Smart House, Evaluation of Current Knowledge in the Field

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Abstract: This paper presents the results of the bibliographic exploration that has been made in this research direction. Although relatively new, the scientific subject of the smart house (or intelligent home) benefits from several scientific reports published so far. It falls within the general field of Internet of things (IoT). The bibliographic study allows to highlight the more significant reported results but also to define future and immediate research directions. In the second part of the paper are reviewed some hardware elements in the market, first of all representative sensors and data communications modules and secondly some protocols and open source applications which can be integrated into a smart house control system based on a microcontrollers network.

Keywords: Smart house, Intelligent home, Knowledge assessment, Sensors, Intelligent control.

1. INTRODUCTION

Humans began to deal with *smart homes systems* for tens of years, but those smart homes systems were a very simple. Recently, they are used to provide security, control, energy efficiency, convenience, quality of life, etc. Smart home includes a centralised control for lighting, HVAC (heating, ventilation and air conditioning), appliance management, and others. Now, most smart homes are used to provide ease to disabled and elderly people. One of the biggest advantages of smart homes is controlling and managing easily from several devices such as a tablet, desktop, laptop and smart phone.

Due to the range of applications for wireless sensor networks (WSNs) being from distributed monitoring systems to smart embedded managing systems, this WSN can be used for smart home. WSNs are comprised of terminal nodes that monitor the statistics of things or events in their coverage zones. The information and senses of the nodes are transmitted by wire to the Base Station (BS) or through a wireless network (Kulkarni et al., 2011). The fault tolerance and precision of WSNs are increased via dispersed processing, and therefore, they have broad request prospects in industries, the army, gardening and daily life. The internet of things (IoT) covers several networks of physical objects with actuation and sensing embedded units. Under the hood, IoT uses multiple network protocols to communicate between devices. For example, different components existing in physical locations share information or actuate based on information received through network communications. One of the fields that have benefitted from the IoT is the smart home witch uses different types of network protocols such as Wi-Fi, Zig Bee and Bluetooth (Raet et al., 2016).

The growth in mobile technology and rapid developments in embedded systems have made it possible to integrate mobile technology into the design of smart home systems. The smart home enables several house devices to be monitored and controlled via a unique system, and it provides household customers with better suitability, greater safety, and greater energy efficiency. The integration of smart home systems in the future will give clients the ability to control their home system and save energy efficiently. Recently, domiciliary energy management has become an active research topic Mohsenian et al., 2010), Molderink, et al., 2010). The involvement of smart grids in building and home automation systems has led to the growth of different standards for interoperable products to control devices, lighting, security and energy management. The smart grid enables users to control the energy usage according to the demand and price. The efficiency of the home management relies on a number of different factors, such as the type of home system (like home management by the internet, home management by GSM etc.) and the conditions that the consumer need.

The Smart Home System can be defined as the system that delivers power to the appliances where the power is needed but not normally present in the required amounts (Gill, 2009). In this system, the management of the home process will be automatically according to the conditions that the designer will be determined it or according to frequent duties. This system has several advantages as compared with the first system. It saves the house owner time, good management of the home, decreases the need for workmanship, and offers more rest of a house owner and saving energy resources. Therefore, this system can be considered as economic system. These smart home systems based on WSNs are ones that can interrelate intelligently to provide safe living and comfort. The smart home is worldwide a new technology for achieving the precision home management.

The renewable energy can be used in a smart system for powering the system, to make its operation in an independent manner face to the classical power sources, usually used.

Table 1 Comparison between different solutions for smart home communications.

Specifications	Bluetooth	Wi-Fi	Zigbee	GSM	Infrared (IR)
Standard	802.15.1	802.11b	802.15.4	ETSI (Cellular Phone)	IRDA
Frequency	2.4 GHz	2.4 GHz	2.4GHz	900 MHz or 1800 MHz bands	430 THz - 300 GHz
Speed	2 Mbps	11-50 Mbps	20-250 Kbps	64 Kbps-3 Mbps	11 Mbps
Range	10 m	1-100 Km	10-100 m	10-35 Km	< 10 meters
Advantages	Low cost & more security	Low cost & more security	Low cost & moderate security	Moderate cost & more security	Low cost & more security
Disadvantage	Short range	It is more complex	Low data rate	Low competence	Line of sight communication
Spectrum	ISM	ISM	ISM	GSM	ISM
Power	Low	Medium	Low	High	Medium

2. SMART HOME SOLUTIONS

2.1 Overview of technologies

End devices used in smart home systems are usually based on Wi-Fi, ZigBee, Z-Wave or Bluetooth technology (Lee et al. 2007). Some of the smart home devices are based on Bluetooth technology. A number of these devices does not require a centralised system but can communicate with a smartphone or tablet directly. Bluetooth is designed as short range and cheap devices, to replace cables for computer peripherals, like printers. Nominal range of Bluetooth is 10 meters. In most cases, this is not enough to be used in home automation systems.

Some of the home automation devices are based on ZigBee (Obaidet al.2014). ZigBee puts focus on low power consumption, and it is optimised for battery powered devices. ZigBee provides extremely reliable. It is ideal for use in large networks with a large number of routers. Nominal range of ZigBee is 10-100 meters (Liu, Z. 2014).

Wi-Fi (Wireless Fidelity) is a well-known, complex technology based on a star topology. It has a nominal range of 100 meters. Wi-Fi has a high data rate and high security. In smart home system, Wi-Fi technology can been used because it provides an excellent medium through which multiple devices can connect to one network. Wi-Fi operates over an internationally approved frequency band of 2.4 GHz (Vikramet al. 2017).

