Comparative study of Smart Home Management

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Abstract - Smart homes can help to improve the quality of lifestyles by making life more intelligent, luxurious and better for communities and productivity by controlling their home tasks. In the process of designing a smart home some criteria need to be considered for the householder needs.

There are many smart home models that show how householder can use various applince such as lights, door locks, and security systems in the home according to the homeowner's motives for comfort, safety, economy, and joy.

This Research compares smart home models to extract techniques, Hardware and software and show the applied benefits and limitations that have been overcomed in each, and compares most popular smart home models to show how models can manage to overcome these challenges, and implement beneficial factors.

Keywords— Smart Home, Home Automation, Sensors, Smart home benefits, Smart home Limitations

1. Introduction

Enhancing the intelligence level of the living environment and improving the quality of lifestyle for a human is important. Smart home environment in which computing, and communications technologies are employed for the use and control of different home appliances remotely or automatically to improve the resident's quality of life.

when building smart home systems, the user aims and needs should be considered, depending on the purpose (e.g., home safety, smart Economy management, automated household, appliances control, Health monitoring) and type of services provided through a smart home, the domain aim is determined for each one of them includes a variety of service function.

The researcher made a comprehensive analysis of the literature to identifying challenges, limitations, and beneficial factors for smart home management .There are common benefits and limitations in smart home systems, some of the systems were able to achieve some of the benefits and overcome a number of limitations.

The scope of this research was comparing models according to their ability of achieving the benefits and overcoming the limitations.

This paper is organized as following:

This article is arranged as follows. Section 1 interviewed the Smart home technology Then; Section 2 describes research trends of smart home solutions have recently focused on achieving the householder's goal. Section 3 proposes a smart home definition. Section 4 presents Benefits of Smart Home technologies Section 5 presents Smart home Limitations Section 6 presents a comparative analysis. Finally, the conclusion is drawn in Section 7

2. Problem definition

Determining the purpose of building a smart home, the household's needs in a smart home, and classifying smart home devices in proportion to this need is a major point of contention between the smart home supplier and may lead to a disagreement in the homeowner's point of view or the expectations of the head of the household.

3. Related work

Smart home solutions have recently focused on achieving the householder's goal of purchasing a smart home through the services offered through a range of smart home solutions.

However, in real-world environments, each solution faces many challenges to achieving benefits and overcome limitations.

There are many works that have proposed aim safety for smart home by using various tools to develop and control the home appliances.

Paper [1] present safety through developing a wireless remote control for elderly to control appliances Using voice command by using Hardwar - Node MCU V3 - ESP 8266 and Software -google assistant -Blynk App- IFTTT overcome -User acceptability -interoperability and can gain befits - Remotely accessed - Healthcare improvement and miss (Quality of lifestyles -Inner security-Energy efficient -Remote Accessibility -make aging in place possible system (AAL) - surveillance and property security) and not tack in view ((Scalability and Extensibility-Universal Platform- Extracted Data- Ability to Learning- Security, Risks and Privacy (cyber security) - Cost)

A secure smart home by using blockchain and hardware ESP32 Presents in [2] a humidity - temperature

sensor, buzzer alert, a LED – relay with software RESTful API- Espruino- Unix HTTPs- consensus algorithm (PoW) overcome -Remoting accessibility (website- Mobile App) gain User accessibility (web services and RESTful API).

Safety by Implementation of home automations using MQTT broker and hardware present in [3] as Raspberry Pi TP-link, LG smart TV, Wi-Fi LED and software openHabian gain -Remotely accessible Available on google platform. Energy efficient intelligent monitor for energy consumptions overcome -user acceptability Web interface and smart phone and voice command (Amazon Alexa) and user can modify the interface according to their preference, universal platform It accommodates most kinds of smart home devices and deal with many platforms such as windows and Linux, scalability and extensibility It accommodates any number of devices with single interface.

And another works that have proposed aim economy for smart home by using various tools to reduce expansive cost the smart home.

Economy for smart home a flexible, low cost and scalable smart home automation system presents in [4] that apply specific techniques to lower power consumption by using Arduino technology and Wi-Fi connections And using sequence algorithms to reduce the power consumption using hardware -Arduino Mega 2560 -Node MCU microcontroller -ESP 266 -ZMPT 10T and -SQL database -ZigBee - google fire base as software and can gain -Energy efficient Reduce power consumption using predefined algorithms -Remoting accessibility Remotely accessed website through limitation -User accessibility Using google firebase as a website server -Extracted Data Not all data collected is saved as it only saves critical data. -security, risks, and privacy Password accessed website and has an alarm system and encrypts data collected from every appliance.

