A Proposed Architecture for Smart Home Systems Based on IoT, Context-awareness and Cloud Computing

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***Abstract*—The main objective of this paper is to propose a simple, low cost, reliable and scalable architecture for building Smart Home Systems (SHSs) that can be used to remotely automate and control home appliances, using microcontroller. The proposed architecture aims to take advantage of emerging technologies to make it easier to develop Smart Home systems and to provide more management by expanding its capabilities suitably. The suggested design intends to make it easier and more convenient for many applications to access context data, as well as providing a new schematic guide for creating as complete and comprehensive Smart Home Systems and data processing as possible. Related topics like smart homes and their intelligent systems will be addressed by examining prior work and proposing the authors' opinions in order to suggest the new architecture. The proposed advanced architecture's building blocks include Classic Smart Homes, Internet of Things (IoT), Context-awareness (CA), Cloud Computing (CC), and Rule-based Event Processing Systems (RbEPS). Finally, the proposed architecture is validated and evaluated by constructing a smart home system.**

Keywords—Smart Home Systems (SHS); Internet of Things (IoT); Context-awareness (CA); Cloud Computing (CC); Rule-based Event Processing Systems (RbEPS); Smart Home System architecture

I. Introduction

Time, money, and energy are very valuable things. Smart Home Systems (SHSs) save time and reduce their owners' stress by ensuring homes are secured even when they are far away. Also, they save money and reduce the amount of effort put every day into running household helping owners having a better life [1], as they alert them of any change, allow users to control their homes when they are out, add safety through appliance, secure home through automated door locks [2], and increase peace of mind and convenience through temperature adjustment and lighting control [3, 4].

The proposed architecture is based on work done by [5], Internet of Things (IoT), Context-awareness (CA), Cloud Computing (CC) and Rule-based Event Processing Systems (RbEPS). Researchers frequently classify the problem of control as one of end-user programming, which causes them to think about research and assessment in terms of device control. End-user programming, on the other hand, gives the user some power over reprogrammed or learning-only systems [6]. The proposed architecture composition incorporates essential traits and technologies from each of the four main paradigms. In the construction of smart homes, the Internet of Things (IoT) plays a significant role. IoT allows for remote management of mobile users/devices/sensors by utilizing an internet connection [5,7,8]. Practically anything in a home might be associated with the Internet via IoT, allowing for remote monitoring and control of all connected objects regardless of time or location [9,10]. Smart homes need to detect, expect and react to home activities to improve families' lives through socially appropriate and timely assistance [11]. In CA, Sensors can be attached to residential systems like air conditioning, lights, and other environmental devices. Computer intelligence is embedded into home devices by attaching sensors to them in order to monitor/control home appliances' functionalities and detect/measure home conditions/context. CC provides scalable infrastructures and platforms for accessing home devices and developing, managing, and executing home services anywhere at any time, in terms of processing power and/or storage space. The RbEPS allows building and controlling a full advanced smart home [5]. Scaling system capabilities, interestingly, might easily transcend some unseen threshold, leaving families feeling at the mercy of, rather than in charge of, technology [6].

There are four specific problems which are addressed for this kind of computing environments, which are: (1) How to combine and integrate the building blocks. (2) How to acquire, distribute, and store context data. (3) How to create means for Smart Home service discovery; for example, how sensors can discover resources in the nearby. (4) Because there is no universal standard for IoT interoperability, it is difficult for devices from various manufacturers to connect with one another.

The following section, the Related Work section, states the main four paradigms' definitions and descriptions. Secondly, the paper presents the proposed architecture which contains new milestones based on previous work to integrate and link the main four paradigms. Thirdly, the proposed architecture is examined by building an intelligent Smart Home System (SHS). Then, the paper is concluded in section four and finally, the future work is stated.

