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An Investigation on Internet of Things Technology (IoT) In Smart Houses

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Abstract

Existing scientific developments have enabled new technological approaches to emerge. 'Internet of Objects' (IoT) technology is one of these approaches. Using the standard internet protocol, this technology can transfer wirelessly the data obtained by digitizing the data of the object or the domain of the adapter that it is adapting to the server. Digitized data; can be humidity, noise, temperature, pressure, of an environment etc., as well as the number of uses of any device, energy consumption, damage analysis, physical condition or security management. A server or interconnected objects can be controlled remotely by the user via the Internet. In this regard, IoT technology offers significant opportunities for use in living spaces. The emergence of applications such as 'Smart Connected Homes' can be expressed in this context. In the literature review, it is seen that there are many academic studies about the use of IoT technology in smart houses. In the literature review, it is seen that there are many academic studies about the use of IoT technology in smart houses. In these researches, IoT technology is used in smart houses; Security, privacy, personalization and physical environment control.

This study aims to examine the academic studies on the use of IoT in smart homes through a systematic literature review from the beginning of the 2000s. Scanned work is classified according to their content and keywords and analyzed in detail within the scope of examining IoT technology. With this study, it is also aimed to draw attention to the untouched points by foreseeing future use of IoT in intelligent houses.

Key Words

"Internet of Things, Technology, Smart House, Interior Design."

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1. GENERAL DESCRIPTION AND THEORETICAL BASIS

In this part of the study, IoT and smart home technologies, which are the subjects of the research, are given.

1.1. Internet of Things (IoT)

In the literature, the term 'Internet of Objects' (IoT) is found in the article by David Brock, who is a researcher in the Auto-ID group, about the 'Electronic Product Code' (Uckelmann vd., 2011). While there is no universal and definite definition for IoT in the literature, the core concept includes that daily objects can be equipped with identification, perception, networking and processing capabilities. Through these capabilities, objects can communicate with each other, with other devices and services over the internet (Whitmore vd., 2014). On the other hand, IoT is a concept that seamlessly integrates the virtual world's information technology with real objects. With this technology, the real world becomes more accessible to both business and everyday scenarios through computers and devices connected to the network. More sophisticated information access has allowed management to move from micro level to macro level, measurable, planned and feasible. However, IoT, which has a much more potential than managing business processes more effectively and efficiently, also reveals a more comfortable life style (Uckelmann vd., 2011).

Gartner, a technology consulting company that makes predictions about the future of emerging technological trends, announces the expectations of these trends every year through a graphic named 'Hype Cycle'. In the hype cycle chart published in 2016, the expectations regarding IoT are shown in Figure 1 (URL-1, 2017).

