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Real-Time Monitoring and Control of a Smart Home using Internet of Things (IoT) Technology

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Abstract

The Internet of Things (IoT) has emerged as a revolutionary paradigm, reshaping various aspects of everyday life, including the way we interact with our living spaces. Smart home systems, empowered by IoT technologies, have gained substantial momentum due to their ability to enhance comfort, convenience, and energy efficiency. Though smart home technology has reached a very high standard level, and so available in developed country. But developing country like Bangladesh smart home is not that much familiar due to unavailability and costliness. This paper presents a complete process of making IoT-based smart home systems integrated with many other technologies, focusing on a prototype and its components, communication protocols, and applications. A prototype smart home is established and all the appliances can be controlled and monitored from a mobile app Bylink through IoT with the help of ESP8266MOD microcontroller. All the appliances can be controlled also through IR remote, manual switches and voice command. The motor of the fan changes its speed according to the temperature. The volume of water flow also can be measured and displayed by LCD display. By using a ESP32CAM module whole smart home has brought under real time monitoring. This smart home is comparatively cost effective.

Keywords: Smart Home, IOT, Bylink, IR Controlled System, Real Time Monitoring

1.Introduction

The world is getting modernized day by day. The use of smart devices also increasing along with the increasing number of internet users. According to Smart Home web page [1] "A smart home, or smart house, is a home that incorporates advanced automation systems to provide the inhabitants with sophisticated monitoring and control over the building's functions. According to [2], IoT is an "interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with Cloud computing as the unifying framework." The provision of continually updated data concerning systems, procedures, or events is known as real-time monitoring. Data collection and analysis happen with the least amount of delay possible thanks to this kind of monitoring, which streams information at zero or low latency. It makes it possible to find abnormalities, problems with performance, and important events quickly.

According to [3] here are some benefits that a smart home might offer; A safer home, A more energy-efficient home, A more convenient home, A more accessible home, A more comfortable, fun home, A more helpful home.

According to [4], Internet of things is based on four simple building blocks also called IoT architecture layers:
i)Sensors ii) Internet of Things (IoT) framework & gateway iii) Cloud server iv) Mobile app.

While there have been notable advancements in IoT-powered smart homes and real-time monitoring. Despite the individual advancements in IoT, there remains a gap in research exploring the seamless integration of these

technologies (IoT, Voice Command, IR Remote and Manual Control) within the context of smart home systems. Maximum smart home systems are expensive and installation process are too much complicated.
Here we will design and build a smart home (Prototype) and collect different sensor data & actuator data from the prototype to test the system that it is functioning properly and well synchronized with each other. We will do the cost analysis of the prototype & recommendation for real life application and we will stream the footage of the smart home by using IP address.

2.Methodology

2.1 Processes Followed to build the system are described below:

i)Equipment selection and buy according to the features: This is the first step where we selected and purchased the necessary equipment based on the required features of the system.
ii)Schematic drawing of the setup: After selecting the equipment, a schematic diagram is created to show how all the components will be connected. This was a crucial step for planning and reference.
iii)Drawing circuit diagram: This involves creating a detailed circuit diagram, which serves as a guide for assembling the electronic components. It's a graphical representation of the electrical circuits.
iv)Components soldering on the Veroboard: Components are then physically assembled. Instead of permanent soldering on a PCB, they are placed on a Veroboard, which allows for easy modifications and debugging.
v)Giving connection between the appliances, relays & display: This step involves connecting the electrical appliances that we want to control with relays (which act like electrically operated switches) and any displays that show the status or provide a user interface.
vi)Upload the code in the Esp8266, Esp32cam module & Arduino nano: After the physical setup, we uploaded the necessary programming code to the microcontroller units (MCUs) and modules like the ESP8266 (a Wi-Fi module), ESP32CAM (a camera module with Wi-Fi capabilities), and Arduino Nano (a small, complete, and Veroboard-friendly board based on the ATmega328P).
vii)Setting Blynk, Google Home: Blynk is an Internet of Things (IoT) platform that allows to control hardware remotely, and Google Home setup would involve integrating the system with Google Assistant for voice commands.
viii)IR Remote and Google Assistant Integration: This step involves programming and configuring the system to respond to an Infrared (IR) remote control and voice commands via Google Assistant.