And another works that have proposed aim combine safety & economy for smart home by using various tools to reduce expansive and achieve safety the smart home.

Safety & Comfort Implementation of home automations Building models and prototype in present [5] By using blockchain and hardware Raspberry Pi 3+, ESP8266-12F, Humidity and temperature SHT31- PIR Sensor D203B PIR and software Hash Algorithm 256 (SHA-256)- HTML-JavaScript-CSS programming and gain Surveillance and property security (automated burglar alarm system, guest attendance monitoring) and overcome user acceptability (through website & application) security and privacy Build systems based on Hash Algorithm 256 (SHA-256, Webserver using for encrypted username, password, and token)

Safety & Comfort through reduce energy costs present in [6] by adapting consumption to variable pricing over the day by using data-mining (A pattern-detecting method) and DHOMUS platform- MATLAB- K-nearest neighbors to gain -Remotely accessible- Energy efficient intelligent adapting energy consumptions and overcome -user acceptability (through (RHOMBUS) platform which developed by ENEA) Scalability and Extensibility (capable of overseeing most sensors installed in the home and monitoring consumption in real time).

And another works that have proposed aim combine safety, economy, and comfort for smart home by using various tools to reduce expansive, achieve safety and joy by using smart home appliance.

Safety & Comfort& Economy through providing a safe and stylish home present in [7] by representing an architecture of home automation for both short-range and long-range utilizing multiple communication technologies by using Chirp Spread Spectrum (CSS) hardware server-based LoRa gateway, and Bluetooth connectivity- Node MCU- RYLX 400 - Bluetooth module - 5 V DC supply Source- Relay and software Android Studio, Android mobile application and gain - Energy efficient - Remotely accessed (radio communication using LoRaWAN technology, mobile application and Bluetooth connectivity) and overcome User Acceptability (Android application) Scalability and Extensibility (Tested on nearly 100 million devices in 100 countries) Universal Platform (It was applied to many kinds of devices) Cost (Low cost of use and low power wireless platforms).

Economy & Safety Reducing energy consumptions present in [8] by improving daily habits in smart homes using Deep Neural Network and mobile applications, hardware Raspberry Pi 3 software Azure, TensorFlow, python3, windows10, NumPy, Pandas - Quality of life Activity recognition to create patterns.

It controls HVAC devices and improve daily habits - Energy efficient Forecast the energy consumptions on patterns of the residents -Healthcare improvement-AAL Detect possible hazards. -user acceptability intelligent platform and simple mobile app security and privacy Build systems based on Microsoft accounts authentications provider and OAuth2.Extract data means extraction from fourteen different sensors in real time and data stream without the need of labelled data -Ability to learning Adjusts its model in real time based on the collected raw data. Interoperability is a large part of the appliances and devices domestic.

Safety& Economy present in [9] by Building automation systems and attacking train models using REST API, Mobile application and web interface gain remote accessibility Through internet or local storage to overcome -user acceptability Web interface, mobile application security, risks, and privacy Identify attack threading for acquiring access to actuator or System control units.

Safety & Comfort & Economy present in [10] through Building a cost-effective and energy-saving smart home automation system using hardware Raspberry pi, ESP8266, ADSL, Wi-Fi modem - Temperature Detector (RTD)- ADS1115(Analog-to-digital converter), PPG101A1 Temperature Detector (RTD), Hall Effect and software Linux operating system, Net Beans IDE, Eclipse (integrated development environment (IDE)) and gain - Energy efficient, - Remotely accessed (Wi-Fi-TCP/IP-

MOBILE APP) and overcome User Acceptability (Smartphone application), COST (low-cost Wi-Fi module with TCP/IP stack)

There are many definitions of the smart home that have appeared recently, including:

The new smart homes concept are not just homes with smart devices, they are homes where all the devices

4. Smart Home

inside interact with each other to find the best plan of lowering the cost of the consumption and avoid risk for better healthcare.

Smart Home devices are divided into smart appliances, security, control and connectivity, home entertainment, energy management, and comfort and lighting [11].