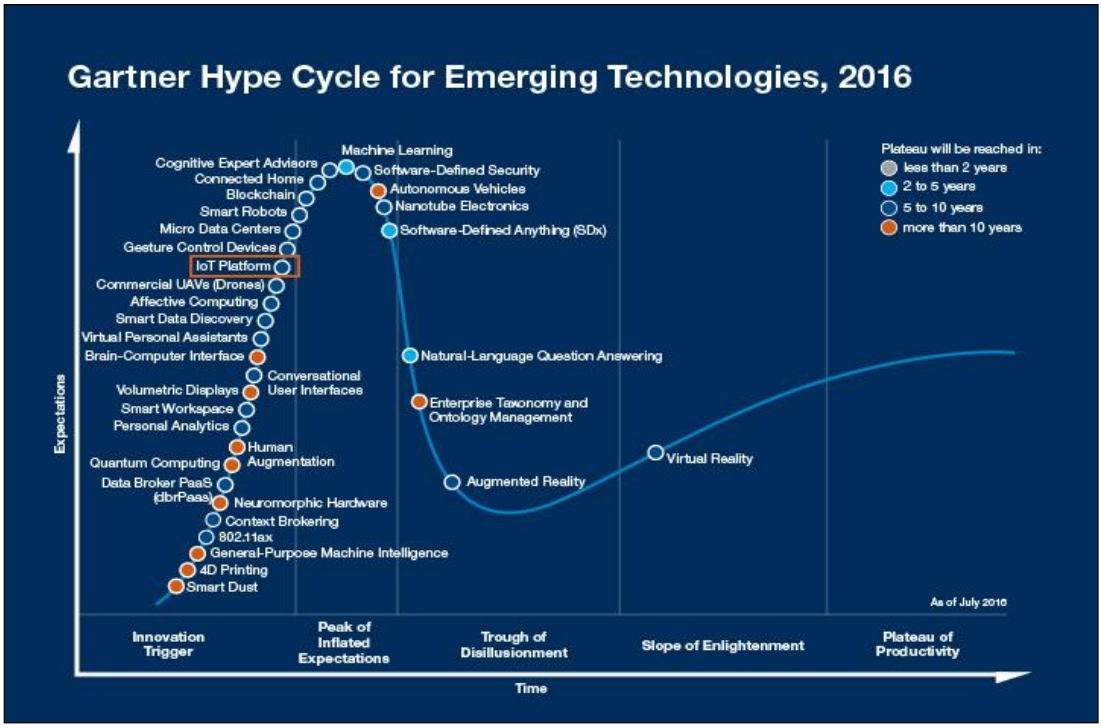

Figure 1. The position of IoT technology in the cycle of Hype Cycle (URL-1, 2017).

In order to identify objects in the environment as IoT objects', these objects must have some electronic devices. These devices are sensors, actuators and devices that perform tasks such as 'Radio Frequency Identification' (RFID). These sensors can analyze the various parameters such as heat, humidity, motion, sound, position according to the need, and transmit it to another connected object or center through the network to which it is connected. These sensors, which are embedded in the objects in a whole, are placed on the chips which are expressed as 'Programmable Card' (PIC). Some of these cards are seen in Figure 2 (URL-2, 2017). 'Raspberry Pi', 'Arduino', and 'BeagleBone' cards are included in these chips. The communication chips that are added to the IoT chip are called 'Wide Area Network' (WAN), 'Personal Area Network' (PAN), 'Local Area Network' (LAN), ' (Bluetooth) and 'Near Field Communication (NFC). During communication, it personalizes communication using a unique network identity such as 'Internet Protocol' (TCP / IP) and 'Media Access Control' (MAC) (Holler vd., 2014).

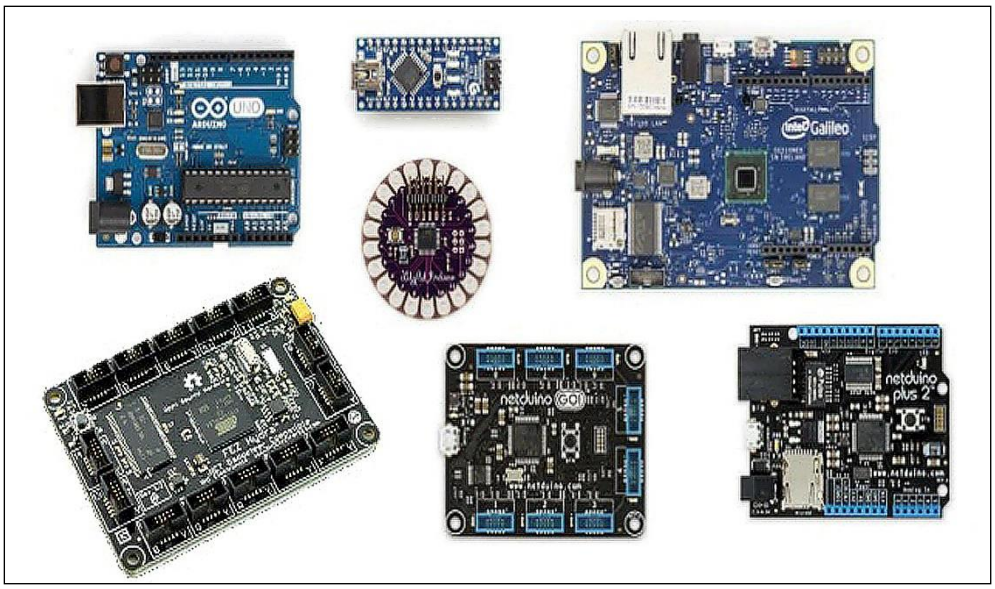

Figure 2. Some programming cards used in IoT project development.