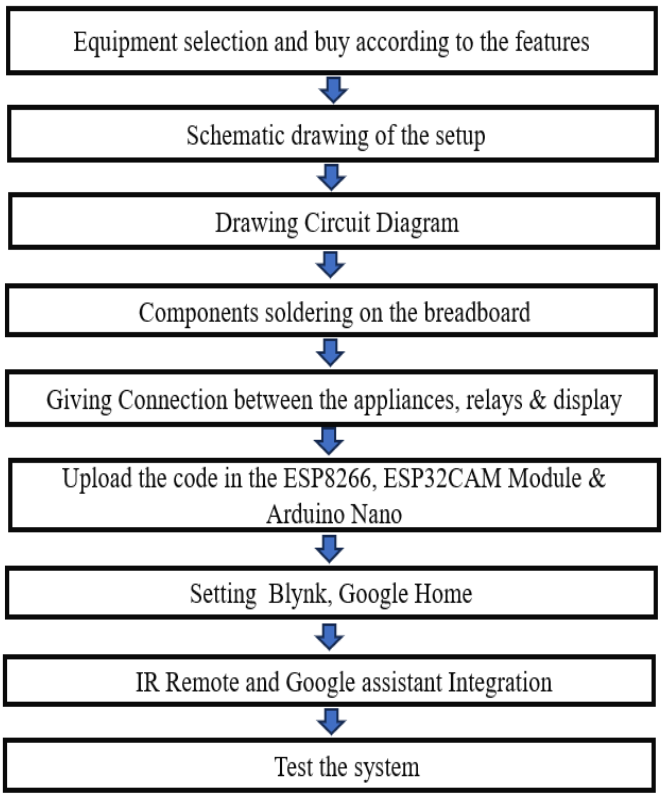


Figure 1: Process Followed to Build the Project

ix)Test the system: The final step is to test the entire system to ensure that it works as intended, with all the components responding correctly to the IR remote and Google Assistant commands.

2.2 List of Components:

Table 1: list of Components

Microcontrollers/Microprocessors	Sensors	Actuators	Software
ESP8266MOD ESP32CAM module Arduino Nano	DTH 11, IR Receiver, Water Flow Sensor	Water Pump, Motor & Driver Module, Relay, IR remote, LCD display	Bylink Synric pro

2.3 System overview

We will control up to 4 DC Appliances using Multiple ways (Blynk Application, Manual Switches,IR Remote, Google Assistant).Fan Speed will change according to real time temperature & humidity Temperature reading, Speed of the fan, flow rate of the pump could be seen in Blynk app and LED display. An IP camera will stream all the video footage and could be seen through IOT.In our smart home prototype, we are controlling the four appliances: Pump, Fan, Motor, Light

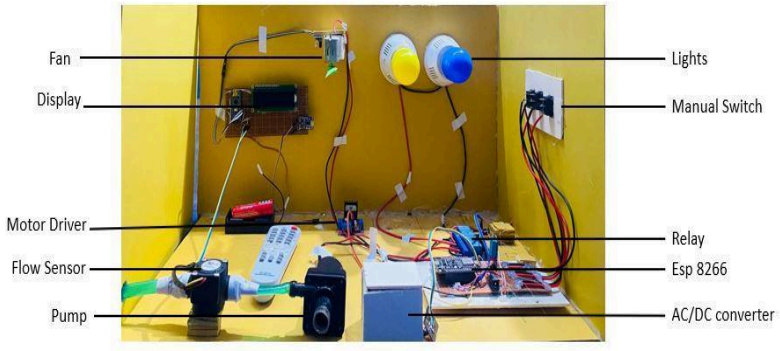


Figure 2: Final Setup of the Prototype

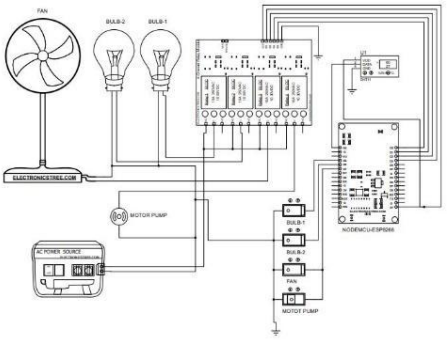


Figure 3: Schematic diagram

2.4 Real Time Monitoring Systems:

The smart home prototype can be monitored from a remote distance through IoT and IP camera. Here the real time temperature and humidity, On/Off state of the Appliances of the smart home (Pump, Lights, Motor, Fan) are send to the operator through the app Blynk. An LED display always shows the temperature and water flow rates of the pump. By the real time stream of the IP camera, we can get the video footage of the home all the time by the Blynk App.