2.2 Overview of available literature

Many projects and researches are focused on smart techniques in the home field.

In 2002, N. Sriskanthan, F. Tan and A. Karande illustrated the operation of a smart home system utilising Bluetooth. They applied a host controller to a personal computer, which linked to microcontroller-dependent device controllers and sensors. The researchers even built a new protocol on top of the Bluetooth stack software, called HAP (Home Automation Protocol), to make the communication between appliances possible. The appliance controller linked to the electronic appliances through the I2C Bus. The system allows more than one appliance controller to be related to the host regulator.

In 2003, H. Kanma, N. Wakabayashi et al. also proposed a smart home system using Bluetooth that can be accessed remotely via GPRS. The investigators used an armed mobile phone with a GSM modem that provides Internet access and Bluetooth connectivity as a host controller. Household appliances are equipped with Bluetooth communication adapters so they can communicate with the host controller's phone via Bluetooth.

This paper discusses the remote update and remote control of home appliances along with fault detection and diagnostics. The project also discussed the provision of an electronic customer manual on the phone via Internet and Bluetooth networks.

In 2004, A. Alheraish proposed a system of smart homes using SMS (Short Message Service). The proposed system senses illegal interruptions in the house and permits valid customers to adjust the key for control-ling the lights and the door to the house. The entry of a thief into the home is detected by monitoring the state of the house door, which comes complete with infrared sensors and an LED. The key to the door can be a combination of four digits, which can be set both by utilising the SMS or the keypad from a recorded customer's phone number.

A customer can regulate the lamps in the house remotely by utilising an SMS message, after their recorded phone number, thereby turning the lamps on in different rooms at variable intervals of time, which is a unique way of giving the impression that the house is occupied, even when it is not.

In 2005, A.R. Delgado, R. Picking and V. Grout utilised a General Packet Radio Service (GPRS) communication as a backup to an Internet-based smart home system. This enhanced the fault tolerance of the system. House owners are alerted by alarms on their telephones about unusual modifications to conditions detected by the sensors. The customer can then take action, either by utilising a web interface or messaging. In any case, there will be two possible techniques to access the house, so if one fails; the customer can depend on the other.

In 2006, B. Yuksekkaya, A. Kayalar, M. Tosun, M. Ozcan, and A. Alkar developed a home appliances automation using GSM, Internet and speech recognition. The microprocessor is used to process the signals from RF antenna. All these techniques successfully merged into a single wireless home automation system. This system offers a complete, low-cost, powerful and user-friendly way of real-time monitoring and remote control of a house.

In 2007, Z. Lin and L. Chen proposed a system for a multiple users' preference model and service provision in a smart home environment. Multiuser preference model represents relationships among users, as well as the dependency between services and sensor observations. They proposed a three-layer model in their work. All the three layers are configured to acquire information about users' inhabitants and learn from these inhabitants. This knowledge was used to provide services for them in the right place and at the right time. In the experiments, they showed that the model could provide appropriate services to multiple users.

In 2009, M. Khiyal, A. Khan, and E. Shehzadi proposed a SMS-based system for house safety call a SMS-established Wireless HACS (Household Appliance Control System). In this system, a house owner can control the house by utilising an SMS from a pre-set recorded phone number. If the SMS message is not from a genuine phone number, the system will disregard the SMS. In the case of an interruption, the device regulator subsystem and safety subsystem in the proposed system will notify the homeowner through an SMS message.

In 2009, K. K. Mezied and A. Aliv presented microcontroller based smart home control system. They proposed a new approach based on token ring serial network to control home's appliances, where the system nodes are designed to communicate and exchange data in the RS-232 signal level. Reliability was considered during the design of the system. The system also is a soft real-time system since the delay of command will not affect system functionality. It was successfully experiment the control of two home devices (Digital Satellite Receiver and the air conditioner remote control).

In 2010, D. Han and J. Lim, the definitions for the home automation devices and interfaces were presented to explain the interoperability amongst ZigBee appliances via numerous electrical tools, intelligent energy producers and meters.

In 2010, M. Babar, N. Khan, U. Saeed,. S.Z Qazi, S. Syed and A. Khan also proposed a SMS-based smart home system. The system was a request for a Java application on the telephone. Genuine customers can log into the application using their password and username and can select the structure / room / floor / appliance that they want to control remotely, along with an appropriate action from the list of available customer actions. The Java application will create an appropriate SMS message and direct it to the GSM in the house. The GSM will receive the SMS message, decipher it and license it to the house network to implement the identified act. The students utilised facial recognition and a 5-digit key for safety.

In 2012, J. Byun, B. Jeon, J. Noh, Y. Kim and S. Park proposed an intelligent self-adjusting sensor for smart home services based on ZigBee communications. They presented a situation-based self-adjusting scheme, an event-based self-adjusting sensor network and hardware and middleware implementation. They also introduce some smart home services using the proposed system. The experiment showed that the system's energy consumption reduces.

In 2013, A.Z.H. Abd Azzis, N.M. Nor and T. Ibrahim proposed automated electrical protection system for the domestic application. A circuit was set up with two current sensors (line and neutral) connected to the input of an Arduino board for simulation purpose. The current sensors deliver the current value to the microprocessor. The microprocessor is responsible for running or cutting the circuit. The automatic system can detect and isolate the fault to ensure the power continuity in the building.