In addition, Pêrez and Barbolla have stated that an IoT system consists of three main layers:

- Hardware Ecosystem (Physical Devices)
- Software Layer
- User Layer (Pêrez&Barbolla, 2014).

On the other hand, three main use cases are defined within the IoT industry. These; sensors, actuators and labels. These uses determine the software and hardware configuration of the IoT device (Mirocha, 2015). With reference to this point, it is possible to formulate IoT technology as follows; Physical Object + Control Devices / Sensors / Actuators + Internet = IoT (McEwen& Cassimally, 2014).

In addition, it is possible to mention that many objects, such as smart TVs, refrigerators, lighting elements, plugs, which are current technology, have IoT technology ready in its place. These objects are characterized as 'intelligent' objects by virtue of their possessions.

Existing scientific developments have played an important role in the spreading of IoT, both in terms of size reduction of communication technologies such as RFID, NFC, Wi-Fi and sophisticated sensors used in IoT technology, and of increasing prices to more reasonable levels. Detecting physical conditions through sensors, collecting and processing detailed data, real-world changes can be answered instantly. Totally interactive and responsive, communications network offers significant potential for businesses and end users (Uckelmann vd., 2011).

1.2. Iot Based Smart Home System

Today, many companies are trying to equip modern houses with the technology used by a single device to control all systems and devices in the house. The targeted solutions seem to focus primarily on environmental monitoring, energy management, life support assistant, comfort and convenience. The IoT -based smart home system relies on open platforms that use an intelligent sensor network to provide information about the state of the house. These sensors perform tasks such as power generation and measurement, heating / ventilation / air conditioning (HVAC), lighting, security system control (Vermesan&Friess, 2014). The user can access the collected information by touching devices such as touch screens, personal computers and mobile phones. Figure 3 depicts an smart home system based on IoT.

IoT-based smart home (IoT SH) refers to a system where all the devices in the house are connected and synchronized. The system that collects information about the user provides an estimate of its behavior and habits. For this reason, the IoT SH system can be characterized as a measurable analytical ecosystem of sensors and actuators designed to automate and control living areas (Mirocha, 2015). In the coming period, IoT SH applications are likely to become a 'social laboratory' where the behavior and preference patterns of users are transformed into data and examined by various social engineering techniques in order to increase sustainability and economic efficiency.