5. Benefits of Smart Home technologies

Smart Homes make the lives of residents of housing better and improve their Quality of Life by controlling and connecting the lighting, heating, air conditioning, smart TV and sound systems, washing machine, fan and many other electronic devices to provide the home user with the power to monitor or control their home task and promote quality of life, convenience, independence, safety, economy, joy and comfort for ordinary people and special need depending on the user's personalized.

A. Quality of lifestyles

In general, smart home technology has several essential benefits that make the lives of householders better and improve their quality of lifestyle by controlling and connecting many electronic devices to provide the householder with the control or schedule for managing home task or daily life information and enhance depending on the householder personalization and aims [12].

B. Energy-efficient

smart home systems proposed methods to energy efficiency in many ways like monitoring the status of the smart home appliance, operational costs and analyzing patterns, generating rules, and discovering householder preferences and habits [13].

Smart homes have many ways like Setting schedule appliances according to the period of non-employment, correlation mechanism and computational intelligence [14].

Smart homes can save expenses by optimizing their Electricity Bill (EB) values by taking advantage of the difference in electricity prices in different periods through many factors including (PAR) which indicates the ratio between the maximum and average energy demand in the peak period Without compromising user comfort (UC) which can be measured by Wait Time Rate (WTR) and Capacity (CPR) [15]

The system has helped smart homes to reduce consumption by using the thermostat programmable is capable of setting schedule according to the period of non-employment home smart and associated with the local climate.

C. Inner security

Smart Home management provides the householder with the ability to monitor or control their home tasks or active emergency response service using a combination of hardware technology with different types of sensors like Window/door, gas leak, water flow, rain, smoke, carbon monoxide and fire. With the help of the sensors and microprocessors and through the smart dashboards to provide a secured home.

D. Surveillance and property

Security a smart home can provide better security by integration with surrounding cameras would improve home householder luxury and security by keeping check the inner and outside surroundings of smart homes and can detect actual crime in real-time without human intervention [16]

E. Healthcare improvement

A smart home can improve healthcare and record the householder's health conditions by providing various services like Life service, Health Management, Safe Care, Spiritual Entertainment, Assisted Living (AAL) and Aging in Place (AIP) according to the Elderly Demands aspects, and the special requirements for each of them.

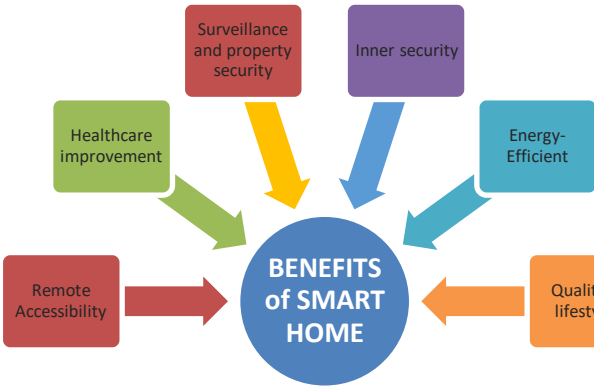
The smart home systems should make full dynamic real-time information exchange between smart home systems, the government, and medical staff, enterprises, social organizations [17].

Smart Home management systems should use passive health monitoring useful for early diagnosis of diseases using various types of sensors and microprocessors to monitor human condition such as respiratory rate, blood glucose, gait, blood oxygen and heart rate or use navigation and localization with wearable devices as an alert for occupancy detection, occupancy detection the fall [18].

F. Remote Accessibility

A smart home that has remotely monitored and controlled sensors set of activities is modified, reshaped by controlling various devices such as TV, air conditioning, washing machine, washer, infrared light, and fan from outside home [19].

Smart homes provide the householder with the power to monitor or control their householder tasks via mobile devices and computers and web browser from a distance location or from a remote location [20].



- *Figure 1 : BENEFITS of SMART HOME*

6. Smart home Limitations

Although smart home technology has been recently used in a wide range of areas, there is a lack of research that has addressed the issue of how choose the correct mix of smart home devices and techniques, which are fit depending on the user's personalized and purpose.

The market contains many solutions for building smart home systems home but is far away from meeting householder expectations, acceptance, and performance expectancy, which required new methodologies for managing the adoption of smart homes and analysis of measurement factors about why it is not widely used for households especially on decision-making systems for smart home management.

