Aqua-Trail: IOT Based Smart Water Bottle

A PROJECT REPORT

Submitted by

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Under the Guidance of

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Assistant Professor, Department of Networking and Communications *In partial fulfillment of the requirements for the degree of*

BACHELOR OF TECHNOLOGY

in

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with a specialization in INTERNET of THINGS

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BONAFIDE CERTIFICATE

Certified that this B.Tech project report titled "Aqua-Trail: IOT Based Smart Water Bottle" is the bonafide work of **Mr. Vanshaj Barnwal [Register Number: RA2011032010035]** and **Mr. Vinay Poddar [Register Number: RA2011032010061]** who carried out the project work under my supervision. Certified further, that to the best of my knowledge, the work reported herein does not form part of any other thesis or dissertation based on which a degree or award was conferred on an earlier occasion for this or any other candidate.

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EXAMINER I

EXAMINER II

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Own Work Declaration Form

Degree/ Course : B.Tech in Computer Science and Engineering with specialization in the Internet of Things

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Title of Work : Aqua-Trail: IOT Based Smart Water Bottle

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TABLE OF CONTENTS

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ABSTRACT

The Smart Water Bottle is a cutting-edge technical solution created to address the ever expanding issue of staying properly hydrated in our daily lives. Dehydration is a serious health problem that can have a range of negative repercussions, including poor physical and cognitive function. A smart water bottle is a type of water bottle that uses sensors and technology to track fluid intake, monitor activity, and provide insights into hydration levels.

Smart water bottles can typically connect to smartphones or other devices via Bluetooth or Wi-Fi, allowing users to track their progress towards hydration goals, receive reminders to drink water, and view data on their hydration habits.

To measure and optimize users' hydration patterns, this smart water bottle makes use of cutting-edge sensor technology, networking, and data analysis. Numerous sensors, including accelerometers, temperature sensors, and fluid level sensors, are included in this smart water bottle. Together, these sensors keep track of ambient conditions and water intake. The information is then transferred to a special smartphone app through Bluetooth or Wi-Fi so that users can quickly access and understand their current level of hydration.

To promote healthier drinking pratices, the app offers insights into daily water intake targets, personalized recommendations, and historical data. The Smart Water Bottle may alter messages and reminders based on the user's activity levels, the weather in the area, and individual preferences in addition to monitoring water intake.

Additionally, it provides the choice of user-customizable hydration goals, allowing users to adjust the suggested water consumption to meet their own requirements. By encouraging proper hydration, assisting in the prevention of health problems associated with dehydration, and minimizing single-use plastic bottle waste, this innovation has the potential to significantly improve public health.

The Smart Water Bottle is a promising option for a healthier and more sustainable future since it combines technology with a necessary component of daily living. Structured data is compatible with a conventional relational database management system (RDBMS) because it adheres to a model or schema that specifies how the data is represented or organized. Structured values, like temperature, pressure, humidity, and so forth, are frequently used in Internet of Things sensor data and are transmitted in a predefined format. Unstructured data does not follow a logical pattern that can be understood and decoded using conventional programming techniques. Unstructured data is generally defined as any data that does not neatly fit into a predefined data model.

LIST OF FIGURES

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LIST OF SYMBOLS AND ABBREVIATIONS

IOT – Internet of Things

R&D – Research and Development

SMTP – Simple Mail Transfer Protocol

GSM – Global System for Mobile Communication

LoRaWAN – Long Range Wide Area Network

Wi-Fi – Wireless Fidelity

MQTT – Message Queuing Telemetry Transport

IPv6 - Internet Protocol version 6

LoWPAN - Low-Power Wireless Personal Area Network

DTLS – Datagram Transport Layer Security

NFC – Near-Field Communication

BLE – Bluetooth Low Energy

RFID - Radio-Frequency Identification

IIOT – Industrial Internet of Things

IP – Internet Protocol

AMQP - Advanced Message Queuing Protocol

XMPP - Extensible Messaging and Presence Protocol

CHAPTER 1

INTRODUCTION

1.1. General

The Internet of Things (IoT) has become a game-changing idea in technology that is redefining how we conduct business, interact with our physical surroundings, and go about our daily lives. The internet of things (IoT) is a network of physically connected "things" that are equipped with sensors, software, and communication technologies to gather, share, and use data. These items can be anything from commonplace gadgets like smart home appliances and cellphones to specialized machinery used in industrial, medical, and agricultural settings, among other fields.

The "things" themselves, which are outfitted with a variety of sensors and actuators, form the basis of the Internet of Things ecosystem. Thanks to these sensors, the devices are able to gather a wide range of environmental data, such as temperature, humidity, light, motion, location, and much more. The devices' actuators enable them to take actions in response to the data they gather. For instance, an Internet of Things-enabled smart thermostat can gather temperature data and modify heating or cooling systems appropriately.

The network of mechanical, digital, and computer devices that can communicate with one another without the need for human-to-human or human-to-computer interaction. These devices are linked together by unique identifiers. These objects include cars, appliances, and other household appliances, as well as other items embedded with electronics, software, sensors, actuators, and connectivity that allows them to communicate and share data. This opens up possibilities for more direct communication between computer systems and the real world, for a deeper comprehension of the world, and for increased effectiveness, productivity, and decision-making.

IoT features such as sensor networks are crucial because of their inherent intelligence, which is further divided into two categories: object intelligence and network intelligence. The following features define a network's intelligence:
The communication standards of the layers connecting nodes to the internet should be open to standardization for layers interacting with the physical world, such as tags and sensors.
Both object addressability—which gives an IP address—and multifunctionality—which allows a network designed for one application to be used by other applications—are important features.

Using the internet and cutting-edge technologies like real-time localization, embedded sensors, and near field communications, everyday objects can become intelligent and respond to their immediate surroundings. This is known as object smartness.

An actuator is a tool that changes the environment around it, much like the temperature controller in an air conditioner. At the network's edge or on a server, data can be remotely processed and stored. If data preprocessing is feasible, it is typically done at the sensor or

another adjacent device. After processing, the data is typically sent to a distant server. An Internet of Things object's processing and storage capacity is also constrained by its available resources. Because of their limitations in terms of size, energy, power, and computational capacity, these resources are frequently severely limited. Apart from the challenges associated with collecting and organizing data, there are also communication problems.

