A survey of various intelligent home applications using IoT and intelligent controllers

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Article Info

ABSTRACT

The tremendous development in technology used in our daily life was one of the most important incentives for researchers to add technology that is easy to use and useful in human life, an example internet of things (IoT) and systems of intelligence used in various fields. This article provides an overview of the smart home (SH) study of the Internet of Things as smart homes (SHs) have attracted great interest with communication technology advancements. The intelligent home is an Internet of Things technology that allows the monitoring and control of devices via the Internet using a home automation system (HAS). Followed by the justification for choosing the smart home and smart home engineering, and what are the most used communication protocols for smart homes, whether wired or wireless.

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1. INTRODUCTION

Internet of things (IoT) can be used in diverse fields [1], in the more productive industries [2], the smart home and smart cities [3]-[6], smart energy [7]-[9], vehicular communications [10], [11], intelligent farming [12], [13], intelligent interconnection of university buildings, logistics, and health care [14], [15]. The IoT enables the communication and exchange of data between various physical devices via the Internet.

Nowadays, people live in an internet-connected world with the majority of devices connected to exchange knowledge, consequently the world has come to be like a small town. The recent fast development of several Bluetooth, Wi-Fi, ZigBee, and 6LoWPAN technologies has made it convenient, easy and inexpensive to connect various devices to the Internet. IoT is composed of two sections: The first is the Internet, while the second is things. The Internet is a massive global network comprised of trillions of computers and other electronic devices, which enables users to use certain common protocols to access all information and everyone else on earth. Stuff contribute to communication with every individual. IoT uses a range of technologies, such as radio frequency identification (RFID), sensors, actuators, smartphones and support for computing cloud. By using IoT, People from anywhere can link anything and at any time to get service and information [16], [17].

The intelligent home has been described as a modern all-intelligence app. in residential management and "comfort, healthcare, protection, and energy conservation" [18]. The opinion adopted in this survey paper also indicates that two complementary viewpoints converge on smart home functioning: user-centred and equipment-centred, Based respectively on occupancy comfort and performance of building systems [19]. Throughout the first half of the twentieth century, the consumer approach for intelligent homes began and has

developed through the generations. The unit or constructing centre view was only achieved by developing ICT and developing intelligent energy infrastructure. In the past decade, the production of modern "intelligent devices capable of being accessed and controlled via remote applications. This network of devices and other products is built into sensors, circuitry, applications and networking.

The Internet of things (IoT) was renamed. In conjunction with a newly developed cloud computing system, it has led to a cloud-centred IoT solution for the development of intelligent home [20]. In recent years, intelligent homes have become more and more sophisticated. These systems have materials and methods for the sharing of knowledge and resources on all forms of appliances [21]. An intelligent home is an IoT domain that provides electronic, sensor, software and network access to a physical device network within a house.

Intelligent households are computerized systems with built-in monitoring and control devices, an example ventilation, heating, air conditioning and lighting. Modern networks with switches and transmitters with the central axis are also known as "gateways." Control systems, which provide a user interface and communicate with a smartphone, cell phone or computer; IoT manages network connectivity [22], [23].

Many smart homes (SHs) are available commercially and classified systems were classified into two broad categories: those that operated locally and those that operated remotely [24]. Users can monitor their home automation equipment with the help of a domestic controller equipped with both stationary and wireless communication technology (Zigbee, Bluetooth, and global system for mobile communication (GSM)). Users can monitor their homes remotely via the internet via their personal computers or mobile devices in the second group. However, the design of such automation systems involves a range of issues and should be considered.

The smart home must provide an easy-to-use interface to easily and efficiently install, track and manage home appliances. Furthermore, the automation device should be quick enough and provide a suitable data rate and a safe communication range, because these things are among the problems facing the SH to know the full potential of wireless technology [25]. The following are the seven parts of this paper: Section 1 provides a general description of the relevant works. Section 2 defines intelligent home and intelligence, why the intelligent home should be chosen, and smart home architecture. Section 3 discusses communication protocols and an overview of wired and wireless communication protocols. Section 4 talks about motivations for studying the intelligent home for the IoT. Section 5 is an overview of the challenges facing smart homes. Section 6 explains recommendations for the user to enhance acceptance and usage of SH app. Section 7 concludes with the conclusions of this study.