A. User Acceptability

User acceptability for smart home services depends on a range of factors, and service providers need to consider these factors to provide services that are acceptable and meet the needs of their householder.

a house that has remotely, monitored and controlled sensors are very different from a house that does not has these capabilities because this set of activities is modified, and reshaped so that ourselves such changes the relations of power and control in the family.

one of the most efficient analysis measurement factors is extracted Acceptance Model for householder factors which shows the degree of meeting the desires and needs of the householder.

Acceptance Mode use PU as (The degree to which the householder believes that the smart home system helps him in performing his daily work) and PEoU as (The degree to which the intelligent user is convinced that the system is not a physical or mental effort on him) in addition of extract Innovation Diffusion Theory (IDT) factors (compatibility, complexity, trialability, and observability) and) in addition of extract Consumer perceived innovativeness factors innovativeness effects) in addition of extract Perceived cost factors cost impacts [19].

Many factors like abbreviation Answer Number, Perceived usefulness, Perceived ease of use, Compatibility, Trialability, Observability, Intention to use Perceived Cost, Consumer perceived innovativeness use of the value of standardized root mean square residual (SRMR) affecting in users' acceptance of services which provided through the smart home [20].

Overall, the acceptability of a smart home service by householder will depend on how well the service meets the needs and expectations of the householder in terms of user-friendly interfaces, clear instructions, simplified installation, security, Privacy, compatibility, Interoperability, cost, customizability, reliability, ability to learning, ease of use and support.

in commercialization factors such as perceived usefulness and service quality of use have important determinants it directly Impact the sustainable use of smart homes by increasing the satisfaction rate and sustainable development of the smart home industry [21]

B. Scalability and Extensibility

The ability to grow in size and add new points and devices or replace existing points and devices and the possibility of changing functions without leading to a bad impact on the performance of the system or changing the core system [22]

Some systems may have a limited number of devices or nods by adding a new device or a new type to a home network may cause inconsistency in the data or the transmission rate between applications, so the system may be vulnerable to data overload or data inconsistency or transmission rate issues between applications, which leads to delays in decision-making.

C. Universal Platform

Research shows standards providing requirements and specifications on the implementation of smart homes and the assessment of the performance of the smart home management system's specific decision support are limited and do not have a standard platform and application programmable interface that makes it difficult for the householder to connect and integrate different devices and systems [23].

D. Interoperability

One of the most communication constraints is power consumption, battery life, distance communication, congestion control mechanism and integration with various devices so some protocols are specially designed for battery-powered devices, providing small power consumption for devices like MQTT and some protocols work with all types of IoT applications and some small distance communication like ZigBee [24].

There is no one-size-fits-all solution to communication constraints in smart homes. the selection of communication protocols is a critical consideration for the development of smart home systems. By selecting the appropriate communication protocols based on the specific requirements and constraints of the system, developers can help to ensure that the smart home system is efficient, reliable, and effective.

E. Extracted Data

Some sensors can broadcast data every 200 milliseconds, and smart home systems can have an average number of sensors in a is 150, which can cause huge data volumes.

One of the main limitations is capturing, storing, transmitting, searching, correlating and analyzing sensor data while the characteristics of this data contain many difficulties such as uncertainty, redundancy, unpredictability, massiveness, or determination of data redundancy and may also come from different types of technologies sensing [25].

moreover, smart homes are becoming smarter, more complex, interconnected, and dependent on each other, and the householder becomes completely dependent on them, which can create major problems [26].

Hargreaves and Wilson framed the interoperability limitation in three dimensions: compatibility with non-smart home devices and appliances, compatibility with householder habits and routines, and compatibility with existing support systems [27].

F. *Ability to Learning*

Smart home devices should be able to detect and learn from householders, behaviors and provides suggestion according to user needs and communicate with each other to do actions based on roles and relationships by simple configuring them.

In addition to that, the ability to learn and recognize user activity and creating a pattern so that an alert is made when a change occur and the pattern is broken and on the other side it could create a better habit pattern for the user which provides better security and improve health.

G. Security and Privacy

The connected devices should connect in a secured way by using the user's authentication/authorization through many processes (user registration, device registration, user sign-in, controlled remotely) [28].