Because Internet of Things devices are typically installed in geographically dispersed locations, their primary means of communication is wireless. The wireless channels are frequently unstable and exhibit high distortion rates. In this case, transmitting data consistently and with a minimal number of retransmissions is a significant issue, so communication technologies are essential to the research by IoT gadgets. Actuators allow us to directly alter the physical world, or we can something that is virtual. For instance, we can communicate with other intelligent items.

The physical world's capacity to accept a change often depends on its current state at that specific time. This is known as context awareness. Every decision is made with the circumstances in mind, as different applications may behave differently in different environments. For example, a person may prefer not to have his office interrupt him while he is on vacation. Sensors, actuators, compute servers, and the communication network are the essential parts of an Internet of Things architecture. However, there are numerous software-related considerations. We first require a middleware in order to connect and manage all of these heterogeneous components. To link a vast array of devices, numerous standards are needed. Numerous fields, such as energy conservation, home automation, fitness, education, entertainment, social life, and health care, have applications for the Internet of Things.Here is a small and prescribed detail of the project:

- **Problem:** It is common for people to forget to drink enough water. A smart water bottle could help users stay hydrated by tracking how much water is consumed. Maintaining hydration when traveling can be difficult. A smart water bottle can track how much water is consumed while a user is away from home by pairing with a smartphone app. For the smart water bottle to be easy to use and comprehend, its user interface must be user-friendly.

- **Solution:** In this innovation, data from the bottle is recorded using sensors and sent to the cloud for analysis. First, the mobile application on a smartphone processes the data, after which it retrieves it.

- **Benefits:** There are many advantages to using a smart water bottle to encourage hydration habits. It monitors water intake, notifies users to stay hydrated, and synchronizes with mobile applications to provide all-encompassing tracking. This makes it easier for people to reach their daily hydration objectives, which promotes better health, more energy, and an all-around sense of wellbeing. It is an excellent tool for customizing one's water intake because of the customizable features, like the ability to set personal hydration targets. Ultimately, by minimizing the use of single-use plastic bottles, a smart water bottle promotes improved health, convenience, and an environmentally friendly way of living.

- **Challenges:** There were numerous challenges which has been faced during the project. It included managing power consumption so that the sensors and other devices consume less power to extend the battery life, there were certain challenges while integrating the hardware components to the cloud using the code as we needed to ensure that the real-time data reaches the cloud. While creating the application we have kept in mind that user experience has to be hassle-free so that they can easily trace their consumption level.

The coming era of technology will witness a growth beyond mobile internet to massive IoT within the next three to four years. The next generation will primarily focus on improving the functionality of critical communication use cases and speeding up data transmission. IoT will allow for quicker, more responsive, and real-time applications thanks to 5G connectivity. Edge computing will speed up the development of IoT and lower latency. Smarter, more independent gadgets and data-driven insights will result from the combination of AI and machine learning. Blockchain will increase trust and security in IoT. Our lives and the world will be better off as IoT is expanded into healthcare, smart cities, agriculture, and environmental monitoring. Privacy and security will be at the forefront of IoT development as interoperability and standardization become increasingly important. In the end, IoT promises to create a more efficient, sustainable, and connected world.

1.2. Purpose

The goal of a smart water bottle is to transform how people manage their hydration, encouraging a sustainable lifestyle and better environment. A smart water bottle combines the convenience of modern living with the analog act of drinking water to create a seamless, tech-savvy companion to traditional hydration. Its main objective is to improve and monitor your drinking habits. These water bottles track how much water you drink and provide you with reminders to stay hydrated all day long thanks to their sensors and connectivity features.

The bottle frequently syncs with a complimentary mobile app to give you real-time information on how hydrated you are. This promotes a more deliberate approach to drinking water and makes it possible to set individualized hydration objectives depending on variables like age, weight, and degree of activity. To maximize your hydration needs, certain smart bottles even take the environment into account.

Furthermore, these bottles could have temperature control capabilities, which guarantee that your drink remains at the ideal temperature for extended periods of time. In order to purify the water and make it healthier to drink, some models also use UV-C technology. By using technology to optimize and track hydration routines, a smart water bottle essentially goes beyond the traditional idea of a simple container to become a comprehensive tool for promoting well-being.

This cutting-edge gadget combines technology, connectivity, and practical features to meet multiple important goals:

- **Hydration Tracking and Optimization:** The ability to precisely monitor a person's water intake is one of the smart water bottle's main functions. It assists users in meeting their

hydration objectives by tracking the quantity of water they drink. The smart water bottle is a dependable tool for making sure users drink enough water each day, as dehydration can cause a number of health problems. It makes it simpler for people to meet their hydration needs by providing real-time data on water consumption.

- **Customized Hydration Goals:** With the help of the smart water bottle, users can customize their hydration objectives according to climate, activity level, age, and weight. By customizing it, the suggested daily intake of water is made to meet the individual needs of the user. Users are therefore able to attain their ideal levels of hydration, which enhances their general wellbeing.

- **Mobile App Integration:** Companion smartphone apps are frequently included with smart water bottles. These apps offer a thorough picture of a person's regular drinking routine. By syncing their bottle data with the app, users can set goals, monitor their progress, and gain insightful information. Users can easily access their hydration data and track their progress over time thanks to this integration.

- **Data-Driven Insights:** The smart water bottle produces insightful data about the hydration habits of its users. These observations can be used to evaluate individual habits, spot patterns, and decide on lifestyle adjustments with knowledge. It provides a more profound comprehension of personal hydration requirements.

- **Environmental Sustainability:** Sustainability of the environment is one of the smart water bottles' primary goals. These gadgets support the global initiative to minimize the environmental impact and reduce plastic waste by lowering the consumption of single-use plastic bottles. This promotes environmentally responsible behavior and a more sustainable future.

- **Encouraging Healthy Hydration Habits:** Certain cleverly designed water bottles have eye-catching and colorful features that draw in kids. By making drinking more enjoyable, these bottles can help kids form good hydration habits early in life. This goal makes sure that people learn the value of staying hydrated at a young age.

