

## An Overview of Smart Home Systems to LPG Leakage Detection

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### المخلص

نتيجة للتقدم الكبير الذي حدث في مجال الذكاء الاصطناعي، ظهر مفهوم المنازل الذكية أو أتمتة المنزل، والتي تقدم العديد من مزايا الراحة والأمان لأصحابها. تلعب السلامة دوراً رئيسياً في عالم اليوم ومن الضروري تنفيذ أنظمة أمان جيدة في أماكن التعليم والعمل والمنزل. في هذا البحث تمت مناقشة أنظمة المنزل الذكي المختلفة لاكتشاف تسريب الغاز من حيث مميزاتها وكذلك مفهوم المنزل الذكي، كما تمت مناقشة تقنيات الاتصال المستخدمة لكي تعمل هذه الأنظمة بجودة عالية من خلال مقارنة أنظمة اكتشاف تسريب الغاز، وتحديد تقنيات الاتصال الأكثر استخداماً والأقل تكلفة والأسهل في الاستخدام.

**الكلمات الدالة:** المنزل الذكي، أتمتة المنزل، المنزل الآمن، المحسسات، تسريب غاز البترول المسال، كاشف الغاز.

### Abstract.

A result of the great progress that has occurred in the field of Artificial intelligence, emerging of a concept smart homes or home automation, which offer many benefits of comfort and safety to owners. Safety plays a major role in today's world and it is necessary that good safety systems are to be implemented in places of education and work and home. In this paper, the survey of different smart home systems for gas leaking detection is discussed as their advantage as well as the concept of smart home, and the

used communication techniques in order for these systems to operate with high quality are discussed by comparing the gas leaking detection systems and determining which of the communication techniques is more used, less expensive, and easier to use.

**Keywords:** Smart home, Home automation; Safety Home, Sensors, LPG leakage, Gas Detector.

## 1. Introduction

In recent years, automation systems and safety systems have increased in popularity, and they have been applied in many various places such as homes, hospitals, factories. A smart home is one that incorporates advanced sensing and automation systems to provide the inhabitants with monitoring and control regardless of whether they are inside or outside the home. For example, a smart home may have controls for lighting, temperature, multi-media, security, window and door operations, as well as many other functions. One of the most exciting applications in the smart home is the smart kitchen through which smart kitchen appliances are controlled such as refrigerator, dishwasher, microwave, etc. The subject of the smart kitchen has raised our interest in this paper, where we discussed it toward the protection, especially the protection of the kitchen from the fire because of Liquefied Petroleum Gas (LPG) leaking from gas cylinders.

LPG is colorless and odorless, for safety reasons, an odorant had been added to LPG for easy detection of any gas leakage. LPG gas is a flammable gas, if leaked it can cause major damage to life and property. Consequently, an LPG increases the risk of fire and explosion since it spreads quickly. This paper is focused on systems that detect any leakage of cooking gas and they will alert the user about leakage. This type of system will reduce the accident of fire and explosion and helps the early detection of gas leakage and reduction of spread and also will avoid human being from gas poisoning.

This paper is organized as follows. In Section 2, smart home overview. In Section 3, the literature sources in field of gas leaking detection in kitchen are discussed. In Section 4, the comparison of

smart home systems is introduced. In Section 5 the communication technologies used in the gas leakage detection systems are discussed. Finally, In Section 6, the conclusion is discussed.

## 2. Smart Home Overview

There are many definitions of Smart home, it may be defined as a residence or a building with equipment that can be remotely controlled and operated from any location in the world using Smart devices or through smart phones . According to one of the most recent definitions “a home that is smart enough to assist the inhabitants to live independently and comfortably with the help of technology is termed as a smart home. In a smart home, all the mechanical and digital devices are interconnected to form a network, which can communicate with each other and with the user to create an interactive space” [1]. In other words, the smart home defined as " home automation, with the use of new technology, to make the domestic activities more convenient, comfortable, secure and economical" [2]. Home automation " refers to the use of computer and information technology to control home appliances and features (such as windows or lighting)" [3], and Automation is " a technique, method, or system of operating or controlling a process by electronic devices with reducing human involvement to a minimum" [2]. Smart Homes contain devices that provide comfort, security, energy efficiency and enhance intelligent living. Devices communicate and interact with each other and form a connected ecosystem. Figure 1 shows a simple smart home system.