In 2013, A. Gurek, C. Gur, C. Gurakin, M. Akdeniz, S. K. Metin and I. Korkmaz proposed an Android-based home automation system that allows multiple users to control the appliances by an Android application or through a web site. The paper presented the outcomes of a survey carried out regarding the properties of home automation systems, and also the evaluation results of the experimental tests conducted with volunteers on the running prototype. The implementation of the proposed prototype system is evaluated based on the criteria considered after the requirement analysis for an adequate home system.

In 2014, G. Ramarao, S. K. Telagamsetti and V. S. Kale designed of microcontroller based multi-functional relay for an automated protective system that can protect the equipment against over-current, over-voltage & under voltage. The programming capability of the microcontroller & the proper sampling of the signals reduces the operating time of relay. Simulations are carried out using proteus platforms and hardware prototype with an ATMega328 as core controller is built to validate the operation of the microcontroller as a multifunctional numerical relay. Integration of three conventional relays into one digital relay makes this device economical.

In 2014, Z. Liu designed a smart home system based on ZigBee technology and GSM / GPRS network. This smart home system includes the hardware circuits as the CC2430 ZigBee wireless sensor networks, real-time acquisition of the parameters of temperature, humidity, infrared, smoke, gas, fire, theft alarm, home appliances, appliances for home environment, through the wireless networking of multiple monitoring devices. Users can receive SMS messages via cell phone or PC, according to the need for remote phone set, to achieve a flexible, convenient home security monitoring.

In 2014, M. Narender and M. Vijayalakshmi proposed Raspberry Pi for advanced scheduled home automation system through E-mail. The main aim of this system is to develop an advanced method of home automation with the application of Raspberry Pi through reading the subject of the E-mail. The results showed that the automation process was successfully completed.

In 2014, S. Jain, A. Vaibhav and L. Goyal proposed Raspberry Pi based interactive home automation system through reading the subject of E-mail and the algorithm developed by Python software. They used LEDs to indicate the switching action. Results show the efficient implementation of a proposed algorithm for a smart home.

In 2014, A. Adriansyah and A. W. Dani offered a small smart home system designed and created by utilising WLAN network based on Arduino microcontroller. The system can monitor and control lights, room temperature, alarms and other household appliances. Results from testing the system showed proper control, and monitoring functions can perform from a device connected to a network.

In 2014, Z.A.S.A. Rhman presented a precision irrigation system using WSNs. The system has two parts: Hardware and software. The hardware part consists of one base station unit (BSU) and several sensor nodes (SNs). The BSU consist of the main unit that represented by an Arduino Uno board which includes an ATmega328 microcontroller, liquid crystal display (LCD) and XBee module. The SN consist of the main unit that represented by an Arduino Uno board, the required sensors, the solenoid and XBee module. The software part contains the programming of Zigbee network and the system protocol. The system can save water used for irrigation by including the controlled solenoid, a low cost hard-ware involved when compared with a classical system.

In 2015, S. Hidayat and S. F. Firmanda proposed Raspberry Pi based on Scheduler and voice recognition on the home automation control system to provide an automated home with the easy operation of the system using voice command. Microphone connected to Raspberry with relays used to monitor the status of electronic devices, scheduling, and remote web control. Detailed configurations of the system could be performed remotely via the Internet.

In 2015, V. Vujovic and M. Maksimovic proposed Raspberry Pi as a sensor Web node for home automation. They proposed and implemented sensor Web node as a part of IoT using a Raspberry Pi. Using this technology in monitoring and determining the confidence of the control a possible fire in the building, a full system based on sensor Web elements is created and developed starting from a scratch. Proposed prototype presents the basic level of home appliance control and remote monitoring while the required goals and objectives of home automation system achieved. Results have shown that the Raspberry Pi is an inexpensive system control with a lot of potential.

In 2015, N. Agrawal and S. Singhal designed smart drip irrigation system using Raspberry Pi and Arduino for a home automation system. Arduino microcontrollers were used to receive the on/off commands from the Raspberry Pi using ZigBee protocol. This smart drip irrigation system proves to be a useful system as it automates and regulates the watering without any manual intervention.

In 2016, A. Ahmim, T. L., E. Ososanya and S. Haghani designed and implemented of a home automation system for smart grid applications. They used Message Queuing Telemetry Transport (MQTT) publish / subscribe protocol and Django web framework to give users the capability to integrate many open-source devices with open-source tools and to optimise mobile sites. The design successfully implemented and tested both hardware and software of home automation device.

In 2016, K. K. Namala, K.K.P. Math, A. Kumari and S. Kulkarni, proposed intelligent and smart Irrigation system which can used for controlling the watering or irrigation of flowering plants. It controls the irrigation of plants automatically where the need of human intervention can reduced. Raspberry Pi used in the design of the prototype model in making the system compact and sustainable. The system has a sensor which measures the moisture of the soil and switches the relay which controls solenoid valve according to the requirement. The model has demonstrated gave expected results at the different moisture levels.

In 2016, W.S. Yoo and S.A. Shaik developed home management system using Arduino and App Inventor. They presented an application of home automation using Bluetooth. A prototype of home management system was successfully developed.

In 2016, J. Rusia, A. Naugarhiya, S. Majumder, S. Majumdar, B. Acharya and S. Verma presented an economic and reconfigurable wireless communication system between two microcontrollers using RF and wireless transmission at 433 MHz. In this system was successfully transmitted the data generated at transmitter microcontroller and was received accurately at receiver microcontroller. The ability of this system to fetch and process data remotely and execute desired application according to the instantaneous data makes this system very proficient.