2. RELATED WORK

In the future, the internet of things is expected to take on an unusual pattern. This segment deals with previously conducted studies on SH in the context of the internet of things, a wide range of SH-based research. This study findings and recommendations help to clarify SH's advanced privacy practices and It is summarized in Table 1.

Table 1. Summary of the smart home systems

SH System	Controller	Indoor Control	Outdoor Control	Energy Manage-ment	Monitoring	Safety	Security	Smartphone	Real Implementation	PC	Wireless Interface
David et al. [26]	Arduino Mega	Yes	Yes	Yes	Yes	Yes		Yes		Yes	Bluetooth/WiFi
Ozeer et al. [27]	Raspberry Pi	Yes	Yes	Yes	Yes				Yes	Yes	Fog-IoT
Jabbar et al. [28]	Arduino Mega	Yes			Yes			Yes			WiFi
Davidovic and Labus [29]	Raspberry Pi	Yes			Yes			Yes			Bluetooth/WiFi
Kodali and Soratkal [30]	Node MCU	Yes						Yes		Yes	WiFi
Konidala et al. [31]	PC Server						Yes	Yes			RFID
Badabaji and Nagaraju [32]	PC Server				Yes	Yes				Yes	GSM/WiFi
Ganesh [33]	8051μc	Yes	Yes							Yes	GSM
Bhat et al. [34]	PC Server			Yes			Yes				WiFi
Gupta and Chhabra [35]	Galileo board	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Ethernet
Kaur et al. [36]	Arduino	Yes		Yes			Yes	Yes			GSM

3. SMART HOME

This segment offers a summary of intelligent home technologies. It begins with the concepts of SHs, and what is the intelligence of SH, followed by the justification for using smart home, and a general overview of smart homes designs.

3.1. Intelligent home description

The idea of intelligent homes first emerged as a wonderful home efficiency vision of the "homes of tomorrow" in the 1930s [37]. Many promises of 'unprecedented comfort, Relief and complacency and advantages of modern household life have only been accomplished in the last few decades of the last century. At the same time, the focus on domestic efficiency has increased to energy efficiency. Darby [19] describes two key concepts for smart homes: home and user-focused, which defines intelligent houses as very automatic housing of integrated devices, with the emphasis on modern techniques, comfort and (domestic) quality.

Building and system centred in building energy efficiency, auxiliary services and generation of distributed electricity, and how information and communication technology can be used to address them. The author notes that both terms share the significance of communication. for the connection of devices and remote access/control and the provision of services [19]. Figure 1 is an example to illustrate the intelligent home concept.
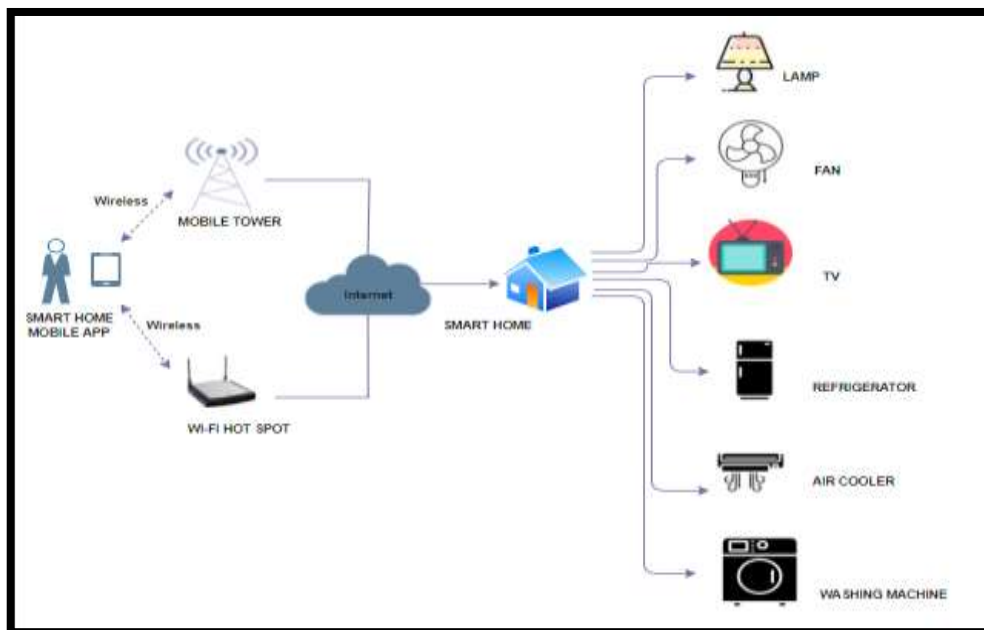

