- First generation: wireless technology with proxy server, e.g. ZigBee automation
- Second generation: artificial intelligence controls electrical devices, e.g. Amazon Echo
- Third generation: robot buddy who interacts with humans, e.g. Robot Rovio, Roomba.

II. System Design

A. Arduino IDE

The Arduino IDE (Integrated Development Environment) is the software to program Arduino Arduino board. It is available as an open source in the internet.

B. Boot loader

The Boot loader is the Software that is loaded on to the A Tmega 328 to facilitate programming of the ATmega328 from within the Arduino IDE. The Boot loader is loaded initially when the board is powered on / reset. Upon receiving a signal from the IDE that a new program needs to be uploaded, it writes into the program memory of the microcontroller using serial communication for reception.

C. Programming

The programming in Arduino IDE is much similar to 'c' programming.

D. Setup () and Loop ()

There are two special functions that are a part of every Arduino sketch: setup () and loop ().
At the start of power or a reset, the setup () function is called once. It is used only for one time operations required at power on. The loop () function takes care of the application code. It keeps on executing until the power supply is switched off. It is mandatory to include both the functions, whether needed or not.

E. Analog to digital converter

The inbuilt ADC present in arduino board has a resolution of 10 bits. Any Analog voltage in the range of 0-5 volts is converted to an equivalent digital value 0-1023.The resolution hence obtained is between readings of: 5 volts / 1024 units or, .0049 volts (4.9 mV) per unit. The input range and resolution can be changed using Analog reference. The conversion time is about 100 microseconds (0.0001s) - to read an analog input, hence the maximum reading rate is about 10,000 times a second.

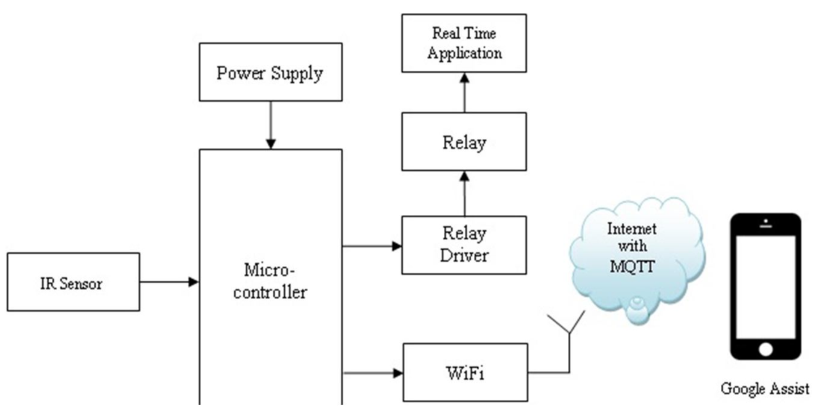

Figure 2.1 Data Flow Diagram

III. System Implementation

MQTT (Message Queuing Telemetry Transport)
MQTT is an extremely simple lightweight messaging protocol, which is designed especially for controlled devices and low-bandwidth or high-latency networks. It has been successfully deployed in satellite links, medical and miniaturized devices [26]. With the help of MQTT, we manage to overcome the network overload. In MQTT, the message is transmitted via TCP/IP protocol and it provides bi-directional connections in order without prejudice. The MQTT is integrated in our system as follows: There are three roles in MQTT, including publish, broker and subscribe. The cloud server, IoT platform and user terminal play the role of broker,

publish and subscribe respectively. Machine Learning make things better for the Internet of Things. Every time the IoT sensors gather data, there has to be someone at the backend to classify the data, process them and guarantee information is sent out back to the device for decision making. If the data set is massive, how could an analyst handle the influx? Driverless cars, for instance, have to make rapid decisions when on autopilot and relying on humans is completely out of the picture. That's where Machine Learning come play with it.

A. Module Description

Login Module

In this module the user need to login with google assistant using their email id for accessing home appliances through voice command. The mail Id is registered in NODEMCU.

Connectivity Module

In this module, the voice command will pass to the NODEMCU using the MQTT (Message Queuing Telemetry Transport). The command passed to NODEMCU is accessed by home appliances using the relay. MQTT is a really simple lightweight messaging protocol, which is designed especially for constrained devices and low-bandwidth or high latency networks.

Occupancy Sensing Module

In this module, it will sense presence of human inside the room using the IR Sensor (Infrared Sensor). By that the home appliances can act accordingly. An infrared sensor is an electronic device, that emits in order to sense some aspects of the background. An IR sensor can measure the heat of an object as well as detects the motion.

IV. SYSTEM TESTING

A. Software Testing

Testing is a set activity that can be planned and conducted systematically. Testing begins at the module level and work towards the integration of entire computers based system. Nothing is complete without testing, as it is vital success of the system.

Testing Objectives

There are several rules that can serve as testing objectives, they are

1. Testing is a process of executing a program with the intent of finding an error.
2. A good test case is one that has high probability of finding an undiscovered error.
3. A successful test is one that uncovers an undiscovered error.

If testing is conducted successfully according to the objectives as stated above, it would uncover errors in the software. Also testing demonstrates that software functions appear to the working according to the specification, that performance requirements appear to have been met.

