Smart Lighting Solution using Clusters of Sensors (Problems with Limited Sensors) and Analyzing Networks for Smart Lighting Solution

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Abstract: ***As described in paper [1], I have mentioned solution to smart lighting and security using arduinouno microprocessor, Wi-Fi module and PIR Sensor. I have used only one PIR (Passive infrared sensor) sensor to create solution but only one PIR sensor is not enough to create perfect smart lighting solution for big rooms because PIR sensors range is limited (approx. 10 meters). We must need to use efficient number of sensors as per room size to successfully create smart lighting solution for smart home. Networking is also most critical decision in creating any smart home solutions. You must take care of variety of parameters like range,topology, frequency, battery ability, cost etc. before selecting any smart home network***

Keywords: Smart Lighting Solutions, Smart Home Networking, Cluster of sensors, Comparison of Smart Home Networks for Smart Lighting Solution

I. INTRODUCTION

This paper mentions case study of smart lighting solutions. It monitors PIR sensors response in big rooms using clusters of PIR sensors. Electricity is very important and to make effective use of electricity one need proper solution for lighting control to save electricity.PIR (Passive infrared sensor) sensors actually used to sense availably of any person in the room. It uses infrared signals to sense the person's movement.In this paper I have also compared different networking solutions to get best fit network for this solution in smart home. In this paper, I have mentioned below topics.

1) Introduction
2) Problems with limited number of PIRs in big room
3) Solutions of described problems with PIR
4) Case Study
5) Comparison of Smart Home Networks for Smart Lighting Solutions
6) Future Extension
7) Conclusions

II. PROBLEMS WITH LIMITED NUMBER OF PIRs IN BIG ROOM

In my previous paper [1], I have developed solution for smart lighting and smart alarm for security using Arduino Uno Microprocessor, ESP8266 Wi-Fi Module, Relay Buzzer, Connectors and Breadboard and only one PIR sensor is connected to lights available in room as shows in figure 1.

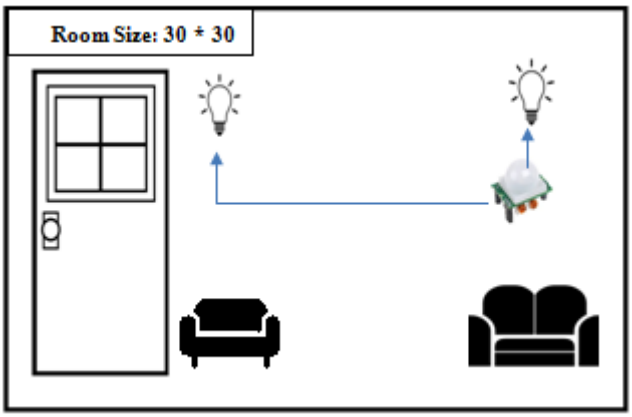

Fig. 1 Room with 2 lights and 1 PIR sensors

But if room size is too big than this solution may not work due to range of PIR sensors. For example, when you enter the room, no lights will turn on and when you step forward to the end of room all lights will turn on. In reverse to that when you leave room from the end, all lights will turn off automatically not last light. So, we must need some proper solution to this problem in order to save electricity and make this solution work.

We must need solution such that when person enters the room only lights nearest to that person will need to turn on not all lights and when person leaving the room only lights at the end need to be turn off not all. We can use Seismic Sensor - Unattended Ground sensors UGS which identifies human detection pattern because position of sensors plays an important role in success of the any system. You must identify number of sensors based on your size to make this solution perfect as shown in Figure 2.

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III. SOLUTIONS OF DESCRIBED PROBLEMS WITH PIR

As shown in figure 1 when your room size is too big and you have used only one PIR sensor for all room lights then this may result in wastage of your electricity because it cannot detect movement of person accurately. Perfect solution for Smart Lighting problem is shown in figure 2.