Figure 1. Is an example of the SH concept

3.2. What does the intelligence meam?

When speaking of intelligent houses, one should too think of how to describe "intelligent" or "smart". What distinguishes an intelligent home from a traditional home in which most of us live? Based on Edwards and Grinter [38], smart environments and omnipresent computing intelligence have four features:

a) The environment uses sensor information to assess the current situation (For eg, if you have triggered a motion sensor detector, it means somebody has to get near).
b) The thing can presume state while taking into account a variety of factors at once (e.g. the machine can determine that it is time for dinner if the table includes several persons).
c) By evaluating the situation, the environment will forecast a user's intentions (e.g. if motion detectors are installed in the future, it means that the consumer goes through the corridor and the user will want his or her path illuminated).
d) The environment can behave preventively on the basis of purpose (e.g. the device can opt to switch the lights in advance so that the user may walk easily).

3.3. Why the SH?

The integrated illumination control system is one of the advantages of SH. The user no longer needs to turn electrical appliances on or off manually. There are two different choices, for instance, if the person enters the bedroom: either the lighting automatically on and off after user exits the room or the user is able to control the software switch on his smartphone. The light luminosity also may be managed to reduce power consumption. Also, based on sensor readings, users can adjust room conditions (humidity, and temperature)

such as regulating the fan speed from their mobile app or automatically changing the fan speed according to room temperature. This will help boost energy efficiency because, if the electrical appliances are turned off automatically or readily if they are not used, it decreases energy usage and power bill costs.

The user may also use a smartphone, tablet or computer to control electrical equipment and monitor the house conditions. For instance, if the user forgot about turn off the fan and has entered his office, he can turn off the fan by using his intelligent device. The user can also mount flood sensors, carbon monoxide, smoke, to warn users if their homes are inundated or whether air is unsafe, so they can only sit at home.

The user receives an alert on the phone for a safety system if an incident occurs. If there is an intruder, no need to worry from the owner because the homeowner can monitor the motion sensor from the smartphone and the alarm continues if any motion is detected. The security system is the main element of safeguarding the houses against intruders. By installing wired surveillance cameras to prevent a burglar from entering the house. All intelligent home components, such as air conditioning, ventilation, heating, central illumination, automated devices and a safety system, can offer comfort and protection in everyday life [28].

3.4. Intelligent home design
At least a few things, including sensors, equipment or actuators, are in an intelligent home that is not inherently intelligent on its own. A sensor generates data but does not contribute to the value of the home environment on its own. For instance, if the homeowner is needed to change the temperature to external temperature, moisture and other variables, a thermostat is not deemed clever. It can hold the temperature constant, but automation is not "intelligence." Only by collectively storing and analyzing all data on the environment, extracting trends and decisions taken without user interference can an environment be considered intelligent. The design of a smart home is based on how devices communicate, how and where the data from sensors and use patterns are stored, how Knowledge and patterns are interpreted and collected and how the user communicates with the devices and how the devices communicate with the user.