II. Related Work

A Smart Home can make things easier as it provides great convenience for users by remotely controlled via Internet. It appears smart and intelligent because its computer systems are capable of monitoring a wide range of activities. For example, the lights will automatically turn off as soon as the sun rises [3]. In addition, such systems also provide security and safety for their users [1]. Developing such kind of systems are made easier with the rise of services provided by IoT, CA, CC, and RbEPS, which are discussed in the following subsection.

A. Related Paradigms

A Smart Home has advanced automatic systems for monitoring, controlling, and automating home capacities with electronic devices throughout the house [12]. It is a central system that can control and create communication between nearly all aspects of the house, which includes lighting, heating and air conditioning, security systems, gas and electric fireplaces, irrigation systems, doors, appliances, and more coming all of the time [13]. A Smart Home may be described as a residence which is equipped with modern technology sensors, appliances and devices that can be controlled, accessed, and monitored remotely in order to deliver services to the home's residents [14]. Smart Homes provide unlimited number of services, as [5]: (1) Measuring Home Conditions, (2) Managing Home Appliances, and (3) Controlling Home Access.

Smart home systems use services provided by Internet of Things (IoT). Academicians, researchers, practitioners, scientists, professionals, innovators, developers, pioneers, and corporate leaders have all come up with their own definitions for the Internet of Things. The initial version of the Internet, according to all definitions, was about data created by people, while the following iteration is about data created by things/objects [15]. The Internet of Things' purpose is to allow things to connect with anything and anybody at anytime, anywhere, and utilizing any path/network and service [16]. According to [16], IoT is classified into three categories interacting through internet, which are: (1). Things/machine to things/machine, (2) People to machine/things, and (3) People to people. The author in [17] defined IoT as "group of infrastructures interconnecting connected objects and allowing their management, data mining and the access to the data they generate." While [18] defined it as "an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment".

Context-aware computing is used to enhance Smart Home Systems. It is concerned with computer systems' ability to collect contextual knowledge to provide better services. Rather than considering mobility as a problem to be solved, context-aware computing attempts to take advantage of its inherent characteristics. A new breed of applications has emerged that increase user-app interaction by seeing/detecting the surrounding environment. Context-aware applications consider both explicit and implicit input. This contextual data is inferred from the application's surroundings. Context-aware applications are defined in terms of their flexibility, adaptability, reactivity, responsiveness, and sensitivity to context. The most prominent definition is defined by Dey et al. In [19], "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves". Also [20] defined context as "any continuous/discrete, dynamic/static, fixed/mobile, self-initiated/non-self-initiated, synchronous/asynchronous and volatile/nonvolatile available data that describe or characterize a principal entity. A principal entity may be a person or an object. Each principal entity has a set of elementary, mandatory and unique attributes. A principal entity has an associated one termed complementary entity. A complementary entity describes the principle one and contains any selective, secondary, inferred or profiling attributes. Its aim is to give more insight and details about the principal entity according to the application requirements. This data when captured, triggers specific events or enables interaction/querying with an application at certain time and responds depending on the current context at the time of service/output delivery".

As systems based on IoT need a huge amount of data to be stored, Cloud Computing paradigm is used. There have been many definitions of Cloud Computing by different researchers since it can and does mean different things to different people. The National Institute of Standards and Technology (NIST) defined cloud computing informally as [21]: "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" while [22] defined cloud computing as "a paradigm which enables unlearned users as well as well-educated developers to create, develop, customize, migrate, deploy, and/or manage legacy, custom, and/or new applications over the Clouds' infrastructure by providing ease of use tools, programing languages, services and/or hardware resources on the basis of a predefined Service Level Agreement (SLA) with the possibility to reconfigure/change application features explicitly by users or implicitly/dynamically by Cloud providers such as scaling, deployment and/or resource allocation".

Event processing systems react to events in the system's environment or user interface and able to perform operations on events, such as: reading, creating, transforming, and deleting events. These systems examine events or streams of events before taking automated actions. Anything that occurs at a given moment and can be documented is referred to as an event. Pre-defined decision tables or more powerful machine learning algorithms can be used to analyze data, and there are a variety of actions that can be taken, from generating a new event to modifying a customer's experience to scaling cloud resources up or down. The key characteristic of event processing systems is that the circumstance of events is unpredictable and the system must be able to deal with these events when they occur [23]. While event processing is concerned with detecting events from large event clouds or streams in almost real-time, reaction rules are concerned with the invocation of actions in response to events and actionable situations [24].