Figure1: A simple smart home system[4]

### 3. Related Works

This section, discussed different Gas Leakage Detection Systems with their used technology by considering systems implemented by using Global System for Mobile communication (GSM), Bluetooth, wi-fi technologies, and the Internet of things (IoT) based Smart home systems.

Shraddha et al. [5] proposed the design and construction of an SMS based Gas Leakage Alert System. The smart kitchen provides gas sensors, which are used to detect the leakage of gas in the system, and weight sensors which are used to detect the weight of the gas cylinder. Temperature sensors are used to detect the current room temperature. The information and related data are stored in the system server, it also stores the information about the hardware sensors, maintain the logs and status of the system, stores the room temperature and information about the users. Threshold values are set into the room, when it crosses that values it will send a notification to the user, about the leakage of a gas cylinder and leakage of gas. The result obtained from the tests carried out shows that the system is capable of sending SMS alerts whenever there is the gas concentration at the inputs of the gas sensors.

Reddy et al [6] suggested Gas pipeline monitoring and leakage detection using IOT to detect increasing pressure in the pipelines and control the pressure through a mobile app. If the leakage occurs, then the MQ-2 sensor will identify the gas and a message will be sent to the registered mobile number can also send the message to alternate numbers.

Priya et al [7] presented the design of a wireless LPG leakage monitoring system for home safety. The system detects the leakage of the LPG and alerts the consumer about the leak by SMS and as an emergency measure, the system will turn off the power supply, while activating the alarm. The additional advantage of the system is that it continuously monitors the level of the LPG present in the cylinder using load sensor and if the gas level reaches below the threshold limit of gas around 2kg so that the user can replace the old cylinder with new in time and automatically books the cylinder

using a GSM module. This project is implemented using the ARM 7 processor and simulated using Keil software.

Bhoir et al [8] proposed the monitor system the surroundings for any leakage. In case of any leakage detection, it will alert the user via a buzzer and by using GSM module and an Android application; it will alert the user about the environmental conditions like the gas level and temperature of that location of installation using social media sites like Twitter or via an email notification.

Anandhakrishnan et al [9] proposed the design and construction of an SMS based Gas Leakage Alert System. The gas sensor is used to detect gas leakages in a kitchen. With the help of an infrared sensor, the issue of gas wastage is also monitored. The proposed system consists of ATmega328 and it is interfaced to sensors like MQ2 sensor, load cell, infrared sensors, etc. which are the input of the system. Here the Wi-Fi-module is interfaced with these which give the ability to communicate with each other.

Salunke et al [10] the proposed system collects the data and stores it in MySQL database if the Gas values exceed the critical value appropriate measures are taken by the raspberry pi. Gas is detected by the Raspberry Pi using gas sensor and which update on webpage and buzzer are turned on. The system automatically turns off the gas regulator, turns off AC power, and automatically opens the window when a leak is detected.

Digambar et al. [11] proposed a smart gas booking system and the leakage detection system detects the leakage of the LPG. The system sounds the alarm to alerts the consumer also it sends the SMS about the gas leakage.

Pandey et al. [12] designed a microcontroller-based toxic gas detecting and alerting system in the LCD. If these gases exceed the normal level (300-1000 PPM) then an alarm is generated immediately and also an alert message (Email) is sent to the authorized person through the internet and used ARM development board. The system can comprise a GPS and GSM technique to attach remotely with the dealer. The system can also comprise the Alerting technique, which can buzz once it goes below the threshold.

Badabaji and Nagaraju [13] proposed a system uses various sensors can get the range of temperature, fire and gas. The system sends information to the particular mobile phone over GSM and displays values on LCD and also when the temperature is detected the fan will be automatically on and when the fire is detected the motor sprinkler will be on. When the gas is detected the buzzer will be automatically on.