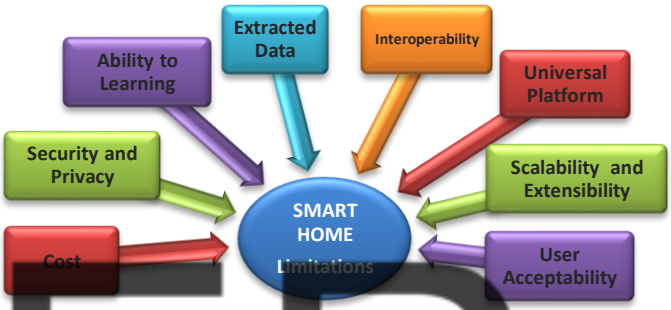
There are many functional, security, privacy and Risks Associated with requirements for a good smart home system: -

- Communication protocols
  There are a lot of open communication protocols which do not rely on cryptographic mechanisms that maybe lead to the system becoming under attack.
- Security Risks
  like Device scanning attack, Device spoofing attack using smart home devices is associated with many security breaches. [29]
- Privacy Risk
  This is a risk if this data is leaked to a third-party service provider thus, the system must authorize the right user only and provide the appropriate access to this data [30].

H. Cost

Several studies have identified the perceived cost of smart home technology as a significant barrier to adoption. For example, a study by Nikou (2019) found that perceived cost had a negative impact on users' intentions to use smart home technology. Similarly, a study by Hsu and Lin (2016) found that perceived cost was a significant factor in determining consumers' attitudes toward smart home technology.

cost is one of the most important factors that impact antecedents of the intention to use smart home technology that a perceived cost will have a negative impact on intent to use [20].



- *Figure 2: SMART HOME Limitations*

7. Comparative Study

A comparative study was conducted for several research papers by taking group of the householder aims , benefits and needs into consideration, and the impact on the family head's intention to buy a smart home. between 10 research papers were compared based on the degree of achievement in buying a smart home and evaluating them based on how well it fulfills the goals of comfort, safety, economy and joy.

Aims (comfort - safety - economy - joy) and Limitations (Cost -Security and Privacy - Ability to Learning - Extracted Data -Interoperability - Universal Platform - Scalability and Extensibility - User Acceptability) and Benefits (Remote Accessibility-Healthcare improvement-Inner security-Energy Efficient - Quality of lifestyles-surveillance and property security) these are the points of comparison that has been collected by reading several papers about developing smart homes. 10 of the most successful research papers were compared according to there degree of achieving these points .

Table 1 Gives an overview of this research and highlights the difference Techniques, Software and Hardware to the papers

Table 1 Summary of recent smart home Comparative Analysis

R	Year	Motivation	Aim	Techniques	Hardware	Software	Applied Benefits	Limitations that are overcome
[1]	2020	Safety	Developing a wireless remote control for elderly to control appliances	Using voice command	-Node MCU V3 - ESP 8266	-Google assistant -Blynk App -IFTTT	**-Remotely accessed** Using mobile phones - Healthcare improvement ease the life of elderly and disabled and make them feel less of a burden	**-User acceptability** Using voice command **-Interoperability** Small power supply
[2]	2020	Safety	Presents a secure smart home	blockchain	ESP32 - humidity - temperature sensor, buzzer alert, a LED - relay	RESTful API-Espruino-Unix HTTPs-consensus algorithm (PoW)	**-Remoting accessibility** (Website-Mobile App)	**-User accessibility** (Web services and RESTful API)
[4]	2021	Economy	Presenting a flexible, low cost and scalable smart home automation system that apply specific techniques to lower power consumption	Arduino technology and Wi-Fi connections and using sequence algorithms to reduce the power consumption	- Arduino Mega 2560 - Node MCU microcontroller - ESP 266 - ZMPT10T	-SQL database -ZigBee - google fi	**-Energy efficient** Reduce power consumption using predefined algorithms. **-Remoting accessibility** Remotely accessed website.	**-User accessibility** Using google firebase as a website server. **- Extracted Data** Not all data collected is saved as it only saves critical data. -security, risks, and privacy Password accessed website and has an alarm system and it encrypts data collected from every appliance.
[8]	2019	Economy - Safety	Reducing energy consumptions by improving daily habits in smart homes	Deep neural network and mobile applications	-Raspberry Pi 3	-Azure -TensorFlow -python3 -windows10 -NumPy -Pandas	- Quality of life Activity recognition to create patterns. It controls HVAC devices and	**-user acceptability** intelligent platform and simple mobile app **-security and privacy**