TABLE I. A COMPARISON OF RELATED SMART HOME SYSTEM ARCHITECTURES AND THE PROPOSED ARCHITECTURE

Paper	Purpose	Technologies	Layers / Components
[5, 2019]	An architecture for integrating classic smart home, IoT, and cloud computing.	IoT, Cloud Computing, and rule-based event processing.	**(1) Sensors:** not IoT sensors, used to collect internal and external data which transferred via the local network to server. **(2) Processors:** used to process sensors' data and perform local and integrated actions. **(3) APIs:** A collection of external software components used to process sensors data or manage actions. **(4) Actuators:** used to execute commands in the server or other control devices. **(5) Database:** used to store, analyze, present, and visualize the processed data.
[25, 2019]	An architecture for big data-driven processing and management.	IoT and Cloud Computing.	**(1) Physical Layer:** includes three types of sensing technologies and devices for health, energy, and security and safety. **(2) Fog-computing Layer:** includes sensor hubs for simple data processing and computing. **(3) Network Layer:** includes gateway and communication protocols. **(4) Cloud-computing Layer:** It is used for extensive processing, computing and for data communication. It includes Data Stream Management System (DSMS), Data Lake, Real-time processing system, and Batch processing system. **(5) Service Layer:** includes two main types of data views for operational and analytical data. **(6) Session Layer:** provide standards and APIs to exchange data between services and application layers. The RESTFUL APIs and URL-based communication are used in this layer. **(7) Application Layer:** includes all the applications which are subscribed to use or exchange data-driven services with such as domestic applications and/or third-parties.
[26, 2019]	An architecture for managing heterogeneous data from third parties.	IoT and Cloud Computing.	**(1) Device Layer:** includes connected IoT devices such as sensors, actuators, and/or appliances. **(2) Gateway Layer:** provides the ability to communicate with different smart devices. It also interacts with databases for data storage. **(3) Application and Service Layer:** provides the main services related to health and energy.
[27, 2021]	An architecture for discovery of resident behavior patterns.	IoT and Machin Learning.	**(1) Presentation Layer:** provides an interface for users to get access to the system. **(2) Security Layer:** provides modules; such as authentication module, to ensure secure access to the platform's functions. **(3) Control Layer:** includes necessary methods/modules; such as user control and automatic control modules, to access connected device's functions. **(4) Communication Layer:** provides communication between different modules and elements through APIs such as REST. **5) Data Layer:** provides data of interest and/or information needed for other modules. It consists of device data, device history, user data, house data, and configuration rules. **(6) Devices Layer:** includes the communication technology necessary to control and monitor devices such as sensors and IoT devices.
[28, 2021]	An architecture for home integration and automation with security services	IoT	**(1) Application Layer:** provides services such as health care, security, video monitoring, entertainment, etc. **(2) Network Layer:** uses internet to transmit information to application level. **(3) Sensing Layer:** guarantees that data from all connected devices/sensors are transferred to the network layer after processing.
[29, 2021]	An architecture for providing secure and safe environment and reducing energy consumption.	IoT, Cloud Computing, and Edge Computing.	**(1) Device Layer:** used to integrate sensors into the system to collect data. **(2) Broker Layer:** used to transmit data and commands from different sensors to the service layer. **(3) Service Layer:** used to receive data from the broker layer to make one or more of the following features; data management, software management, personal cloud, and data aggregation. **(4) Application Layer:** used to implement a user-friendly dashboard to manage and control IoT devices. **(5) Cloud Layer:** used to store home data as a long-term storage for future analysis.
The proposed architecture.	For controlling smart home systems based on context awareness.	IoT, Cloud Computing and Context-awareness.	**(1) Data Collection Layer (DCL):** used to sense and collect data from various devices. **(2) Data Management Layer (DML):** used to manage the collected data. **(3) Context Formulation Layer (CFL):** used to formulate a context based on the collected data, while the fourth one. **(4) Service Inference Layer (SIL):** used to infer specific activities and tasks according to the formulated context. **(5) Service Management Layer (SML):** used to save/manage all this data, information, and/or context.