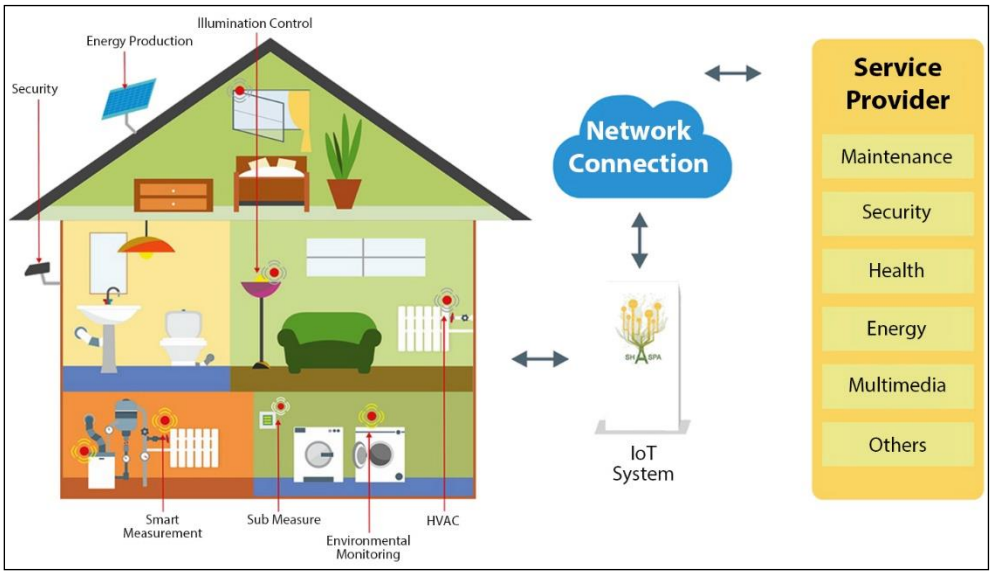

Figure 3. Schematic of the operation of an smart home system based on IoT (Vermesan&Friess, 2014).

When viewed from a different angle, interacting with smart houses and IoT devices is far from being a seamless and hassle-free experience because IoT technology has many different interfaces. While smart home research addresses the growing number and heterogeneity of devices, services and technologies, it emphasizes the growing difficulty of being able to grasp easily and interact smoothly for users (Brush vd., 2011). Technical difficulties in bringing such systems together in smart homes have been recognized by long-standing research communities (Edwards&Grinter, 2001). It is intended to create an integrated interface that combines this kind of technology to prevent the complexity of multiple devices, to provide partial control of interconnected devices and to create a common approach. When this is done, users will feel that they are interacting with the house as a single entity rather than having to feel that they are interacting with more than one system and interface. Tool interfaces such as Apple's "Siri", Amazon's "Alexa", or Microsoft's "Cortana" are another approach to the abstracting of such complexity and provide functionality through speech. These technologies provide a unified interface that allows users to access the natural language spoken, rather than navigate through complex and deep menu structures (Mennicken vd., 2016).

IoT system solutions are divided into 5 different categories in the market: smart wearable, smart business, smart environment, smart city, smart home (Perrera vd., 2015). The focus of this work is on smart home applications and topics that use IoT technology.

2. RESEARCH STRUCTURE

The study focuses on determining which areas of the housing context are weighted by scanning articles on IoT and smart homes. It is another purpose of the study to address future practical problems in this sense and future prospects about possible IoT applications not specifically addressed in the residence. It is also aimed to contribute to the IoT and researchers who work in smart house subjects.

2.1. Research Method

The method of study is systematic literature review. For this purpose, the key words were searched in six separate academic databases. IoT and Residential ',' IoT and Home 'and' IoT and Smart Infrastructure ', considering the scope of the subject. These key words were scanned in the databases 'Scopus', 'Google Scholar', 'ScienceDirect', 'IEEE Xplore', 'ACM Digital Library' and 'Academic Search Premier'. As a result of scanning, 26 articles were accessed. These articles have been carefully analyzed and classified by focusing on what subjects they focus on.

2.2. Classification Method

There are four main categorizations according to the content of the studies obtained in the literature search: smart home system (SH), smart home human-machine interaction (SH -HCI), smart home environment supported life (SH - AAL), smart home privacy and security (SH - The S & P). Some of these categories are later divided into subcategories. The classification made is seen in Table 1.

Table 1. Table prepared according to literature review (Tolga Kılıç).

Main Category	Sub Category	Sub Sub Category
SH System	System Model Suggesiton	Various System Approaches
	Device Management	General Studies
SH HCI	HCI	Device/Smart Plug Control
SH AAL	Person Monitoring	
	System Monitoring	
SH S&P	General Residence Security	
	Bathroom Security	
	Awareness	

Within the scope of the study, 15 of the 26 articles surveyed daily from the beginning of the year 2010 include the works suggested by the model, which are directly related to the smart home system. Twelve of these studies present different model proposals for an IoT based smart home system. Two other studies present model proposals for the control of devices in the smart home system. In one study, it was observed that general approaches to IoT based smart home systems have been examined.