Bagwe et al. [14] proposed a system for detecting and constantly monitor the gas leak and use alert mechanisms to notify the users and concerned authority about the mishap. The functionality of the system will consist of four main steps. In the initial step, the gas leak will be detected using the MQ5 sensor and the sensor values will be sent to NodeMCU. In the second step, NodeMCU will send an activation signal to other external devices attached to it. In the third step, many tasks can be performed such as a buzzer can be activated to send an alarm signal, LED will be turned on, GSM module will send an SMS and NodeMCU will send Email to concerned authority via its inbuilt Wi-Fi. In the last step, the NodeMCU will pass the sensed values from different sensors to the database where analysis of collected data and prediction can be done.

Mohd et al. [15] proposed a security system which ensures the safety of organization from unwanted occurrence, fire and theft. This the system basically bases on Arduino with necessary interface to enable Internet and the control of power through Global (GSM) and Bluetooth module (HC-05) . It also contains a set of sensors such as PIR sensing element is interfaced to the controller to notice the presence of intruders.

Akshay et al. [16] proposed a smart system for human presence detection and alerting gas leakage. human presence detection is done by using PIR sensors, If PIR sensor detect human body in room then it sends signal to Arduino UNO where turn on a light of room when someone arrives, turn off when they leave, and gas leakage detection is done by using MQ2 sensor. If MQ2 gas sensor detect the gas Leakage, it will send signal to Arduino UNO where it will produce alarm by buzzers. also, it sends a warning message to user on mobile phone.

Wahidur et al. [17] designed a smart home system for monitoring and security of the home from anywhere in the world. This system operates by an android application and GSM system which is also operated using the IoT. By this system the user can wirelessly be monitoring light, fan, TV, freeze, etc., also able to detect any type of combustible Gas inside a home and feeling any motion or human presence.

Akship et al. [18] designed an IOT based Hazardous gas detecting and alerting system. The hazardous gases like LPG and combustible gas were sensed by the MQ-6 gas sensor and are monitored by the AVR microcontroller and displayed in the LCD, so when the LPG exceeds from the normal level above 1000 ppm and in the same way when the Propane exceeds the normal level of 10000 ppm then an alarm is generated and an SMS is sent to the authorized user as an alerting system.

Nirav [19] used IOT technology for monitoring and controlling the home appliances by using Wi-Fi as the communication protocol and Arduino Uno. The home automation system uses a variety of sensors for providing required information for detecting the fault in-home devices automatically. Also, it uses portable devices as a user interface that is connected to the microcontroller which will monitor the sensor's values continuously.

Ralevski, and Stojkoska [20] presented IOT based system is simulating detection of gas leaks and possibility house fire in a kitchen environment, by measuring temperature and the gases concentration. The system notifies the end user as soon as it detects an intolerant presence of at least one of the gases (LPG, CO) that are measured, by sending message to the user contains a simple status explanation for each of the measured gases.

Guru and Yoga [21] presented a system continuously monitors the location for any gas leakage, in case of any leakage detection, it'll alert the user about the gas level and temperature by social media sites like Twitter or via an email notification.

Jumaa et al. [22] presented IOT based gas leakage detection system, the leakage is detected using the MQ-2 gas sensor. The

sensor sends a signal to ESP2866 NodeMCU microcontroller. In the next step, microcontroller will send a warning text message alerting the occurrence of a gas leak via (Wi-Fi) technology in conjunction with Blynk application which works on Android and IOS operating systems, at the same time, the buzzer will be On for an alarming, and the fan will be working to change the air of the place and get rid of leaking gas.

Ba and Anh [23] designed a system that monitoring gas level in the environment and display it on LCD, If detecting gas leak, the device will alarm through light and buzzer, also Alarm of danger of gas leak via SMS and phone call to pre-set phone number.

#### 4. Comparative of Smart Home Systems

In this section, we comprised the above-discussed systems in section 3, based on used technology, used sensors, Central microcontroller, advantages and Results as shown in Table 1.