B. Related Architectures

Table I compares among some related Smart Home System architectures done by [5,25,26,27,28,29] and the proposed architecture in terms of purpose, used technologies and consisted layers/components.

III. CONTRIBUTION

A. The Proposed Architecture

As stated in Table I, the proposed architecture composed of five phases achieved by five layers as shown in Fig. 1. The proposed architecture adds a context-awareness layer; data formulation layer, to formulate meaningful data from small pieces of data collected by sensors/actuators.

The first and second layers belong to IoT, the third layer belongs to context-awareness, while the fourth layer is for Rule-based Event Processing Systems, and the fifth one belongs to Cloud Computing in addition to IoT and context-awareness. All of the architecture layers are discussed as follows:

- Data Collection Layer (DCL): This layer is responsible of collecting data from various user devices, sensors, actuators and/or databases (DBs). Smart actuators are devices, such as valves and switches that conduct activities such as turning items. Sensors collect internal and external home data, which is used to measure home conditions and recognize its context. Sensors are linked to both the home and the devices that are connected to it. Users can control the output of smart actuators related with household appliances (Smart Remote), such as lighting and doors, using User Devices (APIs).

- Data Management Layer (DML): The main job of this layer is to provide required data to the Context Formulation Layer (CFL) through the Data Acquisition component. All data collected in the DCL is sent across the local network to the smart home server (Data Storage), which stores the processed data collected from sensors and/or cloud services. It will be used for data analysis, data visualization, and data presentation. For future usage, the processed data is saved in the associated database. The Monitor is specifically designed to collect data; context attributes, in the environment by collaborating with some type of sensor equipment, and properly associate it with a context, whilst Listeners allow users to subscribe to changes to specific data.

- Context Formulation Layer (CFL): A single sensor, in most circumstances, only gives a fraction of contextual data diversity and is susceptible to several constraints. In order to fully understand and increase benefits of captured data, it must be refined by aggregation, transformation, interpretation, filtering, and splitting. These refinements bridge the gap between the raw sensor output and the level of abstraction required by applications through one of the following operations. Although there is enormous amount of low-level context data, it is suggested to store it for better monitoring and auditing as well as expanding context usage. Context Storage provides a data pool with a history of all contextual data obtained. This history can be used to access entities' prior contexts, deduce their activities, make conclusions about their requests, anticipate future situations, and analyze sensor performance. Based on [11], context main operations and their usage are described in Table II.

- Service Inference Layer (SIL): The Service Inference Layer's (SIL) responsibility is to infer appropriate context services which are related to the formulated context given by previous layer and/or any acquired/reasoned context. The inference process is based on Access Control for security reasons. Context Services are controlled by the Access Control component, which ensures that client requests are authenticated correctly. The access control list, which specifies what the requesting clients can access, and the means for authenticating the client, are the two main aspects of this component.

- Service Management Layer (SML): The management of any component included in this architecture is done by this layer. The Data/Context/Service Management is for managing any process related to data, context, and/or services such as context formulation/acquisition, service inference and/or storing data/context while the Device/Sensor Management responsibility is to manage devices/sensors such as attach/reattach them to the Smart Home System. The Communication management component is responsible of managing protocols, technologies, and/or tools needed for the communication process. Also, this layer is responsible of the management of Data/Context Storage, Context Services and/or the Cloud.