In 2016, A. Bhatt and J. Patoliya designed and implemented a reliable, flexible, secure and economical network to transform the traditional house into a smart home. Different sensor and actuator nodes based on wireless network technologies are implemented in the home environment. These nodes communicate to a middleware that runs on the home automation server and acts as a broker to facilitate the MQTT connectivity protocol. The middleware module facilitates control of wireless nodes on a local and remote network. The proposed system is designed to be cheap and scalable and host a variety of devices to be controlled. The test results show that the overall delay between the request and the response time from the user interface (UI) to the Node is less than 600 milliseconds in the local network (with two intermediate routers), which makes the system's interaction time low acceptable.

In 2016, S. Das, S. Ganguly, S. Ghosh, R. Sarker and D. Sengupta proposed the sophisticated home automation system based on Bluetooth using a smartphone. They proposed an intelligent, compact, fast and inexpensive smart home automation system based on the Arduino microcontroller system and the Android application. Different devices, such as lights and DC servomotors, where incorporated into the system to demonstrate the feasibility, reliability and rapid operation of the proposed smart home system. The entire projected system has been tested and is capable of successfully operating and performing the desired operations.

In 2016, S. Khedkar and G. M. Malwatkar used Raspberry Pi and GSM Survey on home automation to develop its application. They showed the switching operation of electronic devices using relays.

In 2016, N.R Kulkami , H.V. Murthy and A.P. Raju proposed PLC-based controller for reactive power control. They calculated power factor using delay time between current and voltage. The overall system includes the interfacing circuit, controller and switching circuits to switch on or off the capacitors. The response of thyristor switched capacitor (TSC) technique is stepwise response and thyristor switched capacitor thyristor controlled reactor (TSC-TCR) response is faster and more accurate than TSC response, and also it is possible to cover all conditions of compensation requirements where the TCR has the ability of continuous controlling and can meet all required conditions.

In 2016, P. Kumar and U. C. Pati proposed a system by Arduino and Raspberry Pi based smart communication and control of home appliance system. This technology provides the control of the home devices as well as a secure and intelligent interaction between inside and outside of the room. The control system gives the status concerning ON or OFF of the selected instrument to the house owner. Using this technology, consumers can save the electrical energy by regular monitoring of home devices or the proper ON/OFF scheduling of the devices.

In 2017, N. Vikram, S. Harish, S. Nihaal, R. Umesh, S. Aashik, and A. Kumar illustrated a methodology to provide a low-cost home automation system using Wire-less Wi-Fi. This crystallises the concept of internetworking of smart devices. A Wi-Fi-based WSN is designed for monitoring and controlling environmental, safety and electrical parameters of a smart interconnected home.

In 2017, M. Schinle, J. Schneider, T. Blöcher, J. Zimmermann, S. Chiriac, and W. Stork. The main idea behind this work is the reuse of mobile devices as smart home systems to reduce market entry barrier for end users and to contribute to a more holistic use of mobile devices. Therefore, they developed a modular architecture concept for smart home systems based on Android devices.

In 2017, E.C. Prima, S.S. Munifaha, R. Salam, M.H. Aziz and A.T. Suryani proposed an automated water tank filling system. The system was designed using the ultrasonic sensor, an automatic switch module, a water-flow sensor, an Arduino ATmega380 microcontroller, and a pumping machine to automatically switch the water filling. The automatic water tank filling system constructed successfully.

In 2017, A. Gloria, F. Cercas and N. Souto proposed a practical implementation of an IoT gateway dedicated to real-time monitoring and remote control of a swimming pool. Based on a Raspberry Pi, the gateway allows bidirectional communication and data exchange between the user and the sensor network implemented in the environment using an Arduino. The developed system so far, accomplishes the proposal features and purpose, giving the user the ability to control the environment remotely. Nevertheless, more tests to the system in multiple situations can be done to prove the efficiency of the proposed system.

In 2017, Y. Kabir, Y. M. Mohsin and M. M. Khan build up automatic power factor correction, which can monitor the energy consumption of a system and automatically improve its power factor depended on reactive power. The automatic power factor correction device reduces the high current drawn from the system and reduces charges on utility bills.

In 2017, O. V. Rusu and A. V. Duka proposed monitoring and control homes system using FPGA, Raspberry Pi and Web technologies. The system allows the control of multiple houses connected to the internet from one single web page. The system was already tested experimentally and it is easily be implemented in practice.

3. SMART HOME. SENSORS REVIEW

The system could not be considered as a smart home without the implementation of a large category of sensors. In principle, occupancy sensors, realized in a very large different technology must detect the presence of people, vehicles, and objects and automatically adjust the home appliances based on the data receiving from them.

3.1 PIR sensor

PIR Sensor measures the infrared (IR) light is radiating from objects in its field of view to detect motion of people and objects. The sensor is highly reliable and resilient to false triggering.

This sensor requires a very little power of operation. Fig. 1 shows the module of PIR sensor (Marlin, Inc. 2013).

Fig. 1. PIR sensor example.