As already mentioned, there is no universally definite rule-based IoT system definition. Since the IoT is a technology that is currently evolving and its content is constantly updated, its components are also diversified. Different hardware is assembled with different software and designed according to different needs and integrated into a system. For example; a system developed to provide control of the sockets in a house and a single device that controls the system in the whole house need different hardware and software types. For this reason, it has been evaluated that a search has been made in order to create a healthy and efficient system with different equipment. On the other hand, when we examine the studies that have been compiled, it is seen that there are some chronic problems faced by the IoT systems. These problems are high cost, coverage areas of objects are not wide enough, and the energy consumption of objects is relatively large. Therefore, in the literature, it has been found that model proposals are offered for an integrated IoT system that will address both these problems and meet different needs. Table 2 shows the key words of the IoT-based smart home system. When these key words are examined, it can be seen that different technological approaches in terms of both software and hardware are put forward.

Table 2. Table showing the key words of the studies on smart home system based on IoT based on literature review (Tolga Kılıç).

Main Category	Sub Category	Sub Sub Category
IoT SH System	System Model Suggestion	Ambient intelligence Android Smartphone Ardunio Arduino microcontroller board Artificial Intelligence AT mega controller Cloud computing technology Component DIY Field programmable gate array Holistic framework Home automation Internet of Things Interworking IoT ISO/IEC/IEEE 21451 KNX Light Emitting Diode Lightweight MAC Low-cost Plug-and-play Relay circuits. Sea Computing Self-configuration Smart grid SmartCities Smart Home Smart Home requirements Transducer Twisted Pair Visible Light Communication Web Service WiFi Wi-Fi shield Wireless sensor network WSN ZigBee ZigBee wireless sensor technology
	Device Management	Smart Home Android Smartphone Gateway Optical fiber REST Smart Plug UC/OS II WiFi Zigbee
	General Study	Ambient intelligence Home Automation Internet of Things SmartCities SmartHome requirements

2.3. Analysis of Obtained Works

The result of the literature review is the IoT based smart home system model proposal. The contents of the studies and their suggestions are briefly mentioned below:

2.3.1. IoT SH Systems

IoT Smart Home Model Proposals

- In the work named '*A review of Internet of Things for smart home: Challenges and solutions*' a cloud-connected smart home system management model proposal that generates its own energy has been put forward. Study; it is seen that the difficulties and problems encountered in this subject are searched by the literature survey (Biljana vd., 2016).

- In this study which has the name '*Designing and Implementing a Lightweight WSN MAC Protocol for Smart Home Networking Applications*', system architecture and GRAFCET (chip programming language / method) design of a network device is presented for IoT based smart home applications. WSN / MAC connection protocol is recommended in the model (Chen vd., 2017).
- In the work titled *'Home Automation and Internet of Things*' presented by Sing et al., An Ardunio based home automation system proposal, which controls all the sensors in the house, is presented. It is emphasized that the model requires low maintenance cost after installation and can be easily modified (Singh vd., 2016).

- A home automation system based on intelligent transducer interactions with energy / cost efficiency has been introduced in the work named *'Home Automation System Based on Intelligent Transducer Enablers*'. The system includes intelligent converter points, home automation gateway and wireless access points. All of these systems; control and management subsystem, communication subsystem and energy converter sub-system (Albela vd., 2016).

- A low cost flexible home monitoring and monitoring system model based on the Android operating system is proposed in the study entitled *'Internet of Things: Ubiquitous Home Control and Monitoring System using Android based Smart Phone*' by Piyare. The system can be managed by intelligent mobile devices. In the model, even if the WI-FI nodule is closed, the system can be accessed with 3G / 4G communication technology (Piyare, 2016).

- A study named *'Research and application on the smart home based on component technologies and Internet of Things*' presents an IoT smart home system based on SOA (service based architecture). In the study, SOA software support has been shown to offer a software proposal that can be controlled over the web to respond to instant needs and requests quickly (Li&Yu, 2011).