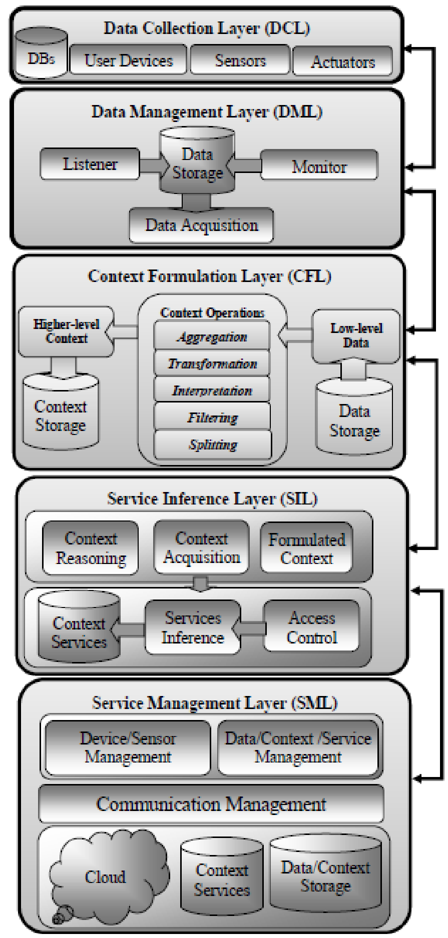

Fig. 1. The Proposed Architecture.

TABLE II. CONTEXT OPERATIONS

Operation	**Usage**
Aggregation	To construct a higher-level context from a variety of logically connected context data collected from various sensors.
Transformation	To convert context data into an appropriate format.
Interpretation	For reusability, the same attributes may be interpreted differently in different contexts.
Filtering	To select an appropriate context by filtering in different context data values.
Splitting	To extract the sensed attribute according to the needed data/format. E.g., extract hours from timestamp.

B. Mapping the Proposed Architecture

In this section, an implemented Smart Home system (SHS) is build based on the proposed architecture, as shown in Fig. 2, SHS consists of eight main components which are described in the following Table III.

C. Applying the Proposed Architecture

The proposed architecture was applied to implement a Smart Home System using the following hardware: (1) Arduino Uno microcontroller board, (2) ESP32 chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth, and (3) Sensors & Actuators such as: (Solenoid Valve, 4x4 keypad, R305 Optical Fingerprint Scanner Sensor, FC-28 Soil moisture Sensor, rain sensor, photoresistor sensor, PIR sensor, DHT11 Sensor, and MQ2 gas sensor), while the software needed for implementation is as the following: (1) Arduino Integrated Development Environment (IDE). Code is written in C++ with an addition of special methods and functions. (2) IFTTT Driver, which is a software platform that links multiple developers' applications, devices, and services in order to trigger one or more automations involving those applications, devices, and services. (3) MQTT, which is an "IoT" connectivity protocol. It was created to be a very light weight publish/subscribe messaging service. (4) an account on the Ubidots cloud by which events are sent, triggered, and brought via Email, SMS, Telegrams, or Voice Call based on a customized design rule created in the application.

A SHS complete scenario may be detailed as: (1) The owner enters the smart home by inputting his/her password on the keypad or finger on the fingerprint sensor. The door will open in case of a known owner, otherwise an alarm will be fired, and a message will be sent to the owner if three tries to open the door are failed. (2) When the owner enters the house, his/her motion will be detected by the motion detection sensor. The light will be automatically turned on. It will be opened and closed using Google assistant or Ubidots cloud. In the night, lights out-of-doors will be turned on based on signals got from the photoresistor sensor. (3) If the temperature sensor detects temperature increase to a certain degree and the motion detection sensor detects that there is a movement in the room, the air conditioner will be opened and a message to inform the owner will be sent. (4) When the soil sensor detects that the quantity of water in soil decreases, the solenoid valve of water will be opened until the value of sensor will be increasing and a message will be sent to owner to monitor the condition of soil through the cloud. (5) When the rain sensor detects that it's raining, a message will be sent to the owner that rains fall outside. (6) If the gas sensor detects a gas leak, an alarm will be fired, and a message will be sent to the owner. (7) If someone asked to open the garage door, the Infrared obstacle avoidance sensor module detects there is a car inside the garage or not. The door will be opened using Google assistant if there is no car inside.