3.2 Ultrasonic sensor

Ultrasonic sensor can sense movement of objects. It senses motion by analysing sound waves in its environments as the way bats or dolphins do. This could be used, for example, to help detect the water level in the smart home water tank and send a signal to a microcontroller. Typical products for ultrasonic motion sensor (Fig. 2) have a very large detection range, around 6-7m in radius, which we valued most for occupancy sensor. However, its main drawback is that its sensitivity could be affected by loud noise, which would affect its sound wave analysing (Elce Freaks, 2013).

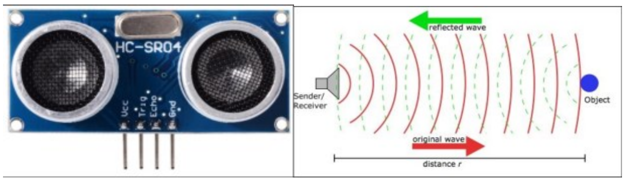


Fig. 2. (a) HC-SR04 model ultrasonic motion sensor module; (b) ultrasonic wave terminology.

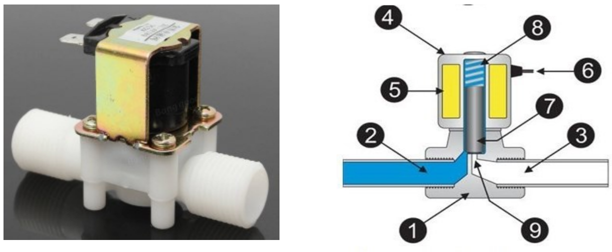
3.3 Moisture soil sensor

The moisture sensor (Fig.3) is used to sensing the soil water content in the farming field. The moisture sensor (Jae, 2013) has two probes and uses them to measure soil moisture in the soil by telling how well an electrical current is passed between the two probes. The probes (electrodes) will directly contact with the ground. The more moisture in the soil gives the better conductivity or lowers the electrical resistance. The sensor consists of four pins: a digital output (D0), an analog output (A0), a VCC and ground.

Fig. 3. Soil moisture sensor (Jae, 2013).

3.4 Solenoid Valve

This solenoid valve is used for allowing and preventing the water flow in the irrigation process (Hadi, 2017).



(a) (b)

Fig. 4. (a) The ROB-10456 model solenoid; (b) The internal structure of the solenoid.

The model (ROB-10456 solenoid) is presented in Fig. 4.a, and in the Fig. 4.b we can observe the internal structure of this type of solenoid, where 1) valve body, 2) inlet port, 3) outlet port, 4) coil /solenoid, 5) coil winding, 6) lead wires, 7) plunger or piston, 8) spring and 9) orifice. Table 2 includes the principal parameters for the solenoid model ROB-10456.

Table 2. Solenoid valve parameters

Four external diameter of thread	20mm / 0.78"
The inner diameter	14mm / 0.55"
Size	LxWxH: 80x35x55mm
Fluid Temperature	0-90 ℃
Pressure	0.02- 0.8 Mpa
Rated Power	5 W
Voltage	12 V DC
Material	Metal + Plastic
threaded inlet and outlet	¾
Voltage	12 V DC
Ampere	300 mA
pressure required	3 PSI minimum

3.5 Humidity and Temperature (DHT) sensor

This DHT11 (Digital output humidity and temperature) sensor (Fig. 5) is used for sensing surrounding relative humidity and temperature (Aosong, 2015).

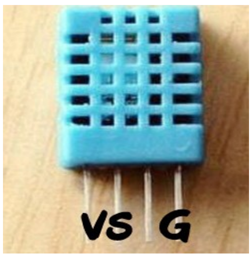


Fig. 5. DHT sensor.

Its sensing elements are connected with 8-bit single chip processor. It has many features as low power consumption, outstanding long-term stability; four pins packaged and fully interchangeable. The DHT-11 model has the specifications included in the Table 3.

Table 3. DHT-11 sensor parameters

Supply	3-5v DC
Humidity	0 to 90% RH
Temperature	0-50 ^{0}C
Humidity accuracy	± 5% RH
Resolution or Sensitivity	0.1% RH
Temperature accuracy	±0.5 ^{0}C

3.6 Flam sensor

The flame sensor basically detects IR (infrared radiation) light wavelength between 760 to 1100 nanometer, emitted from the fire flame. By using this concept, it can understand how to monitor and alert about fire flame. It is most suitable for firefighting, fire alarm etc. Fig. 6 shows the flame sensor module hardware (Future Elctronics, 2013).

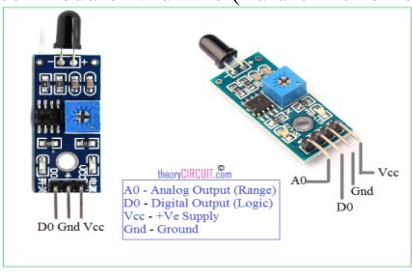


Fig. 6. Flame sensor model.

The fundamental of IR flame sensor is to identify and react to the existence of a flame or fire. It is a low-cost module and can operate on a voltage from 3.3-5 V. The IR flame sensor is interfaced to the microcontroller. The sensitivity is adjusted with the potentiometer available on the module. The general operating range of this sensor for high-intensity flames is 3 feet. The IR flame sensor is widely utilized in the fields of industries, home, colleges.

3.7 Temperature sensor

LM 35 is a three-terminal temperature sensor device. It has its own importance in the field of temperature measurement and it is widely used. It is precision integrated circuit temperature sensor. It has improved performance than a single thermistor and eliminates the issue of oxidation as it is a sealed device. LM 35 output voltage is equivalent to the Celsius temperature. It works at a voltage ranging from 4-30 V and can measure temperature in the range of -55 °C to 150 °C. The LM 35 is interfaced to pins available in the microcontroller. The temperature value produced is more precise than the various temperature measurement devices (Neeraja et al. 2017).