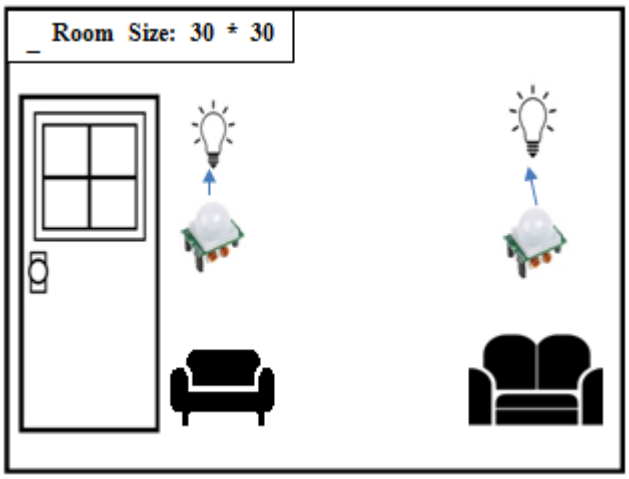
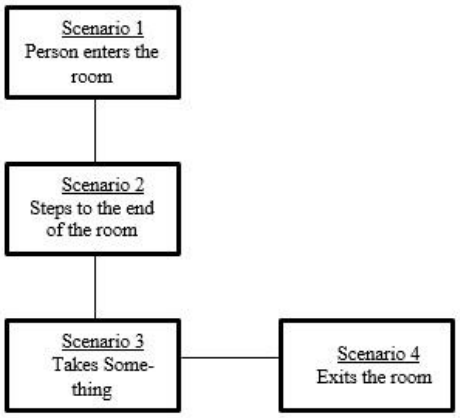


Fig. 2 Solution to Smart Lighting Problem

For example, when you enter the room, first PIR sensor connected to your room will detect the movement of person and switches ononly the entrance lights not all. When you step forward to the end of your room, in this condition your entrance light will switch off as your entrance PIR cannot detect your movement and assumes that you are not present near entrance and only lights at end of your room will switch on due to last PIR sensor detects your movement. In reverse to that when you are leaving your room from the end, only last light will switch off and when you leave whole room and if no one is there in your room then PIR will switch off all lights. So, this way this solution work perfectly for big rooms and it also saves your electricity. To explain more about this solution I have mentioned case study of big room which compares room with one PIR sensor to room with more than one PIR sensors.

IV. CASE STUDY

Below case study shows the real scenario how room with limited sensor works in different conditions compare to room with multiple sensors in same conditions. The Scenario is,



Case 1:-

- **Room Size**: 30 * 30 Feet
- **Sensor Size**: 1
- **Lights connected to sensors**: 2, 1 at entrance and 1 at end of room
- **Sensor Placed in room:** Around 42 feet far from entrance

Table. 1 Case 1 and Expected Results

Test Scenario	Test Steps	Expected Results	Actual Results	Pass/Fail
CheckSmart Light Status	1. Enter in room 2. Check Light Status	Entrance Light Status will turn on	Entrance light is off	Fail
CheckSmart Light Status	1. Step ahead in room till 32 meters far from entrance 2. Check Light Status	Entrance light must be off and light at the end must be on.	Both lights are on	Fail
Check Smart Light Status	1. Again come back at the entrance. 2. Check Light Status	Entrance light must be on and light at the end must be off.	Both lights are off	Fail

Case 2:-

- **Room Size**: 30 * 30 Feet
- **Sensor Size**: 2
- **Lights connected to sensors**: 2, 1 at entrance with one sensor and 1 at end of room with another sensor
- **Sensor Placed in room:** One sensor is placed at entrance and another at end of room

Table. 2 Case 2 and Expected Results

Test Scenario	Test Steps	Expected Results	Actual Results	Pass/Fail
Check Smart Light Status	1. Enter in room 2. Check Light Status	Entrance Light Status will turn on	As Expected	Pass
Check Smart Light Status	3. Step ahead in room till 32 meters far from entrance 4. Check Light Status	Entrance light must be off and light at the end must be on.	As Expected	Pass
Check Smart Light Status	5. Again come back at the entrance. 6. Check Light Status	Entrance light must be on and light at the end must be off.	As Expected	Pass