When any specific activity occurs, SHS gets to work. Table IV, shows some defined activities and related actions inferred according to those activities.

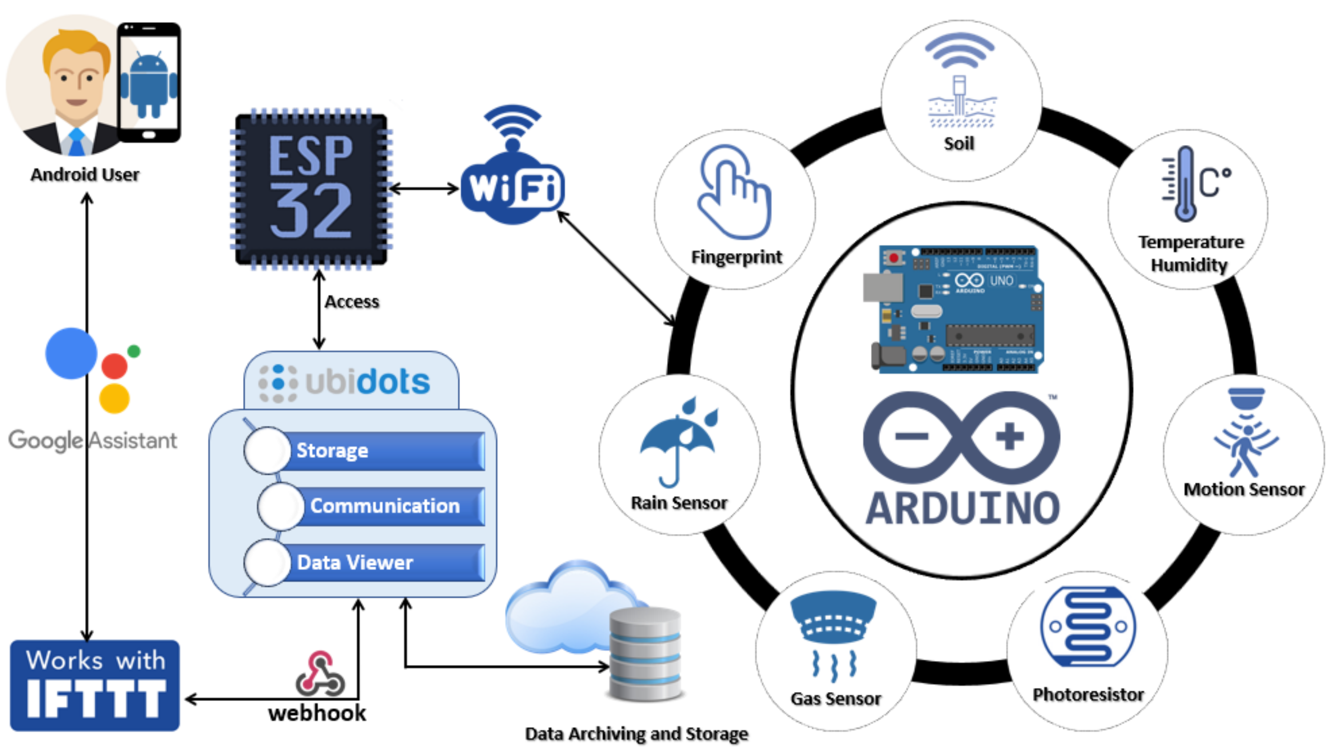

Fig. 2. The Implemented Smart Home System (SHS).