1.3. Scope

Smart water bottles have a wide range of applications, including corporate wellness programs, sports, healthcare, education, research, and environmental sustainability in addition to consumer wellness. These gadgets have the power to completely change how people regulate their hydration levels and promote better practices. They can provide advanced features, customization, and integration into the Internet of Things (IoT) ecosystem with continued innovation. Their multifarious uses render them indispensable resources for individuals who prioritize their health, medical professionals, athletes, scholars, and environmentalists. The smart water bottle market has a lot of room to grow and make a big impact as long as technology and user preferences continue to advance. The scope of smart water bottles includes:

- **Consumer Market:** There is a lot of room for growth in the market for smart water bottles. With the increasing awareness of health and wellness, people are looking for tools to assist

them in staying properly hydrated. Fitness enthusiasts, people who are concerned about their health, and people searching for practical solutions to track and maximize their daily water intake are all part of the market.

- **Applications in Healthcare and Medicine:** Intelligent water bottles have a lot to offer in these fields. They can be used to monitor patients, especially those with certain medical conditions that call for careful hydration control. These gadgets can be used by healthcare facilities and providers to monitor and enhance patient hydration.

- **Sports and Athletics:** There is a lot of room for smart water bottles in the sports and athletics industry. Monitoring and optimizing hydration levels during training and competitions can be beneficial for coaches, trainers, and athletes. Sports performance analytics and fitness tracking can be combined with these bottles.

- **Corporate Wellness Programs:** In an effort to improve the health and wellbeing of their workforce, employers are implementing wellness initiatives more frequently. To encourage staff to stay properly hydrated, these programs can make use of smart water bottles.

- **Educational Institutions:** By using smart water bottles, educational institutions can encourage their students to drink plenty of water. Features like gamification could be included in the design of these bottles to appeal to younger users.

- **Research and Data Collection:** Studies pertaining to hydration, behavior analysis, and public health can all benefit from the data produced by smart water bottles. This data can be used by researchers to better understand patterns of hydration and create plans for enhancing public health.

- **Environmental Sustainability:** One way that smart water bottles support environmental sustainability is through their use. As part of their sustainability initiatives, businesses and organizations can help reduce the usage of single-use plastic bottles, which has positive environmental effects.

- **Integration with the Internet of Things (IoT) Ecosystem:** Smart water bottles can be connected to other smart systems and gadgets in homes, workplaces, and public spaces by being incorporated into the larger IoT ecosystem. A vast array of interactions and applications are made possible by this connectivity.

Smart water bottles have a wide range of applications, user demographics, and industries covered. With technology, consumer tastes, and healthcare priorities always changing, there is still a lot of room for innovation and expansion in the smart water bottle market.

1.4. Internet of Things

We are aware that everything in the modern world is online, which makes life easier. The Internet of Things, or IOT, is one of the rapidly expanding technologies. It enables us to create web and mobile connected application, such as those for smart homes, healthcare, transportation, and other areas.

Dehydration is a common yet frequently ignored health issue. Dehydration, which affects people of all ages and socioeconomic levels, is a serious global health issue, according to the World Health Organisation (WHO). While extreme forms of dehydration, such as heatstroke or extended physical exertion, are frequently associated with dehydration, mild to moderate dehydration is more prevalent and can have subtle but detrimental impacts on our health and daily life. Water helps break down food particles for absorption and is a crucial ingredient of digestive juices. Maintaining adequate water facilitates the easy passage of food through the digestive system, avoiding constipation and enhancing general digestive well-being.

Moreover, water is necessary for the body's metabolic functions, which include turning food into energy. It aids in the body's ability to metabolize fat that has been stored and makes it easier for waste to be expelled through perspiration and urine. Essential for the healthy operation of organs like the kidneys, which remove waste from the blood and excrete it as urine, water is needed. Kidney stones and impaired kidney function can result from inadequate water intake, which may pose major health risks.

Water is an essential component of blood in the circulatory system because it helps carry nutrients and oxygen to cells while eliminating waste. Sustaining appropriate levels of water is essential for promoting heart health and blood circulation. Beyond just feeling thirsty, dehydration has significantly more negative effects. Dehydration, even minor dehydration, can affect physical and mental performance and increase the chance of developing a number of illnesses.

Dehydration is frequently characterized by headaches, weariness, dry skin, and black urine. Chronic dehydration can eventually lead to more serious medical issues like kidney stones and urinary tract infections. For vulnerable populations, such as the elderly, athletes and small children, inadequate hydration is particularly important.

People become less able to recognize thirst as they become older, which increases their risk of dehydration. Children, on the other hand, cannot completely comprehend the significance of adequate hydration and frequently require reminders to do so. Severe dehydration can, in some circumstances, be fatal. Maintaining sufficient hydration might be difficult in today's fast-paced, technologically-driven society.

Modern life's distractions, crammed work schedules, and excessive screen time can cause us to become unaware of how much water we need. Additionally, cities frequently have easy access to sugary drinks and caffeinated beverages, which can dehydrate people and encourage bad hydration practices. In addition to these issues, the way we engage with the outside world has altered as a result of our always-connected digital existence, making it simpler to put our health second to our virtual interests.

We can aid those who need a way to keep track of their water use by developing smart water bottles that are IOT-enabled. The usage of sensors, Arduino, a WiFi module, mobile applications, etc. is part of this technology.

The first step of the approach is to use an ultrasonic sensor to determine how much water the user has consumed. The sensor collects data, which is then transmitted via the WiFi Module to the cloud. To track water consumption at any time, data is regularly transferred to the cloud. The mobile application then retrieves this data from the cloud so that the user may check their state of hydration.

The Smart Water Bottle is a potentially game-changing answer to the problems associated with staying hydrated in today's society. Its effects are felt on a number of levels: The Smart Water Bottle can help prevent a variety of dehydration-related health problems, lessening the strain on healthcare systems, and enhancing general wellbeing by encouraging proper hydration.
The Smart Water Bottle can help athletes and energetic people maintain optimum performance by making real-time hydration recommendations depending on their levels of physical activity. The consumption of single-use plastic bottles can be considerably decreased by promoting the use of reusable water bottles, resulting in a more sustainable and environmentally friendly future. The Smart Water Bottle raises people's consciousness of the value of healthy hydration. Users may choose their fluid intake wisely thanks to the app's reminders and data tracking, which eventually leads to better lives. The Smart Water Bottle can be a lifeline for people in need, including the elderly and little ones, making sure they get the hydration they require even when they aren't conscious of their own thirst.
Researchers and healthcare professionals can benefit from the quantity of data gathered by the Smart Water Bottle app in order to better understand hydration patterns and create strategies to address concerns connected to dehydration. While measuring water consumption is the main function of Aquatrail, it also uses a mobile application to notify the user when their water consumption is lower than usual. Thus, as it enables user interaction with the Smart Water Bottle, the role of mobile applications is just as crucial as the roles of other equipment.
Water is essential to human life and plays a crucial role in preserving health, energy, and general well-being. The fact that it is involved in almost every biological function demonstrates its diverse significance. Recognizing the importance of water and staying well hydrated is essential to a happy and healthy life for humans.