Soliman *et al*. [39] developed an intelligent home device architecture, actuators and sensors are attached to a microcontroller and are used to gather environmental data and carry out some acts. The data is transmitted from the microcontroller allowed by the ZigBee technology to the central server. The server then uploads the data through an application-programming-interface (API) to the cloud storage. A backend server, Storage and app in the front end are included in the cloud solution. The data is back-end processed and analyzed (Google App Engine). The user is able to view and manage the environment with a web application. The architecture proposed by Cook *et al*. [40] was made up of controllers (servers for computers), sensors (door/temperature/motion/light sensors), and relays (actuators). The communications layer is Wireless technology-based including ZigBee wireless network. A publish/subscribe pattern is the basis for the middleware layer. Jie *et al*. [41] suggested an architectural model addressing the scalability problem. The proposed model with a standardized interface allows devices to be connected to or removed with little effort from the intelligent home infrastructure. In [42] Hosek *et al*. define the Technology and hardware specifications of an intelligent Gateway to Home. Guoqiang *et al*. [43] suggest an intelligent house portal architecture that can be configured for approved communication protocols and convert Heterogeneous sensor information in a consistent format. Figure 2 shows the general intelligent home architecture.
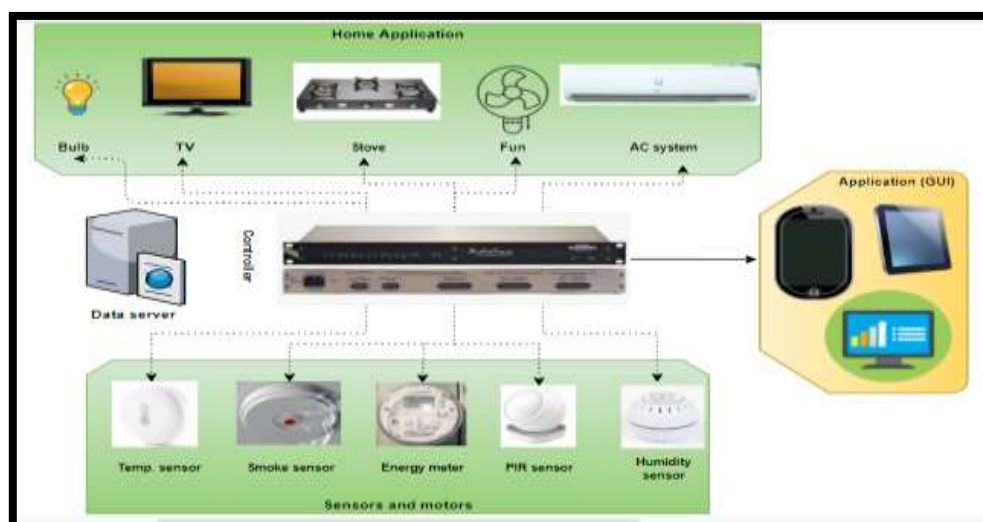

Figure 2. An example of the intelligent home architecture

4. PROTOCOLS OF CONNECTIVITY AND COMMUNICATION

Devices must be linked to share information in an intelligent home environment. Intelligence (as previously stated) occurs when the environment is aware of the system's current state. To accomplish this, a single sensor is insufficient to collect useful data; therefore, multiple sensors are needed to communicate and increase the usefulness of the data gathered. The communication protocols are used to decide how these devices and sensors can interact. These protocols determine how companies and collaborators exchange information with requirements, hardware and licensing protocols. Communication protocols are typically classified into three main media groups: 1) hybrid, 2) wired, and 3) wireless.

Some protocols provide longer distances, while others provide stronger protections, while others reduce energy consumption. The choice is often dependent on the size of the network. Personal area networks (PAN) and local area networks (LAN) are widely used within a smart home body area network (BAN). A comprehensive comparison of multiple home area network (HAN) communication technologies is given in [44]. The remainder of this section offers a summary and recommendations for selecting the most popular and evolving communication technologies (wired and wireless).

4.1. Wired protocols for communication

Wired communication involves the information transmission via a wired media. It's one of the earliest methods of data transmission from electronic telegraph was used to send messages.

Advantages	Disadvantages
1. Safety: As a connection to a network involves a cable to physically link the device, it is almost impossible to spy or tamper from external communication networks.	1. Mobility: it is not possible to adjust the position of the device when the cables are installed without rewired or extending the wire.
2. User-friendly: a network connection is as simple as a cable connection to the device; the correct network doesn't need to be chosen from the list of entries of networks or passwords, as with wireless networks.	2. Power: Wired networks normally require power; when power is cut off, the network can not operate on a battery in a critical condition, as the wireless network may.
3. Distance: wired data transfer goes beyond the normal wireless protocols (Wi-Fi 802.11ac); issues like interference or obstacles would not impede the transmission of wire cables in the encircled media.	3. Expansion: expanding the wired network coverage is not simpler than installing a Fresh wireless modem, cabling and external hardware (hubs) might be required.
4. Data rate: Ethernet potential data rates over 100 Gbps, whereas Wi-Fi 802.11ac's maximum theoretical rate is 1.3 Gbps.	4. Complexity and Cost: professional works and preparation for the wired network; when a smart house is constructed, installing a wired network otherwise running cables through cables will later become a boring task, and can be a little unpleasant.