							improve daily habits. - Energy efficient Forecast the energy consumptio ns on patterns of the residents - Healthcare improveme nt -AAL Detect possible hazards.	Build systems based on Microsoft accounts authentications provider and OAuth2. -Extract data Data is extracted from fourteen different sensors in real time and data stream without the need of labelled data **-Ability to learning** Adjusts its model in real time based on the collected raw data. **-interoperability** Large part of the appliances and devices are domestic
[9]	2016	Safety-Economy	Building automation systems and attack train models	REST API, Mobile application and web interface	**Abstract model**	**Abstract model**	**-Remoting accessibilit y** Through internet or local storage	**-user acceptability** Web interface, mobile application **-security, risks, and privacy** Identify attack threading for acquiring access to actuator or System control units.
[3]	2019	Safety	Implementa tion of home automations	MQTT broker	- Raspberry Pi -TP-link -LG smart TV -Wi-Fi LED	openHabian	- Remotely accessible Availab le on google platform. - Energy efficient intelligent monitor for energy consumptio ns	**-user acceptability** Web interface and smart phone and voice command (Amazon Alexa) and user can modify the interface according to their preference **-universal platform** It accommodates most kinds of smart home devices and deal with many

								platforms such as windows and Linux -scalability and extensibility It accommodates any number of devices with single interface
[5	2020	Safety - Comfort	Building models and prototype	Blockchain	Raspberry Pi 3+-ESP8266-12F-Humidity and temperature SHT31-PIR Sensor D203B PIR.	Hash orithm 25 A-256)-ML-JavaScript programming	**Surveillance and property security (automated burglar alarm system, guest attendance monitoring)**	**-user acceptability** (Through Website & application) **-security and privacy** Build systems based on Hash Algorithm 256 (SHA-256-Webserver using for encrypted username, password, and token)
[6	2023	Safety - Comfort	reduce energy costs by adapting consumption to variable pricing over the day	data-mining (A pattern-detecting method)	DHOMUS platform-MATLAB-K-nearest neighbors		- Remotely accessible - **Energy efficient** intelligent adapting energy consumptions	**-user acceptability** (Through (RHOMBUS) platform which developed by ENEA) -Scalability and Extensibility (Capable of overseeing most sensors installed in the home and monitoring consumption in real time)
[7	2022	Safety – Comfort-Economy	providing a safe and stylish home by represent architecture of home automation for both short-range and long-range utilizing multiple communication	Chirp Spread Spectrum (CSS)	server-based LoRa gateway, and Bluetooth connectivity- Node MCU-RYLX 400-Bluetooth module- 5 V DC supply Source-Relay	-Android Studio -Android mobile application	**- Energy efficient** **-Remotely Accessed** (radio communication using LoRaWAN technology, mobile application and Bluetooth connectivity)	**-User Acceptability** (Android application) Scalability and Extensibility (Tested on nearly 100 million devices in 100 countries) **-Universal Platform** (It was applied to many kinds of devices)

			technologies					**-Cost** (Low cost of use and low power wireless platforms)
[10]	2022	Safety – Comfort- Economy	Building a cost-effective and energy-saving smart home automation system		Raspberry pi- ESP8266-ADSL Wi-Fi modem - Temperature Detector (RTD)- ADS1115(Analog-to-digital converter)- - PPG101A1 Temperature Detector (RTD)- Hall Effect	- Linu rating system- Net Beans IDl Eclipse (integrated development environment (IDE))	**-Energy efficient- Remotely accessed. (**Wi-Fi-TCP/IP-MOBILE APP**)**	**-User Acceptability (**Smartphone application**)** **-COST** (low-cost Wi-Fi module with TCP/IP stack)

8. Conclusions

The smart home is one of the most widespread technologies, especially with the increasing number of smart appliances that use various kinds of sensors such as thermostats, fridges, speakers, light bulbs, locks, meters and smart grids.

Smart home devices should be overcoming these increasing limitations to meet the desires and needs of householders, reduce energy demand, and achieve sustainability goals to improve the householder's quality of lifestyle and make it more intelligent, luxurious, and comfortable.

Furthermore, the researcher plans to develop smart home management decision-making system model to help smart home manufacturers and householders to gain more degree of Applied Benefits and overcome Limitations for smart homes.

9. future work

propose a model to provide guidelines in the context of IoT technology implementation for decision-making systems for smart home management, to overcome the challenges, and identify the helpful critical success factors.