- In the work of *'Smart Home Mobile RFID based Internet Systems*', RFID reader architecture was proposed for smart home applications and services. The system has been developed as an alternative to high energy consuming RFID reading models. In this context, it is understood that a high energy efficiency model is targeted. Examples of use of various smart home services such as work washing programs, cooking, shopping and elderly health care are given as examples of systems using the RFID system (Darianian&Michael, 2008).

- The 'Smart Grid' application, named *'System Design of Internet-of-Things for Residential Smart Grid*', provides a large-scale IoT system design that requires fast response time for many home users Viswanath vd., 2016).

- As an alternative to high-cost traditional smart home technology, ZigBee wireless sensor technology with high cost efficiency and IoT smart home model proposal using cloud technology have been proposed as *'The Design and Application of Low-Cost Smart Home Under the Internet of Things and Cloud Computing Platform*' Provided (Wei&Qin, 2013).

- The work *'WiFi Multi Access Point Smart Home IoT Architecture*' offers a wireless sensor network concept specifically designed for smart home applications. The innovative nature of this network is concerned with the simultaneous use of selected sensors serving as access points and network clients for information transfer and routing. In other words, it is thought that sensors serve for multiple purposes in the model proposal (Lech, 2016).

- In this work called *'The Possibility of Using VLC Data Transfer in the Smart Home'*, we propose an IoT model that provides communication through VLC (Visible Light Communication) method based on KNX (Smart Home-Building Automation System) management system (Vanus vd., 2016).

- In the work called *'Smart Home System Based on Internet of Things*', an Ardunio based IoT model proposal was presented, which was developed to control different types of intelligent devices and IoT objects in a house from a single central system. The system is compatible with Android devices and personal computers with HTML access Verma vd., 2016).

IoT Smart Home Device Control

Two academic studies related to smart home systems based on IoT have shown that the proposed model is related to the control of the devices in the smart home system.

- In the work named *'Design for a Residential Gateway Based on IoT Technology'*, a proposal of an IoT model that fulfills the mission of reading wireless meters to measure electricity, water and gas consumption from a remote place (Guan&Wang, 2013).

- In the second study named *'Design of Smart Home System Based on WiFi Smart Plug*', it is seen that a model proposal that provides smart control of smart sockets in smart house is presented. It has also been understood in this study that it is aimed to control electric devices via smart sockets via an energy / cost effective model (Wang vd., 2015).

IoT Smart Home General Review

In the literature survey, one study has been reached which generally examines IoT based smart home systems. This work is briefly mentioned below:

- Based on 'Smart Cities', it has been determined that a roadmap has been developed in order to meet the basic needs of a smart home system in the work called *'Smart Requirements of Smart Homes in Smart Cities Based on Internet of Things Technologies*' (Terence vd., 2016.)

Table 3. Table showing that the key words of IoT SH System and HCI Interaction, IoT SH System and AAL, IoT SH System and Security and Privacy system according to literature survey (Tolga Kılıç).

Main Category	Sub Category	Sub Sub Category
IoT SH System and HCI	HCI	Agent-based interface Artificial psychology Building information modeling Context Awareness Emotional model Home automation Internet of things Interaction technology IoT Location based service Ontologies Personality Pervasive Computing Sensors Smart home Spatial information SWRLs Virtual human-computer
IoT SH System and AAL	Person Monitoring	Activities of Daily Life Ambient Assisted Living Lab Artificial Intelligence Business ecosystem Business-technology Co-design Device and service integration Enterprise information system ExpertSystem Health Monitoring Home Automation systems Industrial information integration engineering In-home health care station Intelligent medicine box Internet of Things KNX Neurological Disorders Robotic Technologies Sensors Turtlebot Vision Processing Algorithms
	Sytem Monitoring	
IoT SH System and Security&Privacy	General Residence Security	Bathroom Safety Big Data Fire protection Fuzzy logic Internet of Things (IoT) Microcontroller Privacy Representational state transfer Security Sensor web Smart home Temperature sensor Wireless Sensor Network
	Bathroom Security	
	Awareness	

In the literature review; '*IoT* SH *System and HCI*' (Human Computer Interaction), '*IoT* SH *System and AAL*' (Ambient Assistant Living), and '*IoT* SH *System Security and Privacy*'. A total of 11 works focused on these issues.