4.2. Wireless protocols for communication

Wireless communication does not require sending and receive information via RF signals using wires. Due to easy usage and reduced network configuration setup and implementation costs of new devices, wireless communication protocols are becoming common within SH networks. There are many wireless protocols, Table 2 summarizes the main features of the wireless protocols most commonly used in intelligent homes.

Advantages	Disadvantages
1. Mobility: because the connection of a device to a network requires no physical connection, it is possible to move it without losing connectivity; it is also simple to move the device through another wireless network.	1. Protection: Although existing encryption mechanisms are solid, packets are interceptable, and maybe decrypted (although it may be extremely unlikely); most security problems occur in the absence of a proper configuration if the wireless network is not secured in any way.
2. Expandability: it is easy to add additional devices to the network When the maximum approved system number is not surpassed; it is easy to scale up or down wireless networks if necessary at no or minimal cost.	2. Data rates: theoretic wireless networks do not have wired networks (e.g. Ethernet or MoCA); however, for most smart home applications, data rates are also adequate in practice.
3. Costs: it is very easy to create a wireless network, even without professional support.	3. Interference: interference-prone wireless networks may interrupt or Affect network service efficiency.
4. Flexibility: Creating a wireless network in a new location is as simple as the power supply connection of the system; this enables experimenting with new technologies or the placing of sensors.	4. Coverage: wireless networks ideally provide More coverage than wired networks in a specific domain, but barriers or poor positioning can limit coverage and lead to command/message loss.

Table 2. Wireless protocols of communication

	Bluetooth	Bluetooth LE	Wi-Fi 802.11n	Z-Wave	ZigBee	6LowPAN
Encryption	AES-128	AES-128	WPA2	AES-128	AES-128	AES-128
Data rate	0.7-2.1 Mbps	2 Mbps	450 Mbps	10-100 kbps	20/40 kbps, 250 kbps	10-40 kbps, 250 kbps
Frequency	2.402-2.48 GHz	2.402-2.48 GHz	2.4-5.8 GHz	868/915 MHz	868/915 MHz, 2.4 GHz	868/915 MHz, 2.4-5 GHz
Network Topology	Star	Star	Star, tree, p2p, mesh	Mesh	Star, mesh, cluster, tree	Star, mesh, p2p
Network size	8	N/A	Thousands (mesh)	232	65.536	250
Range	15-20 m	10-15 m	10-100 m	30-50 m	10-100 m	10-100 m