TABLE III. THE PROPOSED ARCHITECTURE MAIN COMPONENTS

Component	Description	Usage
User Device	Allows users to regulate the outputs of smart actuators connected to home appliances (Smart Remote) mobile phone.	Control the connected home devices from smart home app (IFTTT).
Home/Residential Gateway	Permits a small network, known as a Local Area Network (LAN), to be connected to a larger network, known as a Wide Area Network (WAN).	It connects home elements with the Internet via Wi-Fi.
ESP32	The ESP32 is a family of low-cost, low-power system-on-a-chip microcontroller that incorporate implicit Wi-Fi and dual-mode Bluetooth.	The principal usage of this board is dealing with all communication, sensor readings, and outputs.
Ubidots	Ubidots is an Internet of Things (IoT) data analytics and visualization company. It keeps dots from devices into variables, and these dots have timestamps associated with them. A “dot” or a data-point is framed each time a gadget refreshes a sensor esteem in a variable. The following items are found in each dot: - **Value**: A numerical value. Ubidots takes values of up to 16 floating-point in length. - **Timestamp**: Unix Epoch time, in milliseconds. If not determined, then servers will assign one upon reception. - **Context**: A set of unlimited arrangement key-value pairs with no restrictions. Latitude and longitude coordinates of GPS devices.	It is the cloud by which the computing and storage takes place on servers in a data center, instead of locally on the user device. It enables users to access files and applications from almost any device. So, users can control their home anywhere. Sensor data is transformed into useful information for corporate choices, machine-to-machine interactions, educational research, and increased global resource economization.
IFTTT	Stands for “If This Then That”, known as IFTTT is a freeware web-based service that builds applets, which are chains of basic conditional statements.	IFTTT helps connecting different applications and devices, manage them from Google assistant in phone.
Database	A repository for storing data collected from sensors and/or cloud services that has been processed.	Utilized for data processing, data visualization, and data display for future usage.
Google Assistant	This service works with Google Home or Pixel devices. It's incredibly flexible.	Used to create custom voice commands for home control, send updates, and more.
Webhooks	Webhooks are the way by which apps can send automated messages or information to other apps when something happens.	Used for speaking between online accounts and receiving automatic notifications when something new occurs. It is used to send data from one application to another automatically.
Sensors / Actuators	Collect data from both inside and outside the home. They are connected to the home and to the gadgets that are connected to the home	Used to capture data and send it to the smart home server on a regular basis across the local network.
- **Fingerprint**	It is one of the most secure methods for detecting and identifying authorized persons.	Used to make pretty sure about security needs.
- **Soil Sensor**	Determine the volumetric water content in soil.	It aids home owners Knowing their gardens' specific soil moisture conditions for helping them better managing their irrigation systems.
- **Temperature/humidity**	Measures the temperature/humidity and converts input data into electronic format for recording/monitoring.	This sensor may simply be connected to any microcontroller, such as an Arduino or a Raspberry Pi, to measure temperature and humidity in real time.
- **Motion**	Designed to detect and measure movement.	Used to detect the movement of home owners to perform highly specific functions.
- **Photoresistor**	Light sensitive resistors most often used to indicate the presence or absence of light, or to measure the light intensity.	Utilized when it is required to detect the presence and absence of light or measure the light intensity.
- **Gas Sensor**	The gas sensor is an electrical device that detects the presence of gas in the atmosphere.	Utilized to detect the presence of gases such as LPG, propane, methane, hydrogen, alcohol, smoke, and carbon monoxide in the air.
- **Keypad**	A keypad is a set of buttons arranged in a block or "pad" which bear digits, symbols, or alphabetical letters. Pads mainly include numbers are called a numeric keypad.	Used for the entry of PINs including Point of Sale payment devices, ATMs, vending machines, combination locks and digital door locks.
- **Rain sensor**	The rain sensor module is a simple tool for detecting rain. It is a rain-activated switching gadget.	When a raindrop falls through the rainy board, it can be used as a switch, as well as for gauging rainfall intensity. Rain sensors have two primary applications: (1) is a water-saving device that is attached to an automatic irrigation system and causes the system to shut down if it rains. (2) is a device that protects the interior of a car from rain and allows windscreen wipers to operate in automated mode.