The aim and motive of using smart homes should be clearly stated; The whole project should fit within an overall strategy on the building of smart homes to satisfy the needs of smart home services users.

REFERENCES

[1] P. Suesaowaluk, "Home Automation System Based Mobile Application," in *2020 2nd World Symposium on Artificial Intelligence (WSAI)*, Guangzhou, China, 2020.

[2] S. ARIF, S. U. REHMAN, A. KHAN, M. A. KABIR and M. IMRAN, "Investigating Smart Home Security: Is Blockchain the Answer?," *IEEE Access*, pp. 117802-117816, 2020.

[3] R. Parocha and E. Q. Macabebe, "Implementation of Home Automation System Using OpenHAB Framework for Heterogeneous IoT Devices," in *IEEE International Conference on Internet of Things and Intelligence System*, 2019.

[4] F. Zaro, A. Tamimi and A. Barakat, "Smart Home Automation System," *International Journal of Engineering and Innovative Research*, pp. 68-88, 2021.

[5] T. A. Khoa, L. B. Nhu, H. H. Son, N. M. Trong, C. H. Phuc, N. H. Phuong, N. V. Dung, N. H. Nam, D. S. T. Chau and D. N. Duc, "Designing Efficient Smart Home Management with IoT Smart Lighting: A Case Study," *Wireless communications and mobile computing*, pp. 1-18, 2020.

[6] M. Caldera, A. Hussain, S. Romano and V. Re, "Energy-Consumption Pattern-Detecting Technique for Household Appliances for Smart Home Platform," *Energies*, pp. 1-23, 2023.

[7] R. Islam, W. Rahman, R. Rubaiat, M. Hasan, M. Reza and M. Rahman, "LoRa and server-based home automation using the internet of things (IoT)," *ScienceDirect*, p. 3703–3712, (2022).

[8] D. Popa, F. Pop, C. Serbanescu and n. Castiglione, "Deep learning model for home

automation and energy reduction in a smart home environment platform," *Neural Computing and Applications*, pp. 1317-1337, 2019.

[9] D. Meyer, J. Haase, M. Eckert and B. Klauer, "A Threat-Model for Building and Home Automation," in *14th international conference on industrial informatics (INDIN)*, INDIN, 2016.

[10] P. Manojkumar, M. Suresh, A. Ahmed, H. Panchal, C. Rajan, . A. Dheepanchakkravarthy, A. Geetha, B. Gunapriya, S. Mann and K. Sadasivuni, "A novel home automation distributed server management system using Internet of Things," *International Journal of Ambient Energy*, pp. 5478-5483, 2022.

[11] T. Janarthanan, M. Bagheri and S. Zargari, "IoT Forensics: An Overview of the Current Issues and Challenges," *Springer, Cham*, pp. 223-254, 2021.

[12] Q. Ni, A. Hernando and I. Cruz, "A context-aware system infrastructure for monitoring activities of daily living in smart home," *Journal of Sensors*, 2016.

[13] A. Nezhad, A. Gadsden and A. Rahimnejad, "Home energy management system for smart buildings with inverter-based air conditioning system," *ScienceDirect*, vol. 133, p. 107230, December 2021.

[14] S. N. Makhadmeh, A. T. Khader, M. A. Al-Betar, S. Naim, A. K. Abas and Z. A. A. Alyasseri, "A Novel Hybrid Grey Wolf Optimizer With Min-conflict Algorithm for Power Scheduling Problem in a Smart Home," *Swarm and Evolutionary Computation*, vol. 60, p. 100793, 2021.

[15] Z. Pang, Y. Chen, J. Zhang, Z. O'Neil and Hwakong, "How much HVAC energy could be saved from the occupant-centric smart home thermostat: A nationwide simulation study," *Applied Energy*, vol. 383, p. 116251, 2021.

[16] Gladence, Mary; Anu, Maria;, "security management in smart home environment," *Research Square*, 2021.

[17] X. Zhang, "Construction for the Smart Old-age Care in an Age of Longevity: A Literature Review," *IOP Conference Series: Earth and Environmental Science*, vol. 632, p. 052042, January 2021.

[18] A. Wu and J. Michelle, "Sannjiv sam Gambhir," *nature*, pp. 1962-2020, 2021.