5. MOTIVATIONS

The advantages that use intelligent home apps based on clear because energy conservation is critical for both the home and health care, in particular the elderly, and the cost of basic home needs, entertainment and comfort is reduced. The benefits are listed in four categories [45]-[48] in Figure 3 summarizes the most important incentives for studying the smart home.
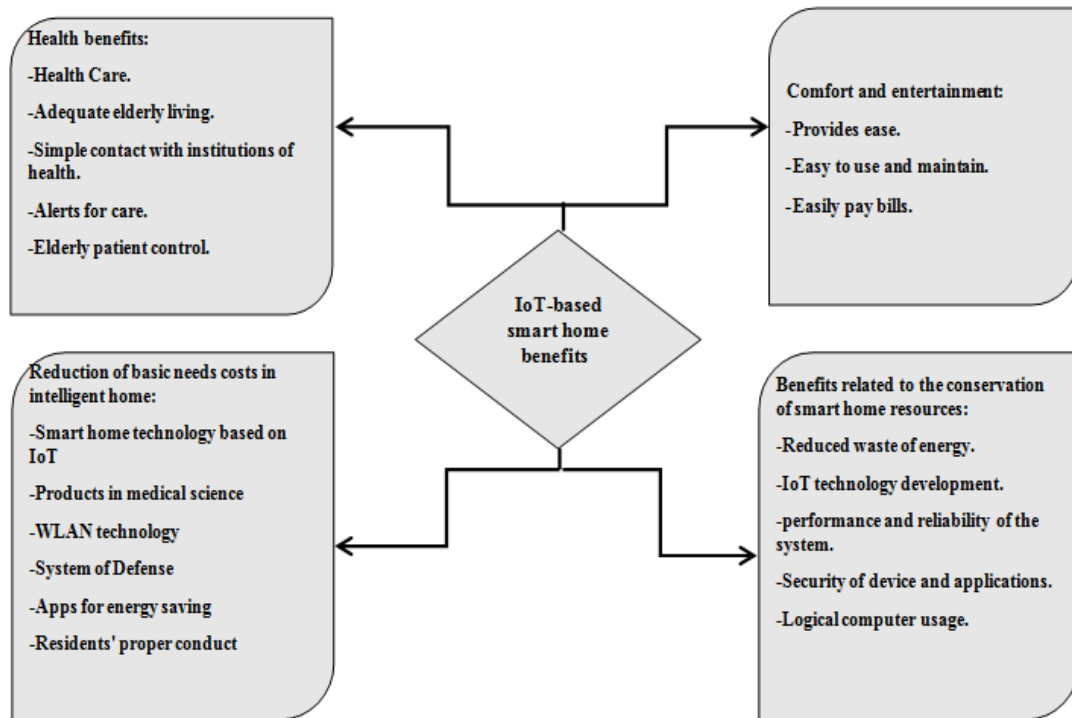

Figure 3. Classifications of advantages of IoT-based intelligent home apps

6. CHALLENGES

There are various advantages of the smart way of smart home applications oriented to the Internet of things, however, these systems are not suitable solutions for connecting telecommunication networks. The survey showed that researchers are concerned about the nuances of smart operation in IoT-based SH applications and their use. Users face obstacles to the high cost of smart systems and the difficulty in maintaining them, unfriendly user interfaces, and most users do not take into account safety and security, restrictions on wired and wireless technologies, In addition to the challenges of energy management, data transfer, and healthcare. Figure 4 Summarizes the main obstacles that users face based on the smart home application method [45].
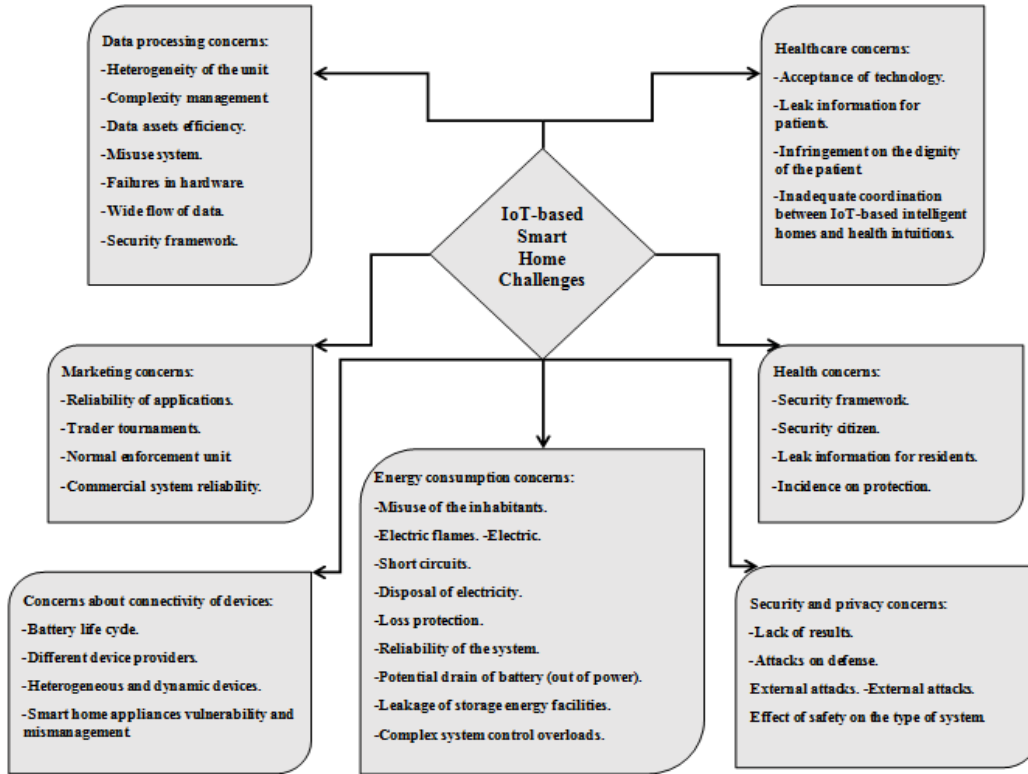
Figure 4. Challenges groups based on IoT intelligent home app methodologies