3.8 Photoresistor

It is a light dependent resistor (LDR). The resistance of a photo resistor decreases while increasing incident light intensity of the light source. When the illumination level increases, the resistance of photo resistor decreases, and when illumination level is not high enough, it will have a higher resistance (Marlin, 2016). Fig. 7 shows the LDR module.

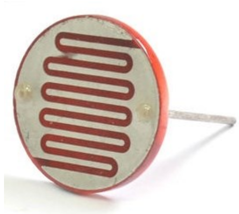


Fig. 7. Photoresistor sensor.

Table 4. LDR sensor parameter

Light resistance (10 Lux)		4-7 KΩ
Dark resistance		0.5 MΩ
Response time	Increase	30 ms
	Decrease	30 ms

3.9 Gas sensor

The module works as an Air Quality Detection Gas Sensor. This sensor is sensitive to gas dangerous to human, like NOx, Benzene, NH3, CO, CO2, and Alchohols (Jindarat et al.,2015). Fig. 8 shows this module.

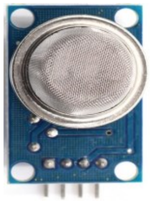


Fig. 8. Gas sensor module.

3.10 Water Flow Sensor

Flow sensor consists of a plastic valve body, a water rotor, and a Hall-effect sensor. The rotor rolls when water flows through the sensor,. Its speed changes with a different rate of flow. The Hall-effect sensor outputs the corresponding pulse signal. This one is suitable to detect flow in water dispenser or coffee machine **(**Indoware,2016)**.**.

Fig. 9. Water flow sensor.

Table 5. Water flow sensor specifications

Working voltage	5V DC
Flow rete range	1~30 l/min
Load capacitor	<10Ma (5V DC)
Operation temperature	<80 ^{0}C
Liquid temperature	<120 ^{0}C
Pressure of water	<1,75 MPa

3.11. Current Transformer

The YHDC current transformer is made up of a ferrite material. The input current ranges from about 0-100A whereas it gives the output current as in the form 0-50 mA. The input to the output ratio is about 20.000:1. The input frequency ranges from about 50Hz to 150 kHz. The device works at a temperature of about -25ºC-70ºC. Some other single input channeled, Hall-effect based, open-loop type current sensors for measuring AC/DC currents operating in the range of -40ºC-150ºC whose measurement is as per radiometric voltage are very accurate (Beijing Yaohuadechang Electronics, 2015).

Fig. 10. Current transformer sensor.

4. SMART HOME. DATA COMMUNICATIONS REVIEW

4.1 *Radio frequency modules*

4.1.1 *RF Transmitter*

The module RF Transmitter STT-433 (Fig. 11) is utilized to transmit the data in the form of RF 433.92 MHz signals. The important features are as follows: 433.92 MHz frequency, low cost, small size, 1.5-12V operation, 4dB output power at 3V and 11mA current consumption (Dorji Tech., 2012).

Fig. 11. The module STT-433 RF Transmitter.

4.1.2 *RF Receiver*

The module RF Receiver STR-433 (Fig. 12) receives the RF signals which are transmitted by the RF Transmitter. The features are as follows: 433.92 MHz frequency, low cost, no external parts required, 5V operation, typical sensitivity -105dB, 3.5mA current drain (Dorji Tech., 2012).

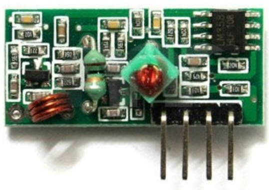


Fig. 12. The module RF Receiver STR-433.

4.1.3 *MFRC522 RFID card*

RFID (Radio Frequency Identification) refers to a wireless system comprised of two components: tags and reader. MFRC522 RFID Reader / Writer features are:

- Integrated MF RC522 13.56 MHz contactless communication card chip
- The reader and RF card terminal design meet advanced applications development and production needs
- Advanced modulation and demodulation concept completely integrated into all types of 13.56 MHz passive contactless communication methods and protocols
- Low-voltage, low-cost, small size of the non-contact card chip to read and write
- Supports rapid CRYPTO1 encryption algorithm, terminology validation MIFARE products
- ISO14443A frames and error detection
- 14443A compatible transponder signals
- Can be directly loaded into the various reader molds, very convenient.MFRC522 support MIFARE series of high-speed non-contact communication, two-way data transmission rate up to 424 kbit/s (NXP Semic., 2016).

Fig. 13. MFRC522 reader / writer with MIFARE classic passive card and transponder (tag).

4.2 *GSM Module*

GSM (Global System for Mobile) module is based on SIM900A Quad-band GSM/GPRS module. This module allows us to benefit from small dimensions and cost-effective solutions (Advance Technical Research, 2014),. It is controlled by AT commands, and fully compatible with Raspberry Pi3.

The principals GSM SIM 900A features (Wiki, 2017) are: operation temperature: -40 to +85; RTC supported with SuperCap; all SIM900 pins breakout; free serial port selection; short message service; control by AT commands; class 1 (1 W (AT) 1800/1900MHz), class 4 (2 W (AT) 850/900 MHz); GPRS mobile station class B; GPRS multi-slot class 10/8; Quad-Band 1900/1800/900/850 MHz. Fig. 14 shows the GSM SIM 900A module hardware components.