Components of IOT:

- **Devices and Sensors:** The essential elements that connect the digital and physical realms are sensors and devices. Wearable technology and smart thermostats are two examples of devices that have sensors built in to record data from the real world, such as location, motion, and temperature. As the "eyes and ears" of the Internet of Things, sensors gather data from its surroundings. Following transmission and processing, this data is used for a number of purposes, including automation, data-driven decision-making, and remote monitoring. Devices and sensors are essential in turning commonplace items into intelligent, networked entities that improve our lives by offering convenience and new perspectives.

- **Connectivity:** The foundation of the Internet of Things is connectivity, which makes it easier for systems and devices to communicate with one another. Internet of Things (IoT) devices use various communication protocols and technologies, such as Bluetooth, Wi-Fi, cellular networks, and LoRaWAN, for data transmission. This makes it possible for smooth, real-time data exchange, which is necessary for data-driven decision-making, control, and monitoring. Users can access and interact with their IoT devices remotely thanks to connectivity, which guarantees that the devices can transmit information to the cloud or other data processing layers. It's an essential part that makes the Internet of Things function

and opens up a world of possibilities for smart homes, healthcare, transportation, and other industries.

- **Data Processing:** In the Internet of Things, data processing is a crucial stage that converts unprocessed data from sensors and devices into insightful knowledge. Some techniques for analyzing, filtering, and organizing data—often in the cloud or at the edge—include data analytics, machine learning, and artificial intelligence. Real-time monitoring, pattern recognition, and decision-making are made possible by data processing, which also makes it possible for IoT applications to automate procedures, deliver useful information, and improve user experiences. It is crucial for deciphering the enormous amounts of data generated by Internet of Things (IoT) devices, encouraging innovation, productivity, and thoughtful decision-making across a variety of industries and uses.
- **User Interface:** User interface acts as a conduit between users and the massive network of data and connected devices. It consists of voice assistants, web dashboards, and mobile apps that let users communicate with and manage Internet of Things devices. This interface makes it easy for users to monitor and manage their Internet of Things ecosystem by giving them real-time access to device status, data, and settings. IoT technology is made more approachable and useful by user-friendly interfaces, which enable people and organizations to take advantage of connected devices' capabilities, automate processes, and make well-informed decisions—all of which contribute to increased convenience and productivity in a variety of spheres of life and business.
- **Security:** Access control, encryption, secure firmware updates, and authentication are examples of IoT security techniques. Cyberattacks and privacy violations may result from vulnerabilities in IoT systems. Data confidentiality and integrity need to be upheld in order to safeguard people and organizations. In order to protect IoT devices and networks from potential threats and maintain their resilience and trustworthiness, strong security protocols are necessary. Security measures are essential to reduce risks and create a safe foundation for a networked, data-driven world as the IoT ecosystem grows.

Layers of IOT:

- **Perception Layer:** Real-world data is captured by the IoT's foundational component, the Perception Layer. Actuators, devices, and sensors are all part of it. Sensors gather information from the physical world, including motion and temperature sensors. Actuators use this data to control their movements, such as locking doors or modifying thermostat settings. By processing data close to the source, edge devices can lower latency. This layer acts as a link between the digital and physical realms, gathering vital data that powers the Internet of Things ecosystem and allowing for data-driven insights, automation, and real-time monitoring.
- **Network Layer:** In the Internet of Things, the Network Layer enables data transmission to higher layers and device-to-device communication. It uses Bluetooth, cellular networks, Wi-Fi, and other communication technologies to manage connectivity between IoT devices, gateways, and central systems. Acting as go-betweens, gateways gather information from various sources and send it to data processing layers or the cloud. At this layer, edge

computing can also take place to optimize data transfer and lower latency. By establishing connections between IoT devices and enabling real-time monitoring, control, and analysis, the Network Layer guarantees effective and secure data transmission.

- **Middleware Layer:** The middleware layer acts as a crucial bridge connecting the upper and lower layers. It prepares data gathered by IoT devices for analysis and action by processing, organizing, and managing it. This layer provides security features like encryption and authentication, filters and aggregates data, and converts protocols to guarantee compatibility. By combining data from different sources, middleware offers a thorough understanding of the IoT ecosystem. In the end, it enables real-time monitoring, automation, and data-driven decision-making within the IoT architecture by converting raw data into insightful knowledge and making it available for applications and services.

- **Application Layer:** Data is used practically at the Application Layer. It consists of a number of software programs and applications that use the information gathered from lower layers to provide automation, user interaction, and insights. This layer can include sophisticated software systems, web-based dashboards, and mobile apps. It permits real-time IoT device monitoring, analysis, and control, empowering users to act and make decisions based on data. The Application Layer enhances convenience and efficiency across many domains by enabling a broad range of Internet of Things applications, from industrial automation to smart home control.

IOT Network Technologies:

LPWAN networks are starting to adopt NB-IoT as the standard. These technologies facilitate intelligent decision-making in a variety of industries by enabling real-time monitoring, control, and automation. IoT networks improve the delivery of healthcare by enabling smart medical devices and facilitating remote patient monitoring. Field sensors collect data for precision farming in agriculture, which maximizes crop yields and efficient use of resources. By linking systems and machinery, industrial IoT (IIoT) networks transform manufacturing and enable streamlined operations and predictive maintenance. IoT is used by smart cities to effectively manage traffic, dispose of waste, and save energy. IoT network security and scalability are critical for maintaining data integrity and the ecosystem's continued expansion. IoT network technologies, taken as a whole, redefine connectivity and provide a basis for increased productivity, creativity, and overall quality of life in a variety of fields.