**Table 1. A comparison between the available research papers on smart kitchens**

The System	Technology		sensors	Internet connection	microcontroller	advantages
Smart kitchen system [5]	IOT GSM	•	<ul style="list-style-type: none"> <li>• Gas sensor</li> <li>• Weight sensor</li> <li>• Terminator sensor</li> </ul>	There is connection	ATmega 32	<ul style="list-style-type: none"> <li>• It is a cost-effective and time-consuming solution.</li> <li>• It can use this in various applications like home automation, Hospital management, Military management, industrial applications monitoring of gas leakages in the kitchen.</li> <li>• Alarms in the form of text messages (SMS)</li> </ul>
System of gas pipeline monitoring and leakage detection [6]	IOT	•	<ul style="list-style-type: none"> <li>• MQ2 sensor</li> </ul>	There is connection	Arduino UNO board	The system offers an interface that user can control and monitor several features of system and users to view the system information and consider the processed data and sense flammable gases and alert the applicants.
Wireless LPG leakage	GSM	•	<ul style="list-style-type: none"> <li>• Load sensor</li> </ul>	There is no connection	ATmega 16	The alert mechanism includes an LED

monitoring system [7]			•MQ5 sensor			indication, buzzer and an SMS
IoT Based Gas Detection System [8]	IOT GSM	•	•MQ6 sensor	There is connection	•ATmega 328 •Arduino UNO board	<ul style="list-style-type: none"> <li>•The system wirelessly transfers alert notification to the sensor and the user can easily connect the devices through a smartphone from any location.</li> <li>• Using the Arduino microcontroller makes the system cheaper.</li> <li>•Easy access and control make the system very useful.</li> </ul>
Monitoring system to monitors gas leakage in a kitchen [9]	IOT Wi-Fi	•	<ul style="list-style-type: none"> <li>• Load cell</li> <li>•MQ2 sensor</li> <li>•Infrared sensor</li> </ul>	There is connection	ATmega 328	<ul style="list-style-type: none"> <li>•The advantage of the system is that it continuously monitors the level of the LPG present in the cylinder using a load sensor.</li> <li>• the system allows us to book the gas from the gas agency when the weight of the gas cylinder reduces below a threshold value.</li> <li>• It also uses to alert the consumers about the wastage of gas while removing the utensils from the burner by using an object detection sensor.</li> </ul>
Controlling of LPG leakage automatically [10]	IOT		MQ2 gas sensor	There is connection	Raspberry Pi	<ul style="list-style-type: none"> <li>•A cost-effective and highly accurate system, which detect gas leakage and alert by a buzzer and control the leakage</li> <li>•Turn off A.C. mains supply</li> <li>•Open the window to throw out hazardous gas</li> </ul>
Smart Gas Booking System & Leakage Detection [11]	GSM		MQ6 sensor	There is connection	ARM	<ul style="list-style-type: none"> <li>•Very fast in response to detecting leakage and takes control action over it</li> <li>•Sending of automatically SMS for the agency and cylinder is booked.</li> </ul>