Fig. 14. GSM SIM 900A modul.

4.3. *Bluetooth module*

Fig. 15 shows the Bluetooth HC-05 this hardware.

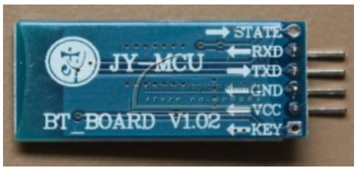


Fig. 15. HC-05 Bluetooth module.

The principals technical specification for HC-05 module are (ITead Studio, 2010): Working temperature: -20 to +75 0C; Dimensions: 26.9mm x 13mm x 2.2mm; Power supply: +3.3V DC, 50mA; profiles: Bluetooth serial port; security: authentication and encryption; speed synchronous: 1Mbps; speed asynchronous 2.1Mbps(Max)/160 kbps; sensitivity: ≤-84dBm at 0.1% BER; emission power: ≤4dBm (Class 2); Bluetooth protocol: Bluetooth specification v2.0 + EDR; frequency: 2.4GHz ISM band; modulation: GFSK (Gaussian Frequency Shift Keying).

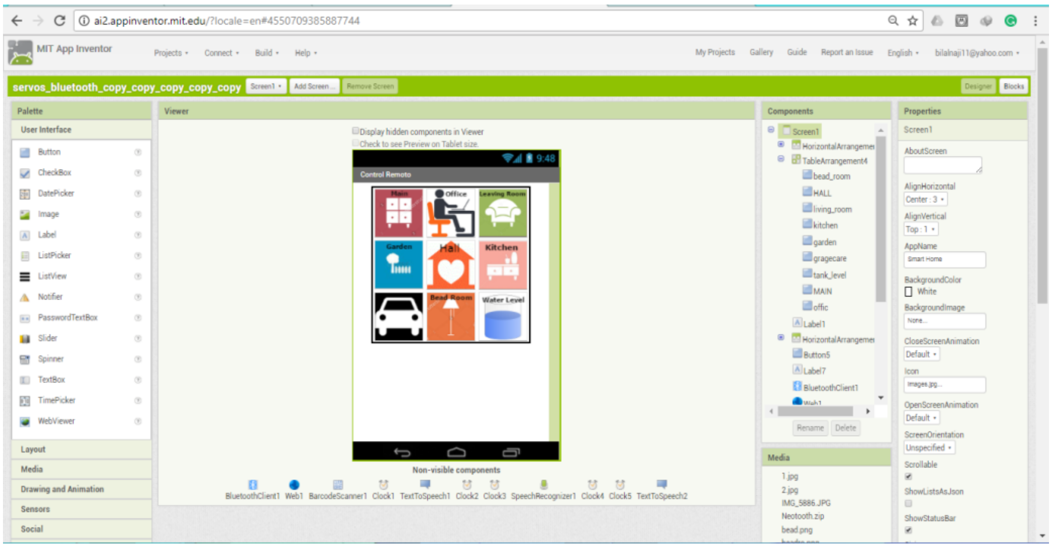


Fig. 16. Designing smart phone application for a Bluetooth system.

4.4 Message Queuing Telemetry Transport (MQTT)

MQTT is a light weight transport protocol that efficiently uses the network bandwidth with a 2 byte fixed header. MQTT works on TCP and assures the delivery of messages from node to the server. Being a message-oriented information exchange protocol, MQTT is ideally suited for the Internet of Things (IoT) nodes which have limited capabilities and resources.

MQTT was initially developed by IBM in 1999 and recently has been recognized as the standard by OASIS (Organization Advancement of Structured Information Standards). MQTT is a publish / subscribe based protocol. Any MQTT connection typically involves two kinds of agents: MQTT clients and MQTT public broker or MQTT server. Data that is being transported by MQTT is referred to as application message. Any device or program that is connected to the network and exchanges application messages through MQTT is called as an MQTT client. MQTT client can be either publisher or subscriber. MQTT server is a device or program that interconnects the MQTT clients. It accepts and transmits the application messages among multiple clients connected to it. Devices such as sensors, mobiles, etc. are considered as MQTT client. When an MQTT client has certain information to broadcast, it publishes the data to the MQTT broker. MQTT broker is responsible for data collection and organization. The application messages that are published by MQTT client is forwarded to other MQTT clients that subscribe to it. MQTT is designed to simplify the implementation on the client by concentrating all the complexities at the broker (Barbon et al., 2016). In MQTT there are four basics: Publish / Subscribe, Messages, Topics and Broker.

4.5 MIT App Inventor

MIT App Inventor is a Web application for creating Android apps with a blocks-based programming language. It was developed by Google's Mark Friedman and MIT professor Hal Abelso. The major goal of MIT App Inventor is to make Android programming easier to access for novices. Instead of needing to understand the Android framework and use complex Java syntax, novice programmers can build an Android application with visual drag-and-drop blocks.

MIT App Inventor consists of two editors: designer and blocks. In the designing, developers can design the user interface of an application by dragging and dropping components onto the screen. There are two types of components: visible components (such as button and label) which are shown inside a mock phone screen in the editor and no-visible components (such as camera) which are shown in a list under the mock phone screen (Fig. 16). Each type of component has a set of properties that developers can configure and a set of blocks that developers can use to control the behavior of a component. Fig. 18

shows designer smart phone application for a Bluetooth system like controlling a smart home.