- **LPWAN:** For Internet of Things (IoT) and machine-to-machine (M2M) applications, Low Power Wide Area Network (LPWAN) technology is a wireless communication protocol that enables long-range communication with low power consumption. LPWANs are especially well suited for tying together devices that must send modest amounts of data over long distances while using a lot of battery power. Large-scale geographic coverage is one of LPWANs' primary advantages, which makes them perfect for uses in smart city, smart agriculture, and industrial IoT applications. Lower frequencies—typically in the sub-GHz range—are used by LPWANs to accomplish this, enabling signals to traverse larger spaces and more successfully pass through obstructions like vegetation and buildings. Many LPWAN technologies exist; two of the most well-known ones are Sigfox and

LoRaWANtechnology . For example, LoRaWAN uses unlicensed frequency bands to provide flexibility and cost-effectiveness while enabling long-range communication through the use of spread spectrum modulation. Opting in the unlicensed Industrial, Scientific, and Medical (ISM) bands. Because of its low consumption of energy, LPWAN technology is unique in that it enables connected devices to run for years on tiny, cheap batteries without needing to be replaced. This feature is essential for Internet of Things applications where devices might be placed in difficult-to-reach or remote areas.

- **Cellular:** Through a network of connected base stations, cellular network technology provides wireless communication over a large geographic area for both voice and data transmission. The 4G, 5G, and 2G cellular networks are currently the most widely used. In addition to supporting, these networks offer wireless communication services to billions of users worldwide. These applications include web surfing, video streaming, and various Internet of Things devices. A base station or antenna that serves each of the cells that make up a cellular network's coverage area. Mobile devices smoothly transition between these cells as they move, keeping their connection open at all times. The radio frequency band can be used more effectively thanks to the cellular architecture, which permits interference-free reuse of the same frequencies across various cells. The newest cellular technology, 5G, promises even faster data speeds, reduced latency, and more network capacity. To achieve these improvements, it introduces new technologies such as millimeter-wave frequencies. The Internet of Thing (IoT), which is expected to have more and more connected devices, will depend heavily on 5G to support and enable features like augmented reality and driverless cars. Reliable and secure transmission is ensured by cellular networks operating on licensed bands of frequency assigned by regulatory authorities. Cellular technology is a mainstay of contemporary telecommunications due to its broad adoption, which has revolutionized communication and information access. Cellular networks will be essential in determining the direction of connectivity in the future and in facilitating the development of novel applications and services as technology advances.

- **Bluetooth Low Energy:** The wireless communication technology known as Bluetooth Low Energy (BLE), or Bluetooth Smart, is intended for short-range and power-efficient data transfer. It is a feature of Bluetooth 4.0 and later versions, and its low power consumption makes it perfect for a wide range of applications, especially those involving wearable technology and the Internet of Thing (IoT). In order to minimize interference from other electronic devices operating in the same frequency range, BLE uses a frequency-hopping spread spectrum. BLE functions in the 2.4 gigahertz band. BLE's capacity to communicate over short distances—typically up to 100 meters—while using a lot less power than conventional Bluetooth is one of its primary characteristics. Devices that run on batteries, like monitors for fitness, smartwatches, medical equipment, and different types of Internet of Things sensors, are a good fit for BLE. It allows these gadgets to communicate with mobile phones, tablets, and other devices that are compatible without rapidly depleting their batteries. Fewer packets of data, lower transmitting power, and the option to switch to low-power sleep patterns when not actively broadcasting data are some of the power-saving techniques used to accomplish this. BLE's simplicity as well as ease of integration are also important features. The central, which looks for and communicates to peripherals, and the

peripheral devices, which broadcasts data, are its two main functions that it supports. Every new version of BLE brings improvements in terms of features, range, and data transfer rates. BLE has been evolving continuously. The technology's adoption has spread across numerous industries and is now considered acceptable for short-range wireless communication. Bluetooth low-energy technology is a short-range and low power consumption wireless communication standard. Its effectiveness, adaptability, and interoperability have rendered it a popular option for many applications, facilitating seamless communication in the quickly expanding wearable and Internet of Things ecosystem.

- **Zigbee:** Wireless communication technology known as Zigbee was created with short-term, low-power systems, and low-data-rate applications in mind. Operating on the IEEE 802.15.4 protocol, it is specifically designed for devices that have low power requirements, which makes it ideal for use in industrial automation, automation of homes, healthcare, and other Internet of Things (or IoT) applications. The ability of Zigbee to establish a mesh network that enables communication between devices even when they are not in close proximity to one another is one of its primary features. Every device, or node, in a Zigbee meshes network has the ability to function as a router by sending signals to other nodes, increasing dependability and extending the network's overall range. Zigbee networks are more resilient and adaptable thanks to this mesh topology, which lowers the possibility of communication failure by allowing devices to identify multiple communication paths. Zigbee uses the unlicensed, worldwide 2.4 GHz frequency for its operations. This band is divided into 16 channels, and in order to prevent interference from different wireless technologies using the same frequency range, Zigbee devices randomly select channels. Zigbee devices are able to run on small batteries for a longer period of time because of the use of low-power devices, short-range transmissions. While devices in a tree topology may interact with one another and transmit information through intermediary nodes, devices in a star topology interact via a central coordinator. As was already mentioned, the mesh topology is especially useful in scenarios where sensors may be dispersed over a large area. The application profiles for Zigbee specify how particular types of devices are supposed to interact with one another on the network. This guarantees compatibility between gadgets made by various manufacturers. For instance, there are profiles for automation of homes and lighting control called Zigbee automation and Zigbee Smart Link, respectively. One important feature of Zigbee networks is security. To secure data during transmission, the technology uses strong encryption techniques like Advanced Encryption Standard (AES). Zigbee further enhances a secure transmission environment by supporting features like network key management and device authentication. Zigbee is a low-power, short-range wireless communication technology designed for Internet of Things applications. Its energy-efficient design, mesh network formation capabilities, support for multiple network topologies, and application profile definitions make it a popular option for IoT applications such as healthcare, home and manufacturing automation, and others where dependable and energy-efficient transmission is crucial.