						<ul style="list-style-type: none"> <li>•Continuously displaying the level of the gas in the cylinder.</li> <li>•turn off of automatically the regulator knob if the gas leakage is taking place</li> </ul>
Toxic gas detecting and alerting system [12]	IOT		MQ2 sensor	There is connection	Raspberry pi 3 ARM CORTEX M4	<ul style="list-style-type: none"> <li>•the system offers quick response time and accurate detection of an emergency and in turn leading faster diffusion of the critical situation.</li> <li>•generating alarm immediately if gases exceed the normal level</li> <li>•Alert message (Email) is sent to the authorized person through the internet.</li> </ul>
Smart Home Service System [13]	IOT GSM WI-FI	•	<ul style="list-style-type: none"> <li>•LM35 Temperature sensor</li> <li>•Fire Sensor</li> <li>•MQ2 gas sensor</li> </ul>	There is connection	Arduino UNO board	<ul style="list-style-type: none"> <li>•promptly alert the person by sending SMS to mobile.</li> <li>• alert the people at home by triggering the Buzzer alarm when the gas leakage is detected display the message on the LCD .</li> <li>•if detected fire it will send the SMS and automatically the sprinkler motor will be ON.</li> <li>•If the temperature is detected the fan will be automatically ON.</li> </ul>
Gas Leakage Detection System [14]	IOT GSM WI-FI	•	<ul style="list-style-type: none"> <li>•MQ5 sensor</li> <li>•DHT22 Sensor</li> </ul>	There is connection	Arduino UNO board	<p>.the system provide us safety and also analyze the data stored in database to make predictions which can be helpful in current and future use.</p> <p>.It use of IoT reduce the cost of system to a greater extent which will make it less expensive than the traditional Gas detector systems . Operate many tasks when the gas leaks are detected such as sending of alarm signal , text messages(SMS)SMS and LED is turned on.</p>

Security system for an Organization [15]	IOT GSM Bluetooth	•	<ul style="list-style-type: none"> <li>•PIR motion</li> <li>•MQ-2 Gas</li> <li>•laser sensor</li> </ul>	There is connection	Arduino (Mega2560)	<ul style="list-style-type: none"> <li>•A low cost and flexible security system.</li> <li>•Energy-efficient and time-saving.</li> <li>•Sending of SMS.</li> <li>•Alarms when detecting movement around the motion sensor and detecting fire or gas around the gas sensor.</li> </ul>
Smart System for Human Presence Detection and Alerting Gas Leakage [16]	IOT	•	<ul style="list-style-type: none"> <li>•MQ2 sensor</li> <li>•PIR sensor</li> </ul>	There is no connection	ATmega328	<ul style="list-style-type: none"> <li>•Turn on a light of room when that PIR Sensor detects someone in the room.</li> <li>•Turn on the alarm system when that MQ2 gas sensor detects the LPG gas leakage</li> <li>•Sending a warning message to a user on the mobile phone.</li> </ul>
Smart Home Security System [17]	IOT GSM/GPR Bluetooth		<ul style="list-style-type: none"> <li>•MQ9 sensor</li> <li>•PIR motion</li> <li>•HC-SR04 Ultrasonic</li> <li>•Sonar Sensor</li> </ul>	There is no connection	Arduino mega board (ATmega2560)	<ul style="list-style-type: none"> <li>•A very low-cost security system.</li> <li>•Control of all electrical components such as fan, light, TV, refrigerator, air-condition.</li> <li>•Send SMS messages to mobile phones.</li> <li>•Turn on all the lights in the boundary of the house automatically When the strangers cross the Laser shield</li> </ul>
Hazardous Gas Detection System [18]	IOT GSM		MQ6 sensor	There is connection	AVR	<ul style="list-style-type: none"> <li>•Easy to use and gives a remote indication to the user .</li> <li>•The time required to carry out the inspection is dramatically reduced, reducing the cost .</li> <li>•Sending SMS messages to the authorized user as an alerting system.</li> <li>•Turn on the Buzzer as an alarm</li> </ul>
monitoring and controlling the home	IOT Wi-Fi	•	<ul style="list-style-type: none"> <li>•PIR sensor</li> <li>•MQ2 sensor</li> </ul>	There is connection	Arduino uno Board	<ul style="list-style-type: none"> <li>•Abridged implementation costs because of the use of wireless technologies.</li> </ul>