2.3.2. IoT SH and HCI

The contents of the IoT SH System and HCI related studies are briefly summarized below:

- This study aims to develop a location-based technology that can provide improved information services to users depending on their location in the work named *'Developing a the Advanced IoT (Technology of Information) Technology Based on Spatial Information*'. The ultimate goal is to develop an advanced platform for 'Location Based Service' (LBS) using spatial information. It has been seen that the work will ultimately contribute to 'Human Space Interaction' (HSI) (Jang vd., 2016).

- In the study named *'Human machine interactive system on smart home of IoT*', the emotional interaction system in the smart home system based on IoT was examined. For this, the user's emotional reactions, which are spilled out of the way, are given in the form of writing to the user and the user-machine interaction is aimed to be raised to the upper level. Thus, in the future it seems to be aimed at increasing spatial awareness by working with people and machines more harmoniously (Kun-kun, 2013).

- "*Perceptions of Personality Traits in a Smart Home", "Does a smart home need to be a proactive or passive character?" Should we try to socialize with the residents?*" seems to have been tried to be answered by taking center of human-machine interaction. In the study of 41 participants experiencing the generated scenario and giving feedback on the designs, the design of the agent-based IoT interfaces was analyzed in the direction of the participants' preferences and various improvements were proposed (Mennicken vd., 2016).

- It has been seen that users of the work named *'Pervasive semantic representation and integration of context-aware homes in context sensitive cities*' are aiming to present a viewpoint on the interaction of users and IoT ecosystem that collects data from devices and transitions. The ecosystem has been modeled using 'Semantic Web' technologies in the perspective of IoT. Semantic network technology improves by learning and analyzing the environment of the system to which it is connected. In this context, it is aimed to include both home and city measurements of a learned IoT ecosystem (Vlachostergiou, 2015).

2.3.3. IoT SH and AAL

The contents of the IoT SH System and the studies related to the AAL are briefly mentioned below:

- An IoT system model proposal that can be used to collect, analyze and process the necessary information from the patient's home to assist medical specialists in the diagnosis of Parkinson's disease is given in the article titled *'An Approach of a Decision Support and Home Monitoring System for Patients with Neurological Disorders*' It offers. In addition, 'Web Based Home Health Monitoring Portal' model is recommended for patients with Parkinson's disease or other neurological disorders (Chiuchisan&Geman, 2014).
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- A method for remote control and integration of home health care devices and services has been proposed in the work entitled *'The Internet-Of-Things' of' Design of A Terminal Solution for In-Home Health Care Devices and Services Towards'*. In this framework, it is planned that the model (business model, device / service integration architecture and information system integration architecture) will be realized by organically combining three basic elements with IoT technology (Pang vd., 2013).

- '*Designing the Next Generation of Home Automation Combination IoT and Robotic Technologies*' presents a new home automation system design that combines IoT and robot technologies. In the study, he proposed a model that could help people living alone at home (Christopoulos vd., 2016).

2.3.4. IoT SH and Security & Privacy

The contents of the IOT SH System and the studies related to security and privacy are briefly summarized below:

- The project entitled *'An Internet-of-Things (IoT) System Development and Implementation for Bathroom Safety Enhancement*' presents a holistic conceptual approach to the development and implementation of the IoT system to enhance residential bathroom security. The concept is focused on implementing a large nursing facility as pilot testing environment (Koo vd., 2016).

- '*Developing A Fuzzy Logic Based System For Monitoring And Early Detection of Residential Fire Based on Thermistor Sensors*' named work focuses on the development of a fuzzy logic based IoT system for monitoring and early detection of residential fire based on thermistor sensors (Maksimovic vd., 2014).