Developers use blocks to control the behavior of the application. Blocks are an open-source JavaScript library to create a visual programming editor for both the web and mobile apps. It is being developed and opens sourced by Google. The blocks can be dragged and dropped onto the workspace, and connected with other blocks to form a complete logic. There are built-in blocks and component-specific blocks. The built-in blocks contain logic common to many programming languages, such as lists, conditions, and loops. The component-specific blocks contain the specific functions related to the type of the component. On the workspace, developers can move a set of blocks to any location by dragging them. They can expand and collapse a set of blocks so that they can customize the view of the workspace to work on a certain set of blocks. Also, they can enable and disable blocks. By disabling a set of blocks, this set will not be executed by the application. Fig. 17 shows blocks of the Bluetooth system controlling a smart home.

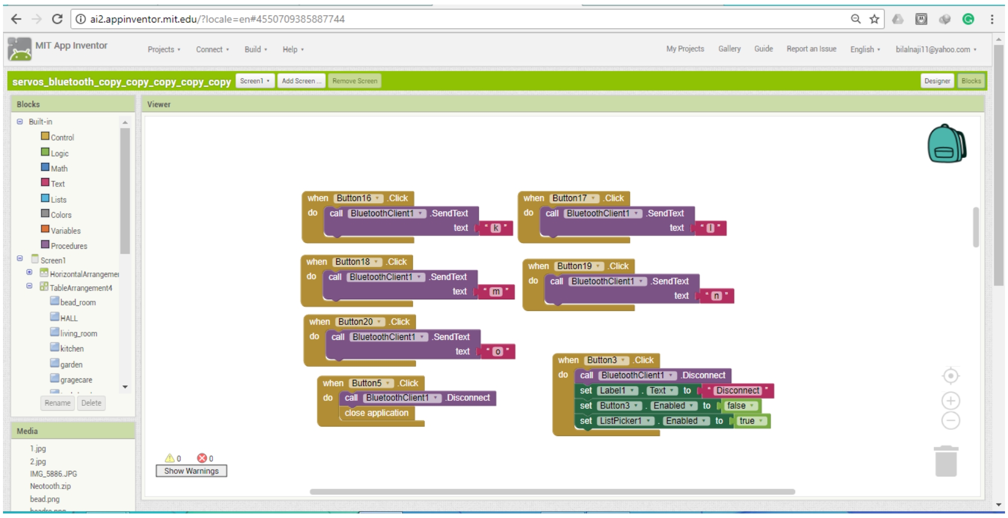


Fig. 17. Blocks used for a Bluetooth system controlling a smart home.

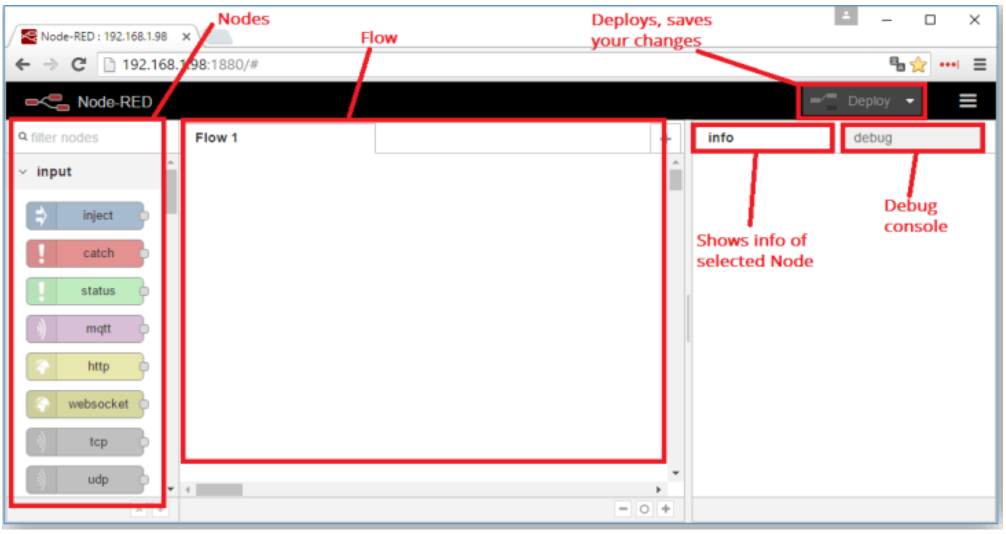


Fig. 18. Node-RED start page.

4.6 Node-RED

Node-RED is an open source application developed by IBM (International Business Machines). Node-RED is a powerful open source tool for building IoT applications with the aim of simplifying the programming component. It uses a visual programming that allows connecting code blocks, known as nodes, together to perform a task.

Node-RED (Fig. 18) is a visual tool developed for wiring IoT centric applications. Can be run on a large variety of hardware and software platforms such as Raspberry Pi, BeagleBone Black, Docker, Arduino, Android, IBM Bluemix, Amazon Web Services, and Microsoft Azure under Open Source Apache2.0license (Ray, 2017).

6. CONCLUSIONS

This paper presents the results of the bibliographic exploration that has been made in this research direction. Although relatively new, the scientific subject of the smart house (or intelligent home) benefits from several scientific reports published so far. It falls within the general field of Internet of things (IoT).

The bibliographic study allows to highlight the more significant reported results but also to define future and immediate research directions.

In the second part of the paper are reviewed some hardware elements in the market, first of all representative sensors and data communications modules and secondly some protocols and open source applications which can be integrated into a smart house control system based on a microcontrollers network.

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