appliances [19]			<ul style="list-style-type: none"> <li>•Terminator Sensor</li> <li>•LDR Sensor</li> </ul>			<ul style="list-style-type: none"> <li>•providing house owners, a new level of control by automation of technology and modern building.</li> </ul>
System for detection of gas leakage and house fire in kitchen[20]	IOT	•	<ul style="list-style-type: none"> <li>•MQ5 gas sensor</li> <li>•DS18B20 temperature measuring sensor</li> </ul>	There is not connection ( local network)	MCP3008	<ul style="list-style-type: none"> <li>•Using of the maximum value method when measuring the gases. This method enables cover the worst-case scenario when measuring the concentrations of the gasses.</li> <li>•Using of Moving Average 3 algorithm in order to provide better energy efficiency</li> </ul>
Gas Monitoring system [21]	IOT	•	<ul style="list-style-type: none"> <li>•MQ-6 Gas sensor</li> <li>•MQ-2 Gas sensor</li> </ul>	There is connection	ATmega 328	<ul style="list-style-type: none"> <li>•The system is inexpensive due to Using of the Arduino microcontroller.</li> <li>•the system also uses to alert the consumers about the wastage of gas while removing the utensils from the burner by using an object detection sensor</li> </ul>
.Gas Leakage Detection and Alarming System [22]	IOT		<ul style="list-style-type: none"> <li>•MQ-2 Gas sensor</li> </ul>	There is connection	NodeMCU ESP8266 Wi-Fi	<ul style="list-style-type: none"> <li>•the system uses two IoT platforms; Blynk IoT application to alarm the regarding person and the Thingspeak IoT cloud for data recording and visualization.</li> <li>•Low system cost due to the use of the NodeMCU microcontroller</li> </ul>
System for Gas Leakages Monitoring [23]	IOT	•	<ul style="list-style-type: none"> <li>•MQ-2 Gas sensor</li> </ul>	There is connection By SIM800L, ESP8266Node MCU, LM2596	Arduino mega 2560	<ul style="list-style-type: none"> <li>•possibility of using the system in homes and places that need fire - fighting.</li> <li>•The system Helps detection of gas leakges and warn of potential accidents.</li> </ul>

Figure 2 indicates the number of included articles in table1 according to the year of publication. The distribution of scholarly papers from 2014 to 2022 is shown.

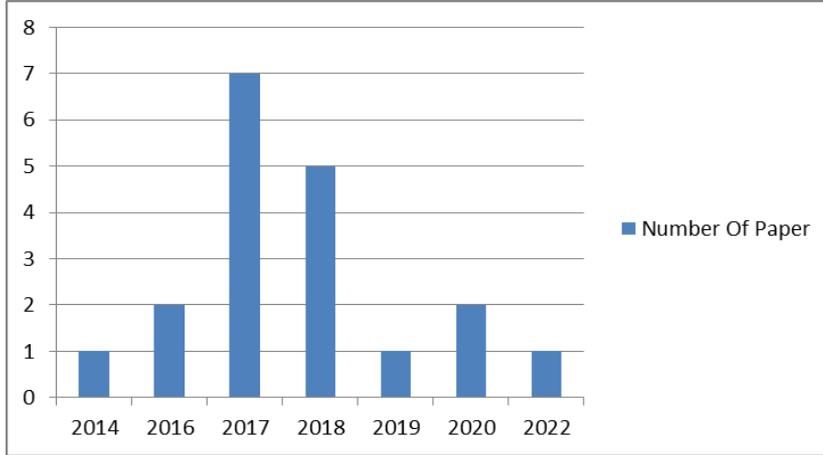


Figure2: The number of included articles in gas leaking detection systems by year of publication according to table 1

## 5. Discussion

Several smart home systems use various wireless communication technologies as Bluetooth, GSM, Wi-Fi, and IOT. In this section, we discussed the communication technologies used in the systems that discussed in table 1, so that the user can choose the appropriate technology by presenting the advantages and disadvantages of each technology.

**Bluetooth-** Bluetooth technology aims to exchange information wirelessly in a range of short distance up to 10-100M, it is known as "the IEEE 802.15.1 standard is based on a wireless radio system designed for short-range and cheap devices to replace cables for computer peripherals, such as computer mouse, keyboards, joysticks, and printers" [24]. When using Bluetooth technology communication between home appliances and the users is done using a smart phone or PC. One of the disadvantages of Bluetooth that it works on a limited range, this means that as long as the smart phone or computer is out of the Bluetooth network range, then it will not be able to control the home devices.