- **NFC:** A short-range communication method known as near field communication, or NFC, allows devices to communicate with one another when they are brought close together—typically within just a few centimeters. NFC is suitable for a range of applications, such as cashless transactions, transmission of data, and identification. It works on the concepts of electromagnetic induction & is designed to be simple and convenient. NFC is based on an inductive connection of two coils, one for each communication device, and operates at a frequency of 13.56 MHz. Active and passive are the two main ways that NFC communication occurs. Active Mode: This mode enables bidirectional data exchange between the two devices by enabling them to produce unique radio frequency fields. Peer-to-peer communication via this mode is frequently used to share files between cellphones or establish connections with other NFC-enabled devices. Passive Mode: In this mode, the target reacts while the initiator, or one device, creates the radio frequency field. This mode is frequently utilized in situations where data collected by NFC tags is accessed or contactless payments are made. The simplicity and usability of NFC is one of its main benefits. All it takes to connect two devices is to bring them close to one another; complicated setup or pairing procedures are not needed. Because of this, NFC can be used in a range of scenarios where seamless and rapid interactions are crucial. Contactless payment systems, which allow customers to make purchases by tapping their smartphones or NFC-enabled cards on point-of-sale terminals, make extensive use of NFC technology. NFC is used by mobile payment apps like Samsung Pay, Apple Pay, and Google Pay to facilitate safe and easy transactions. Transferring data among devices also uses NFC. When two NFC-enabled devices are brought close to one another, for example, users may exchange contact details, images, or other files. This function is frequently used to make Bluetooth pairing and Wi-Fi setup easier. NFC is also used in access control and identification applications. You can use NFC cards or tags to gain secure access to events, public transportation, and buildings. These tags have the capacity to hold data that NFC-capable devices can read to authorize access or deliver pertinent data. One important feature of NFC technology is security. NFC data transmissions may be encoded to guard against unwanted access. NFC communication's short range also provides an extra degree of physical security because successful data exchange requires close proximity between devices.
- **RFID:** Radio waves are used in radio-frequency identification, or RFID, technology to transfer data between an RFID tag and a reader. It is widely used in many different applications to track and identify people, animals, and objects. The three primary parts of an RFID system are the radio frequency identification (RFID) tag, the reader for RFID, and the database or backend system. RFID tags are tiny electronic devices made up of an antenna and a microchip. Information is stored in the microchip, and radio frequency signals are used by the antenna to communicate with RFID readers. There are two varieties of RFID tags: passive and active. Although tags that are active have their own electrical power and can transmit signals over greater distances, passive tags depend on the power that is emitted by the reader that reads RFID tags for sending data. RFID devices are gadgets that communicate with tags with RFID tags by emitting radio frequency signals. The information on the tag's microprocessor is read by the reader, which then has the ability

to send it to a desktop or backend device for further processing. Depending on the needs of the application, sensors may be fixed or portable and come in a variety of frequencies. The data gathered by RFID readers is processed and managed by the backend system. The system in question could be an inventory control system, a system that controls access for security reasons, or a database that holds data regarding the tagged items. Numerous sectors and uses of RFID technology exist, including: This technology is widely used in logistics and supply chain operations to track and manage inventory. It lowers errors and boosts overall efficiency by providing immediate insight into the transportation of goods. RFID is used in retail to improve the overall shopping experience, prevent theft, and manage inventory. RFID tags are used by retailers to monitor the flow of merchandise from the storage facility onto the store shelves. RFID tags or cards are frequently used for parking lots, events, and building access control. They offer an easy and safe method of controlling entry and departure. In healthcare settings, RFID is used for tracking assets, medication management, and patient tracking. It enhances effectiveness and lowers mistakes in patient care.In agricultural and management of wildlife, RFID chips are employed for identifying animals and tracking. They let farmers and researchers keep an eye on the whereabouts and well-being of their animals.

- **Wi-Fi:** Wi-Fi, an acronym for broadband connectivity, is a popular wireless technology that eliminates the requirement for physical wires when connecting devices to the World Wide Web and neighborhood networks. It functions using the IEEE 802.11 series of standards and is now a crucial component of contemporary networking, offering wireless access in a variety of settings, including homes, workplaces, and public areas. Among Wi-Fi technology's salient features are: Typically, routers or wireless access points are used to set up Wi-Fi networks. By using wireless technology, these devices send and receive data, establishing a LAN, or local area network, that enables connections and communication between numerous devices. The 2.4 GHz & 5 GHz bands of frequencies are used by Wi-Fi. Although the 2.4 GHz band has a wider frequency range, it is more vulnerable to interference from devices that are using the same band. Applications requiring quicker and more dependable connections can benefit from the 5 GHz band's higher rate of data transfer and lack of congestion. Data transfer rates are specified by Wi-Fi standards, and performance and speed are improved with every new generation of Wi-Fi standards. the 802.11b 802.11g, 802.11n, 802.11ac, & the most recent norm, 802.11ax (Wi-Fi 6) are examples of common Wi-Fi standards. Specifically, Wi-Fi 6 brings new features like faster data transfer speeds, more effectiveness in congested areas, and enhanced multi-device support. Security protocols are used by Wi-Fi networks to safeguard data while it is being transmitted. In order to safeguard wireless communication and prevent unauthorized access to the network, encryption standards such as WEP encryption have been developed. MIMO technology improves Wi-Fi performance by using multiple antennas for simultaneous data transmission and reception. As a result, network efficiency rises and data transfer rates are enhanced. The IEEE establishes Wi-Fi standards, which guarantee compatibility between gadgets made by various manufacturers. Users can now easily connect a variety of Wi-Fi-capable devices thanks to this. With the ability to utilize the internet as well as network resources via a wide range of gadgets, including tablets, smartphones, laptops, smart TVs,

and Internet of Things devices, Wi-Fi connectivity has become widely used. Wi-Fi has been integrated into a number of industries, include healthcare, education, hospitality, and manufacturing, due to its widespread adoption and ease of use. Even though Wi-Fi has many benefits in terms of portability and user-friendliness, issues like congestion in the networks and security worries are still being addressed by constant improvements in Wi-Fi protocols and technology. The direction of wireless connectivity and communication in the future will probably be greatly influenced by the development of Wi-Fi.