There are three ways to test a program

1. For Correctness.
2. For Implementation efficiency.
3. For Computational Complexity.

Tests for exactness are supposed to verify that a program does exactly what it was designed to do. This is much more difficult than it may at first appear, especially for large programs. Tests for implementation competence attempt to find ways to make a correct program faster or use less storage. It is a code-refining process, which reexamines the implementation phase of algorithm development. Tests for computational complexity amount to an experimental analysis of the complexity of an algorithm or an experimental comparison of two or more algorithms, which solve the same problem. He data is entered in all forms separately and whenever an error occurred, it is corrected immediately. A quality team deputed by the management verified all the necessary documents and tested the Software while entering the data at all levels. The development process involves various types of testing. Each test type addresses a specific testing requirement.

B. Testing Techniques

Unit Testing

The first test in the development process is the unit test. The source code is normally divided into modules, which in turn are divided into smaller units called units. These units have specific behaviour. The test done on these units of code is called unit test. Unit test depends upon the language on which the project is developed. Unit tests guarantee that each unique path of the project performs accurately to the documented specifications and contains clearly defined inputs and expected results. Functional and reliability testing in an Engineering environment. Producing tests for the behaviour of components (nodes and vertices) of a product to ensure their correct behaviour prior to system integration.

Functional Testing

Functional test can be defined as testing two or more modules together with the intent of finding defects, representing that defects are not present, verifying that the module performs its planned functions as stated in the specification and establishing confidence that a program does what it is supposed to do.

Integration Testing

Testing in which modules are combined and tested as a group. Modules are typically code modules, individual applications, source and destination applications on a network, etc. Integration Testing follows unit testing and precedes system testing. Testing after the product is code complete. Betas are often widely distributed or even distributed to the public at large in hopes that they will buy the final product when it is released.

White Box Testing

Testing based on an analysis of internal workings and structure of a piece of software. This testing can be done sing the percentage value of load and energy. The tester should know what exactly is done in the internal program. Includes techniques such as Branch Testing and Path Testing. Also known as Structural Testing and Glass Box Testing.

Black Box Testing

Testing without knowledge of the internal workings of the item being tested. Tests are usually functional. This testing can be done by the user who has no knowledge of how the shortest path is found.

V. CONCLUSION

In this project, we design a object-enabled IoT platform for occupancy sensing in smart homes, and present two pioneering applications based on it. Our platform only employs commodity Wi-Fi routers and thus can be easily deployed in smart homes. It consists of three parts, referring to IoT platform, cloud server and user end. We firstly integrate object occupancy system with IR sensor tools and then the Node MCU reported in the IoT devices will be transmitted to cloud server for processing. Finally, the results are displayed in the user end. To demonstrate the availability, we implement two cases including occupancy detection and human activity recognition. The evaluation demonstrates that our method achieves more than 90% exactness. As a result, our platforms provide a momentous opportunity to enable many CSI-based applications.

FUTURE WORK

For the future work, we mainly consider multi-user situations and data fusion approach. It is possible to employ very costly access points and network cards, mini-controllers such as ESP8266. This can provide more associates and more detailed sensing data. As various sensing technologies can compensate for each other, it is believed that fine-grained sensing can be achieved by blend of these approaches.

REFERENCES

[1] L. M. Candanedo and V. Feldheim, “Accurate occupancy detection of an office room from light, temperature, humidity and co 2 measurements using statistical learning models,” Energy and Buildings, vol. 112, pp. 28–39, 2016.

[2] Z. Chen, Q. Zhu, Y. C. Soh, and L. Zhang, “Robust human activity recognition using smartphone sensors via ct-pca and online svm,” IEEE Transactions on Industrial Informatics, vol. 13, no. 6, pp. 3070–3080, 2017.

[3] M. Jin, H. Zou, K. Weekly, R. Jia, A. M. Bayen, and C. J. Spanos, “Environmental sensing by wearable device for indoor activity and location estimation,” in Industrial Electronics Society, IECON 2014-40th Annual Conference of the IEEE. IEEE, pp. 5369–5375, 2014.

[4] N. Ravi, N. Dandekar, P. Mysore, and M. L. Littman, “Activity recognition from accelerometer data,” in AAAI, vol. 5, pp. 1541–1546, 2005.

[5] L. Wang, Y. Qiao, and X. Tang, “Action recognition with trajectory pooled deep-convolutional descriptors,” in Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 4305– 4314, 2015.

[6] K. Weekly, M. Jin, H. Zou, C. Hsu, A. Bayen, and C. Spanos, “Building in-briefcase (bib),” preprint arXiv:1409-1660, 2014.

[7] H. Zou, B. Huang, X. Lu, H. Jiang, and L. Xie, "Standardizing location fingerprints across heterogeneous mobile devices for indoor localization," in 2016 IEEE Wireless Communications and Networking Conference (WCNC). IEEE, pp. 1–6, 2016.
[8] M. Zhao, S. Yue, D. Katabi, T. S. Jaakkola, and M. T. Bianchi, "Learning sleep stages from radio signals: A conditional adversarial architecture," in International Conference on Machine Learning, pp. 4100–4109, 2017.
[9] J. Yang, M. Santamouris, and S. E. Lee, "Review of occupancy sensing systems and occupancy modeling methodologies for the application in institutional buildings," Energy and Buildings, vol. 121, pp. 344–349, 2014.