**WI-Fi-** It is an acronym that stands for Wireless Fidelity. Wi-Fi is " a wireless technology like a cell phone" [25], it enables computers and mobile phones to send and receive data anywhere within the range of a base station. One of the disadvantages of Wi-Fi that the frequency specification used is 802.11b, which is the same frequency many cellular phones, Bluetooth, microwave ovens operate on. This makes the security rate is low, In addition to the high cost. The advantage of Wi-Fi covers long-range up to 100-500 feet.

**GSM-** It is an international standard for mobile telephones. It is an acronym that stands for Global System for Mobile Communications [26]. when using GSM technology, communication between home appliances and the user is done through a mobile phone by sending SMS on a person's mobile, so the user can monitor and control the home devices by sending a text message from the mobile phone. One Disadvantage of GSM is no guarantee text message delivered to the system every time so it is not a reliable system.

**IOT-** It is an acronym that stands for the Internet of Things. It is " The ability of various things to be connected through the Internet or it is a network of physical devices (vehicles, building) connected to the embedded device (software, sensor) through the internet"[9]. In section 3, some literature review used IoT technology for remote controlling and monitoring of electronic and electrical appliances at home from any remote location. When using IOT technology, Communication between home appliances and the user is done through the internet, it provides services with or without direct human intervention.

Figure 3 indicates the most used of communication technology in the discussed systems according to table 1. We have noticed through the figure 3 that IOT is the most used technology among the papers reviewed for the following reasons:

- Less expensive than other technology.
- The possibility and ease of connecting all things in the home with the internet.
- Monitoring the home from anywhere in the world.

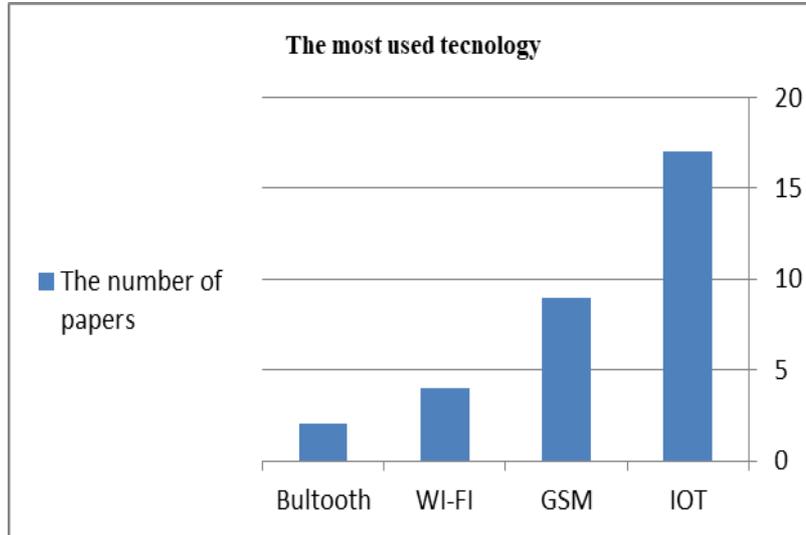


Figure3: The most used of communication technologies

## Conclusion

Nowadays, home safety is important to all people because it can avoid any injuries and accidents. The gas cylinder is used extensively in our homes. Liquefied Petroleum Gas (LPG) leakage is one of the biggest problems in the kitchen. where LPG is a highly flammable chemical. The leakage of this gas is dangerous as it enhances the risk of explosion. Moreover, LPG is colorless and odorless, for safety reasons, an odorant is added to LPG for easy detection of any gas leakage. In this paper, the concept of smart home have been presented , an extensive study on various types of smart home systems for gas leaking detection is discussed and their advantage by showing comparison of some smart home automation systems. , the used communication techniques in bulding a smart home systems in table 1 which include Bluetooth, GSM, Wi-Fi, and IOT have been evaluated by presenting the advantages and disadvantages of each technology. We believe that this paper will be greatly useful to devlopers and users to determine the best communication technologies for a smart home.

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