- **Ethernet:** A popular and widely accepted method of wired local area networks (LAN) is Ethernet. It offers a dependable and effective way for devices connected to a local network to talk to one another and access the wider internet. The International IEEE 802.3 norm, which outlines both the physical as well as data connection-layer requirements for wired LANs, governs Ethernet technology. Among Ethernet technology's salient features are: Multiple physical media, such as coaxial, fiber optic, and twisted-pair copper cables, can be used to operate Ethernet. Twisted-pair wires with RJ45 connectors are the foundation of the most widely used form of Ethernet in use today. Applications requiring high bandwidth and longer distances are served by Ethernet instead of fiber optics. Ethernet provides a frame-based protocol for communication and functions at the OSI model's data link layer. The data payload, type or length subject matter, destination and source MAC addresses of the data, and a cyclical redundancy check (CRC) enabling error detection are all included in an Ethernet frame. When Ethernet first came into use, several devices shared a single communication path via a shared medium called a bus topology. Data corruption could result from collisions between two devices transmitting data at the same time. Collision domains were divided with the advent of Ethernet switches, enabling full-duplex in interaction among devices and doing away with collisions. With the initial ten megabits per second (Ethernet), 100 megabits per second (Fast Ethernet), one gigabit per second (Gigabit Ethernet), ten gigabits per second (Gbps) (10 Gigabyte Ethernet), 75 Gbps, 40 Gbps, and 100 Gbps, to the latest technologies enabling speeds of 400 Gbps, Ethernet supports a variety of data transfer speeds. The specific needs of the network determine which speed to choose. Power lines can be used to extend Ethernet in addition to conventional wired connections. The transfer of data over existing power lines is made possible by this technology, which is called Ethernet over Powers Lines (EoPL). This offers an alternative for connecting to networks in places where running fresh wires may be difficult. Ethernet cables can now transmit data and electricity thanks to a feature called PoE. With this, there is no longer a need for separate power cables for gadgets like IP cameras, VoIP cellphones, and wireless access points. The majority of wired LANs are built on Ethernet, which provides a dependable and affordable way to connect devices inside a limited geographic area. It is frequently utilized in many industries, homes, and data centers. Ethernet keeps developing to accommodate faster data transfers, more efficiency, and enhanced features to satisfy the ever-increasing needs of contemporary networking.

INTERNET LAYER IOT NETWORK TECHNOLOGIES:

For efficient communication and data exchange among a broad spectrum of networked devices, IOT technology require an Internet layer. As the foundational layer of the Internet Protocol (IP) suite, it guarantees that data packets can pass through a variety of networks, allowing devices to connect with each other anywhere on the planet.

The large number of devices requiring unique IP addresses in the IoT context makes IPv6, a crucial part of the Internet layer, even more important. Every IoT entity has a unique identifier thanks to its extended address space, which supports the exponential growth of connected devices.

Additionally, regardless of the underlying network technologies, heterogeneous IoT devices and systems can communicate thanks to the Internet layer's promotion of interoperability. The Internet layer provides a uniform and global language for data transmission regardless of the device's connection method—Wi-Fi, cellular networks, or other protocols.

To safeguard confidentiality and data integrity in communications over the Internet of Things, protocols like Datagram Transport Layer Security (DTLS) are used at this layer, where security considerations are crucial. To put it simply, the Internet layer is the central component of IoT network technologies, allowing for a unified and globally interconnected ecosystem that supports the Internet of Things' scalability and functionality. This layer is connected to commonly used IoT technologies.

- **IPv6:** IP addresses are used at the web layer to identify devices. IoT applications usually use IPv6 instead of legacy IPv4 addressing. IPv6 uses 128 bits and can provide 2 128 addresses (about 3.4 × 10 38 or 340 billion billion billion billion) addresses, whereas IPv4 can only provide 32-bit addresses, which can only provide about 4.3 billion addresses overall—less than the current number of connected IoT devices. Not every IoT device actually requires public addresses. Tens of billions of devices are anticipated to connect to the Internet of Things over the course of the next several years, many of which will be installed in private networks with private address ranges that only use gateways to communicate with other devices or services on external networks.

- **6LoWPAN:** All thanks towards the IPv6 Low Power Cellular Private Area Network (6LoWPAN) standard, IPv6 may be employed over 802.15.4 wireless connections. Wireless sensor networks frequently use 6LoWPAN, and home automation devices use the Thread protocol, which is also run over 6LoWPAN.

- **RPL:** The Internet Layer contains routing. The Routing Protocol for IPv6 in Low-Power and Lossy en Networks (RPL) is designed to route traffic using IPv6 over low-power devices networks, like those constructed with 6LoWPAN. RPL, which is pronounced "ripple," is intended to route packets in networks with constraints, like wireless sensor networks, where packet loss is high or unpredictable and not every device is always reachable. Using dynamic metrics and constraints such as minimizing latency or energy consumption, RPL can construct a graph of the network's nodes and then calculate the optimal path.

APPLICATION-LAYER IOT NETWORK TECHNOLOGY:

IOT apps make extensive use of HTTP and HTTPS interfaces. HTTP and HTTPS are widely used in internet-based applications as well. Constrained Application Protocol, or CoAP, is frequently used in conjunction with 6LoWPAN over UDP. It functions similarly to a lightweight version of HTTP. In IoT applications, messaging protocols:

- **MQTT:** Through the use of the publish/subscribe paradigm, MQTT enables decoupled device communication. According to this model, devices can function as subscribers who receive messages or as publishers who send messages. By controlling message distribution, the broker—the central entity—ensures effective communication amongst devices.MQTT has several advantages, one of which is its low bandwidth and resource requirements. Due to its header-only design, the protocol minimizes data exchange, which makes it perfect in scenarios where network bandwidth is expensive or scarce. Because IoT devices frequently operate in environments with limited power and processing capabilities, this efficiency is especially important. Moreover, MQTT offers Quality of Service (QoS) tiers to ensure message delivery. The two QoS levels offer different levels of assurance. Level 0 denotes a maximum of one delivery, Level 1 guarantees a minimum of one delivery, and Level 2 offers a precise delivery, thereby enhancing communication process reliability. Furthermore, MQTT can adjust to different network architectures due to its intrinsic flexibility. With its support for both secure and non-secure connections, it can be used in a variety of contexts. Mechanisms that ensure the confidentiality and integrity of the data being transferred, such as Secure Sockets Layer (SSL) and Transport Layer Security (TLS), are frequently used to implement security. To summarize, MQTT is a key component of Internet of Things communication due to its efficiency, lightweight design, and support for a publish/subscribe model. Its broad industry adoption attests to its dependability in coordinating the smooth transfer of data in the networked Internet of Things world.