V. COMPARISON OF SMART HOME NETWORKS FOR SMART LIGHTING SOLUTION

Network selection is most important parameter in any smart home system. Without network you cannot apply any intelligent decision on your smart home rather it is called home automation not smart home. Let's show one example of how network is important in Smart Lighting Solution,

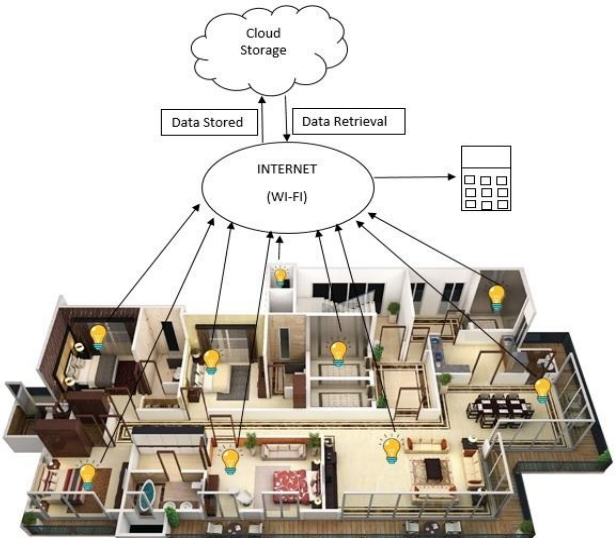


Fig. 3 Use of network in Smart Lighting Problem

So as shown in figure 3, all lights of your home is connected to network and data is stored and retrieved from cloud. If you are not present in your home and someone enters your home then this solution will let you know that some intruder enters you home. So this way network is most important parameter in any Smart Home system.

Before selecting any Smart Home network you must monitor number of parameters like range of network, battery life, and extension of your nodes in future etc. As per comparison of networks shown in table 3 Wi Fi is best solution for Smart Lighting for big homes due to its range, battery capacity, Nodes extensions and costs. Following table compares different Smart Home networks parameters,

Table. 3Comparison of networks

Parameters	Bluetooth	Wi-Fi	ZigBee	Z-Wave	802.15.4
Frequency	2.4 Ghz	SubGhz,2.4 Ghz,5Ghz	2.4 Ghz	SubGhz	SubGhz,2.4 Ghz
Data Rate	1, 2, 3 MBPS	0.1-54 MBPS	250 KBPS	40 KBPS	40, 250 KBPS
Range	~300 Feet	<300 Feet	~300 Feet	~100 Feet	>100 Square Miles
Power Usage	Low	Medium	Low	Low	Low
Nodes	8	32	65,000	232	Nodes are configured according to the IEEE 802.15.4 standard
Battery	Rechargeable (Days to Weeks)	Rechargeable (Hours)	Alkaline (Months to Years)	More than 10 years	Long battery life
Cost	Low	Low	Medium	Medium	Low

VI. FUTURE EXTENSION

To increase the range of PIR sensors we can use amplifier gain adjusted according to the application.The achievable range is however mostly limited by sensor noise, the usual means to achieve a wide sensor range is a different (single zone, large aperture) Fresnel lens.The PIR sensors normally have parabolic mirrors or Fresnel lenses that have essentially an infinite focus (which turns out to be about 30 - 50 feet.). You will need to either get a PIR with different focal length or experiment with the threshold level of the amplifier within the unit. Note that they usually have some type of sample-and-hold amp or other filter as well to prolong the response. Also, there are often multiple little sensors with multiple mirrors on a wide-angle sensor. They are usually wired so activation of one trips the overall sensor. Also, those multiple sensors could be wired as difference amps so temp change doesn't cause a signal.

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