7.   RECOMMENDATIONS

This section summarizes the literature recommendations most relevant to mitigating challenges and promoting the safe and successful use of smart home technologies such as IoT-based devices and sensors. There are recommendations for the user in terms of behaviour, energy consumption and device breakdowns, and safety and security recommendations to protect against external attacks and the entry of hackers [49]-[51] in Figure 5 explains the recommendations that the user should observe in SH systems.
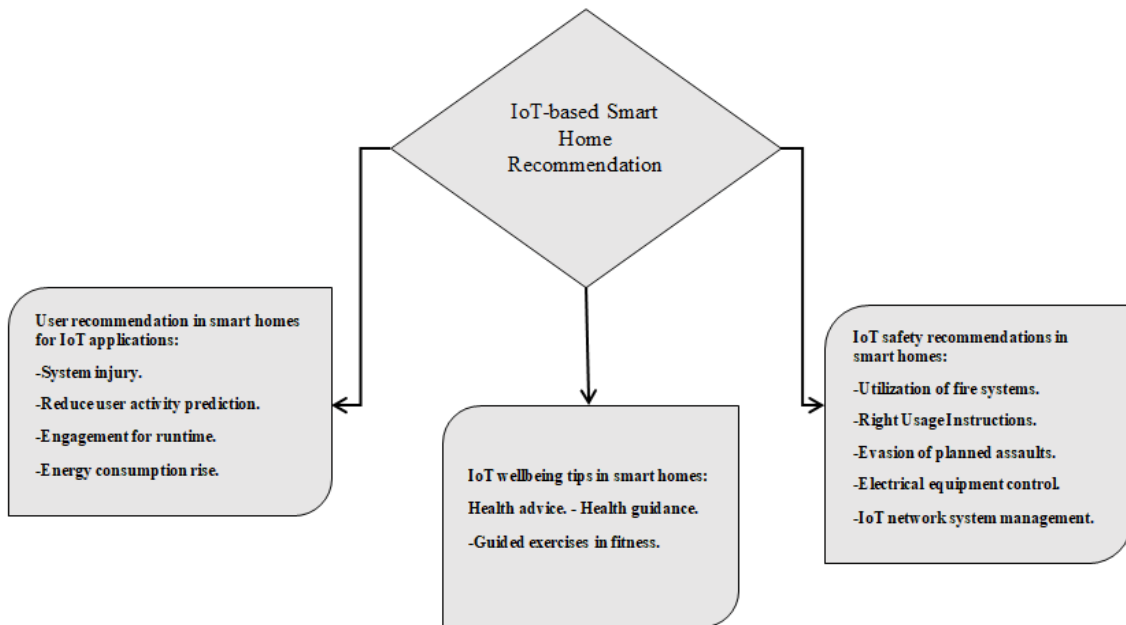

Figure 5. Recommendations groups for IoT applications in intelligent homes

8.   CONCLUSION

Recently, there has been a major emergence in the use of the intelligent process of Internet of Things applications in intelligent home technology. Although further research is being conducted, the descriptions and limitations associated with them continue to be ambiguous. This review paper focuses on the various studies of the IoT and intelligent systems, and what are the motivations that incentives us to study the smart home, in addition to discussing a different type of challenges facing smart homes, and finally, recommendations for increasing smart home application acceptance and use.

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