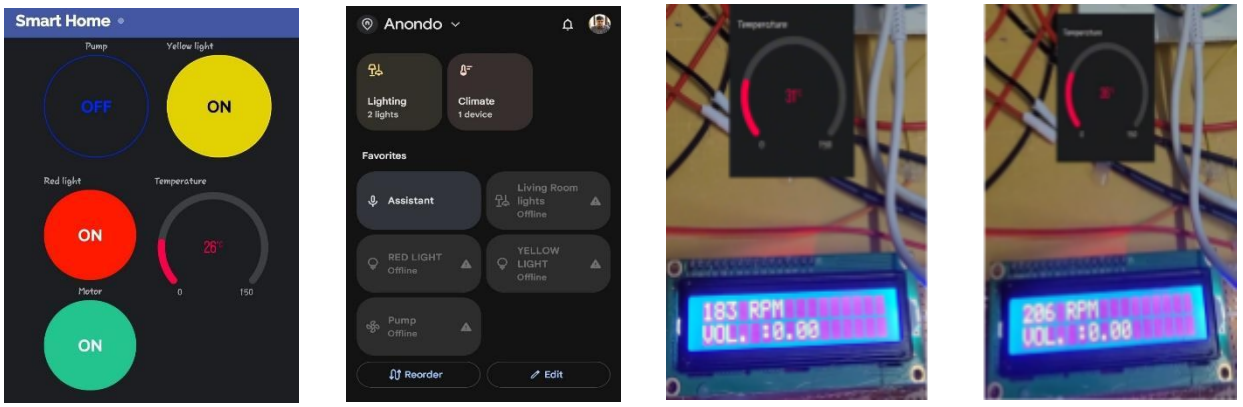


Figure 4: Interface of the Blynk Software, Google Home & LCD display Data of RPM & Vol. flow rate

2.5 Cost Analysis:

The following Table shows the costs of the equipment to make a conventional home to smart home.

Table 2: Cost analysis

Equipment	Quantity	Total Price (TK.)
ESP8266MOD	1	420
ESP32CAM module	1	840
DHT11	1	180
RELAY module	1(4 Channel)	290
IR remote	1	100
LCD display	1	220
Arduino nano	1	480
Motor driver module	1	220
Wiring	As Required	100

Total		2850

Conventionally, if we want to make a home smart, we need to change all the appliances and the whole house needs to construct accordingly which is very much costly. That's why people are not adopting the smart home technologies but after the cost analysis of our prototype we can say that a home could be made smart in a very cheap cost.

3 Result & Discussion:

3.1 Numerical Data of the Project:

As the system will run in a home. So, the Wi-Fi working range is very much important for the proper working of the system. Wi-Fi Operating Range of the System is dependent on the strength of the Wi-Fi router. Generally, the range is in between 20-80m. The sensor can read temperature from 0 to 50 Degre Celsius. Can measure a water flow rate of 1-30 L/min. The IR Remote works from a distance of 15 meters.

Table 3. Some Numerical Data of the System

Device	Range
Wi-Fi	20-80 meter
DTH 11	0-50°C
Flow sensor	1-30 L/min.
IR Sensor	10-15 meter

3.2 Latency of the System:

We measured the response time of the commands through different ways to compare the latencies. Times were measured by stop watch and several trials were taken for exact measurement. The data table and graph is given below

Table 4: Latency of the System

Control System	Latency (Seconds)	Average Latency (Seconds)
Manual Switch	0.12	0.156
	0.15	
	0.20	
IR Remote	0.78	0.706
	0.62	
	0.72	
Bylink Application	0.25	0.310
	0.30	
	0.40	
Voice Command	2.25	2.230
	2.38	
	2.07	