- '*Home Automation Using Internet of Things*' seems to develop a system to remotely control home appliances and provide maximum security against problems that would arise when not in the home (Patel vd., 2016).
- The *'On Privacy and Security Challenges in Smart Connected Homes*' software provides a 'new' IoT security approach to prevent smart home users from accessing their private information without permission (Bugeja vd., 2016).

3. CLASSIFICATION RESULTS

When the results obtained by literature review are examined; It seems that IoT technology has not yet become stable and stable in terms of both software and hardware in the smart home system. It is possible to show that one of the most important reasons for this is that the IoT technology is still in its developmental stage. Today, on the market, a wide variety of development cards, sensors and other external equipment used in IoT systems are found. These hardware components are assembled and programmed to meet different needs. But it seems to be difficult to produce a healthy working system and to suggest it as a model with high energy / cost efficiency. It seems that scientists are working with different hardware and software to overcome this problem and to create a stable IoT model for smart houses. In this respect, it has been evaluated that a house concentrates on an IoT SH model proposal, which controls all electrical or electronic devices via a single central device, which can be instantly accessed by users' smart devices or personal computers and has an easy interface. The 12 studies obtained in the literature search are the studies that have been put forward to produce a model proposal in this respect. In other works on smart home management, it is understood that studies have been made specifically about the control / access of certain devices or systems.
In the four studies conducted for the use of IoT in SH, it is seen that the relation of IoT with the user in the place is discussed. In the studies, the emotional interaction of the machine with the users was investigated and the models in which this approach was supported with the learned technology were suggested. It has been understood that the IoT SH systems have been integrated with technologies such as the semantic network to create a concrete infrastructure for this thinking. Therefore, it seems that in these studies, the search for a user-friendly IoT model, in which man-machine interaction becomes more flexible and easier, is aimed at. IoT is a technology where the level of environmental feedback is at a high level. Therefore, it has a promising potential for 'Ambient Assisted Living'. The academic research that has been done has also come up with studies on this subject. In these studies, it has been pointed out that automatic transmission of data about the health status of sick or elderly people living alone to a specific center or taking precautions against the problems that these people will live in their homes. In this context, it is seen that different IoT model proposals for needy users are presented.

Security and privacy issues have high protection in IoT SH systems. In the literature review, four studies were carried out for this subject. All of the works are in contact with different points in terms of security and privacy issues. It has been seen that models have been developed in order to take measures against fire, to provide bathroom security and general home security. It has also been assessed that a model recommendation is provided to ensure the safety of the user's personal data.

4. CONCLUSIONS AND RECOMMENDATIONS

This study aims to examine the academic work on the use of IoT in smart homes through a systematic literature review from the beginning of the 2000's. Key words related to the subject were scanned in six separate academic databases and 26 studies were reached. These studies have been classified in terms of intelligent households, focusing on the points and key words they focus on. Thus, it was aimed to determine the points contacted by academic studies on the use of IoT technology in smart home context. On the other hand, it has been thought that working will also be useful in the discovery of IoT's potential use points in smart home technology, but not addressed.
According to the data obtained through literature review; No work has been done specifically on the interface design for the IoT SH system. It is thought that the interface design, which has a vital prescription to interact with the user, has an impressive role in the performance of the system in interacting with the user. On the other hand, it should be emphasized that the interface design,

which will also affect the outer appearance of the IoT object aesthetically, will reflect directly on the interior space and affect the integrity of the design.

In addition, I need to emphasize that the use of a technology such as 'Face Recognition' in the IoT SH system will be important for the personalization of design patterns. It is possible to produce custom behavior patterns by defining the faces of the users in separate systems. In addition, the integration of Augmented Reality technology with IoT, which combines virtuality and reality, is seen as a potential user environmental awareness.

IoT technology has the ability to integrate furniture in the house. Furniture equipped with actuators, such as various sensors and servo motors, are likely to gain the ability to vibrate or act according to the user's commands. Although not very likely in the near future, an IoT SH system designed in this way stands as an approach that will influence the mobility of the space.

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