[19] C. Biele, J. Kowalski and K. Krzysztofek, "Smart Home Technology as a Creator of a Super-Empowered User," *Telematics and Informatics*, 2019.

[20] S. Nikou, "Factors driving the adoption of smart home technology: An empirical assessment," *Telematics and Informatics*, September 2019.

[21] W. . Gu, P. Bao, W. Hao and J. Kim, "Empirical Examination of Intention to Continue to Use Smart Home Services," *Sustainability*, p. 1, 2019.

[22] S. Saberi, M. Kouhizadeh, J. Sarkis and L. Shen, "Blockchain technology and its relationships to sustainable supply chain management," *International Journal of Production Research*, p. 2118, 2019.

[23] S. Balakrishnan, H. Vasudavan and R. Murugesan, "Smart Home Technologies: A Preliminary Review," *Proceedings of the 6th International Conference on Information Technology*, pp. 120-127, 2018.

[24] N. Verma, S. Singh and D. Prasad, "A Review on existing IoT Architecture and Communication Protocols used in Healthcare Monitoring System," *The Institution of Engineers*, pp. 1-13, 2021.

[25] H. Chen, X. Xie, W. Shu and N. Xiong, "An Efficient Recommendation Filter Model on Smart Home Big Data Analytics for Enhanced Living Environments," *Sensors*, vol. 16, p. 1706, 2016.

[26] B. Sovacool and D. Rio, "Policy mixes for more sustainable smart home technologies," *Environmental Research Letters*, vol. 16, no. 5, 2021.

[27] D. Mekuria, P. Sernani, N. Falcionelli and A. Dragoni, "Smart home reasoning systems: a systematic literature review," *Journal of Ambient Intelligence and Humanized Computing*, p. 4485–4502, 2021.

[28] M. Challa and K. Soujanya, "Secured smart mobile app for smart home environment," *Materials Today*, pp. 2109-2113, 2021.

[29] Z. Ling, J. Luo, Y. Xu, C. Gao, K. Wu and X. Fu, "Security Vulnerabilities of Internet of Things: A Case Study of the Smart Plug System," *IEEE*, 2017.

[30] X. Zheng, Z. Cai and Y. Li, "Data Linkage in Smart Internet of Things Systems: A Consideration from a Privacy Perspective," *IEEE Communications Magazine*, p. 55, 2018.

[31] E. Seo and W. Yang, "Evaluating Smart Home Services and Items: A Living Lab User Evaluating Smart Home Services and Items: A Living Lab User," *Buildings*, vol. 1, p. 263, 17 1 2023.

[32] Z. Asif and M. Mandviwalla, "Integrating the Supply Chain with RFID: A Technical and Business Analysis," *Communications of the*

Association for Information Systems, vol. 15, p. 393–427, 2005.

[33] E. Boumpa and A. Kakarountas, "Home Supporting Smart Systems for Elderly People," *springer*, 2020.

[34] R. Hosaka, "An analysis for specifications of medical use RFID system as a wireless communication," in *IEEE Engineering in Medicine and Biology Society*, 2007.

[35] Y. Lim, Y. Tan and Y. Du, "A Novel Human Activity Recognition and Prediction in Smart Home Based on Interaction," *Sensors*, no. 19, p. 4474, 2019.

[36] K. Bouchard and S. Giroux, "Smart homes and the challenges of data," *researchgate*, 2015.

[37] M. Ferdous, M. Chowdhury, K. Biswas and N. Chowdhury, "Integrated platforms for blockchain enablement," *researchgate*, 25 March 2019.

[38] Z. Zheng, Z. Sun, J. Pan and X. Luo, "An integrated smart home energy management model based on a pyramid taxonomy for residential houses with photovoltaic-battery systems," *science direct*, vol. 298, p. 117159, 2021.

[39] P. Mauro, C. Andrea, G. Maselli and J. Stankovic, "Environment-driven Communication in Battery-free Smart Buildings," *ACM Transactions on Internet of Things*, vol. 2, no. 2, pp. 1-30, 2021.

[40] T. Richardson, "https://zigbeealliance.org/about/alliance-staff/," 24 12 2021. [Online]. Available: https://zigbeealliance.org/about/alliance-staff/.

[41] K. Dahlgren, S. Pink, Y. Strengers, L. Nicholls and J. Sadowski, "Personalization and the Smart Home: questioning techno-hedonist imaginaries," *Convergence - SAGE*, 2021.