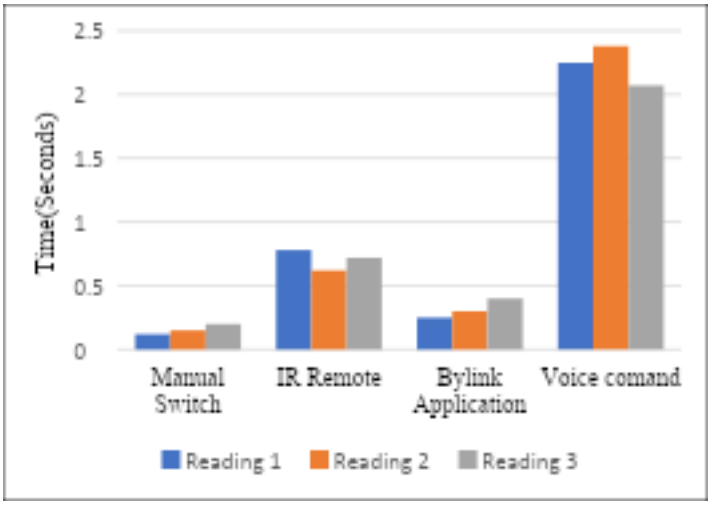


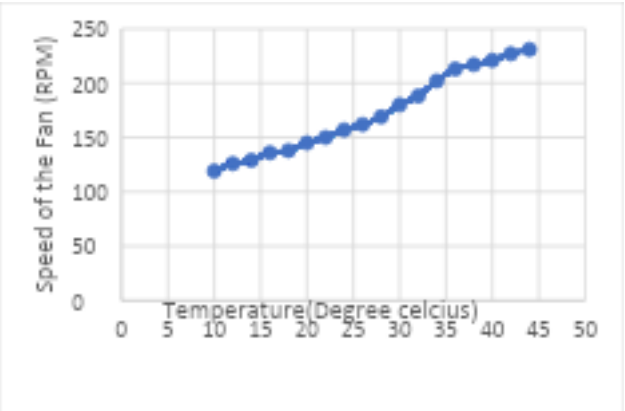
Figure 5: Bar Chart of Latency of the System

3.3 Motor Speed at Varied Room Temperature:

The following data shows the variation of the motor speed according to the temperature sensor data

Table 5: Motor Speed at Varied Temperature

No of Readings	Temperature °C	Speed of the Fan (RPM)
1	10	119
2	14	129
3	18	138
4	24	157
5	26	162
6	32	188
7	34	202
8	38	217



9	44	231

Figure 6: Temperature VS Speed Graph

3.4 Temperature Reading from Sensor:

NO of Obs.	Time	Temperature ° (C)
01	6:00 AM	20
03	8:00 AM	22
05	10:00 AM	24
07	12:00 PM	28
09	2:00 PM	33
11	4:00 PM	30
13	6:00 PM	28
15	8:00 PM	26
17	10:00 PM	25
19	12:00 AM	23

Table 6: Temperature Reading from sensor

We have collected the temperatures readings form the sensors and this data helps to find the proper functionality of the prototype

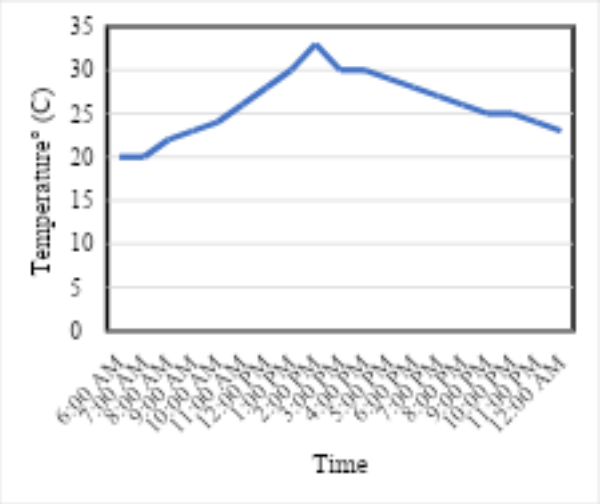


Figure 7: Temperature VS Time Graph

3.5 Discussion

In this project, we propose an effective and efficient construction method of an IoT based Smart Home system. Here, we developed a Smart home system that can be controlled through internet by mobile phone, IR remote, voice command and manually by switches. It can sense temperature, humidity, fan speed, water flow rate and takes action according to it and an IP camera streams the footage of the home which is very intensive and feasible. We developed an algorithm to control the whole system. We have also done the cost analysis of the whole project. With this project, any conventional home could be turned into a Smart Home just by installing the project in the home in a very cheap cost. It shows that within only 2500-3000 BDT we can transform our homes into A Smart Home. All the data is collected from Shahid Lt. Selim Hall, RUET with our prototype setup and the performance of the system is satisfactory. In the prototype the voice command has the maximum latency of 2.23 seconds and the manual switches and Bylink app shows almost zero latency. We have reached our goal with compensating the considerable difficulties that we have faced as much as possible

4. Conclusion:

In today's world, IoT-based smart homes can affect the people's life greatly. People can control devices from anywhere, save energy, and make daily life easier. They make living comfortable and give a sense of safety, showing how technology is deeply woven into our lives. Here we have made a prototype of a smart home. This prototype shows controlling various devices like light, motor, fan, pump etc.by using Bylink App, IR remote, Voice command. To ensure ultimate safety manual switches also integrated. So, this smart home ensures human comfort and energy saving utterly. Collected the sensor and actuator data from the prototype and we can say that the system is functioning properly and the performance is satisfactory This prototype not only enhances comfort but also promotes sustainability and cost-effectiveness through optimized resource utilization. Cost calculation gives the idea of cost effectiveness to establish this system in developing country like Bangladesh. This is a prototype model, so there needs some modification to build it in larger scale.

5. References

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