TABLE IV SHS MAIN ACTIVITIES AND ACTIONS

Service		Activity	Initialization	Sensor/Device	Input	Processing	Output/Action
Smart Lighting system	Inside home.	Owner enters the home.	Owner movement.	A passive infrared sensor (PIR).	Signal from the motion detection sensor.	The system detects there is a movement.	The light automatically turns on. It will be opened and closed using Google assistant or Ubidots cloud.
	Outside home.		Sun set.	Photoresistor sensor.	Signal from the photoresistor sensor.	The system detects that it is night.	Lights out-of-doors will be turned on only in the night.
Smart Security system	Fingerprint	A person puts his/her finger on the fingerprint sensor.	Detecting finger on fingerprint sensor.	Fingerprint sensor.	Person fingerprint.	The system compares between this fingerprint and enrolled fingerprints; then sends a signal to door lock and alarm.	1) If the fingerprint/password is known: the door will open. 2) If a wrong fingerprint/password was entered three times: turn alarm on and send owner a message that there was an attack.
	Keypad	A person enters his/her password.	Entered password in the keypad.	keypad 4*4 standard device.	The entered password.	The system compares between the entered password and saved ones, then sends a signal to door lock and alarm.	
Smart watering system.		No or less water in soil.	The quantity of water soil decreases.	FC-28 Soil moisture sensor.	The value of soil sensor.	Solenoid valve of water opens.	The solenoid valve of water will be opened until the value of sensor increases. A message to owner will be sent to monitor the conditions of soil through the cloud.
Smart Rain system		Rain drops fall on the sensor.	The rain drop fall.	Rain sensor.	The value of the rain sensor.	The sensor detects that it's raining.	A message will be sent to the owner that it’s raining. Store that in the database weather session.
Smart Temperature		A certain temperature degree has reached and there is a movement.	The temperature degree increases	DHT11 Precision humidity & temperature.	Temperature degree and movement in the room.	Temperature will adjust by opening air conditioner.	Temperature will adjust by opening air conditioner and a message was sent to inform the owner.
Smart Gas system		A gas leak is detected by the gas sensor.	There is a gas leak in the home.	MQ2 smoke, gas, liquid-field module.	The gas sensor's value.	The gas sensor detects the leak and alerts the alarm system.	The owner will receive an alert message, and the alarm is fired. Data is stored in the database.
Smart Garage door		Detecting car in the garage.	A person asked to open the garage door.	Infrared obstacle avoidance sensor module.	Number of cars inside.	Detect if there is car inside or not and send a signal to door lock.	Unlock the garage door if there's no care inside using Google assistant.

IV. CONCLUSION

Smart homes are large systems that comprise a variety of technologies and applications that can be utilized to provide home protection and control. They have wireless communications, sensors, monitors, and tracking connections.

An efficient technique for smart home systems was presented and implemented in this paper. The proposed architecture shows how to combine benefit features from IoT, Context-Awareness, Cloud Computing and Rule-based event processing systems paradigms to facilitate the building of Smart Home systems in a more systematic manner.

The implemented system has been subjected to a range of tests and experiments. These experiments demonstrate the concept of employing ultrasonic sensors to create a house navigator that can measure and control temperature in all rooms, detect any fires, water leaks, smoke, and/or detect any motion in the home. Furthermore, these experiments demonstrate how to observe and track the home by sending messages to the owner about actions that have occurred, as well as how to secure it using an access code.

Three microcontroller system designs were used to create a central control system for the entire house. These designs were for home access control, temperature validation, and a control board system that would connect all of the security and control circuits.

V. FUTURE WORK

Regarding the proof-of-concept system developed by this work, it is understood that it provides a subset of a fully functional smart home system. Therefore, the first recommendation would be to develop and implement other areas. Additionally, future work should also include the implementation of the core as a web service and the development of a web-based user interface to accommodate heterogeneous web-based clients.

There are several improvements that might be made to the existing system to improve sensing and detection accuracy. There are also a variety of different sensors that can be utilized to improve the security and control of the home.

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