- **AMQP:** A robust, open-standard messaging protocol called AMQP was developed to enable compatible, dependable system-to-system communication. In contrast to certain other messaging protocols, AMQP is not restricted to a particular application domain and can be utilized in a variety of contexts, such as financial services, enterprise messaging, and the Internet of Things (IoT). AMQP functions primarily through a client-server architecture. The producer, who is in charge of sending messages, and the consumer, who is in charge of receiving them, are the two main parts. An organization that serves as a middleman and facilitates communication between producers and consumers is called a message broker. This broker, which is essential to the AMQP ecosystem, makes sure that messages are exchanged in a dependable and organized manner. AMQP is renowned for its ability to accommodate a wide range of messaging patterns. It supports both the publish/subscribe model and point-to-point communication, but it mostly adheres to the message queue paradigm, in which messages are held in queues until they are read by a recipient. Because of its adaptability, AMQP can meet a variety of communication requirements. Message integrity and dependability are highly valued in AMQP. It defines various modes of delivery, enabling messages to be designated as either transient or persistent based on whether or not they should withstand system failures. This guarantees

the persistence of important information even in the event of unforeseen disruptions. Additionally, AMQP ensures that systems can communicate synchronously and in both directions by supporting a variety of communication patterns, such as request/reply. This is especially helpful in situations where prompt replies and acknowledgements are essential. An additional fundamental component of AMQP is security. In order to safeguard data integrity and confidentiality while it is being transmitted, the protocol can be implemented over secure channels like Transport Layer Security (TLS). It also includes mechanisms for authorization and authentication. The strengths of AMQP are found in its adaptability, consistency, and focus on facilitating safe and systematic communication among various systems. Its importance in contemporary messaging architectures is highlighted by its broad adoption in enterprise environments and its industry-wide applicability.

- **XMPP:** An open-standard communication protocol for real-time messaging, presence data, and teamwork is called XMPP. Jabber was the original name of this flexible protocol, but XMPP is now widely used for voice and video calls, instant messaging, and other collaborative applications because of its extensibility and decentralized design. Fundamentally, XMPP functions through a client-server architecture, in which clients are applications used by end users and servers act as messengers. The unique feature of XMPP is its federated architecture, which facilitates smooth communication between users on various servers. XMPP serves as the basis for a global, networked messaging system because of its decentralized model, which encourages interoperability. The fact that XMPP supports presence information is one of its main advantages. Users have the ability to express their real-time communication status, availability, and willingness. This feature, which gives users insight into their contacts' online presence, is essential to many instant messaging and collaboration apps. Because of XMPP's high degree of extensibility, new features can be integrated using extensions or XEPs (XMPP Extension Protocols). The key to XMPP's flexibility is its extensibility, which allows the protocol to change and grow to meet new demands for communication. XMPP is versatile due in part to its extensions, which enable multi-user chats and file transfers. The top priority in XMPP is security. The data integrity and confidentiality can be guaranteed when using the protocol over encrypted connections. Moreover, end-to-end encryption, user authentication, and authorization are supported by XMPP, offering a secure communication platform. Because XMPP is open-source, a thriving ecosystem of both proprietary and open-source clients and servers is supported. This variety adds to the protocol's adaptability and broad use in a variety of industries, such as social networking, healthcare, and the Internet of Things, where real-time communication is crucial. With its emphasis on security, extensibility via XEPs, decentralized architecture, and support for presence information, XMPP is a robust and adaptable protocol that serves as the foundation for real-time communication and collaboration in a wide range of applications.

XMPP is federated and extensible, making it appropriate for real-time communication and collaboration, while AMQP is dependable for enterprise messaging. MQTT excels in the Internet of Things due to its efficiency. The decision is based on requirements and particular use cases, as each protocol has distinct advantages in various fields.

CHAPTER 2

LITERATURE REVIEW

We were able to get a basic understanding of the technologies that were in use earlier thanks to a thorough analysis of the articles that were previously published about smart water bottles. We were given a brief overview of the improvements that need to be made in the next iteration of the smart water bottle innovation by the architecture diagram, sensors, devices, and modules.

This article makes use of a water float sensor that is linked to both the microcontroller and the GSM. Sensor are attached within the water bottles or flasks to detect the liquid inside and determine the level of water as LOW and HIGH [1]. The micro-controller should receive the measured level and use an RS232 chip to determine the message from there. By inserting a SIM card into the GSM module, the message can be transmitted to it. It uses SMS to send the water level data to the mobile device.

The author predicted water consumption using a microcontroller-based prediction tool and then sent out a reminder based on that prediction. Fuzzy logic algorithms[2] are computer methods used in control and decision-making systems to handle imprecise or uncertain data. A microcontroller that employs fuzzy logic to determine the result among Low, Medium, and High water consumption outputs. The user receives a reminder to drink water based on that.

Utilizing a sensor, the smart water bottle gathers data and tracks it in multiple ways. A push button, an O-LED display, an ESP 32 module, an ultrasonic sensor, and a DS1307 RTC module are among the many components and devices that are used [3]. The DS 1307 RTC module receives the data gathered by the ultrasonic sensor, which gauges the bottle's water level. The DS 1307 RTC monitors all stored data, including the quantity of water consumed the previous time and the number of times a day. Reminders are sent by email using the ESP 32 module and the SMTP protocol. The push button serves a number of functions. For example, it can be used to wake up a device from sleep or to transmit data about the average daily water consumption when pressed twice. While the O-LED display and DS 1307 RTC are utilized as output components, the push button and ultrasonic sensor serve as input devices.

The market's worth for smart water bottles[4] has been rising over time, and by 2030, it is projected to reach USD 145.2 million from USD 36.94 million in 2022. The growing use of smart water bottles in both developed and some developing economies is one of the main factors driving the growth of the market for these bottles. More technological advancements in manufacturing techniques along with more commercial R&D will open up new opportunities for the smart water bottle market. The market for smart bottles is expected to grow over the course of the forecast period as IOT for smart bottle products gains traction.

A smart water bottle with an integrated smartphone application. The controller[5] uses a built-in Bluetooth connectivity Smart wireless interface to establish a connection with the customized smartphone application. The data from the smart water bottle is received by the

smartphone application, which then processes it before transferring it to a backend servers. The limited range of the Bt wireless interface may be an issue for some applications. In the context of group monitoring—such as that found in assisted living facilities and medical facilities—it is not feasible for each user to always carry a smartphone platform. We created a system that makes use of WiFi connectivity and the cloud to give medical professionals instant access to all of the bottles' stored data via the cloud's interface.

Dehydration is a major concern because it can result in dangerous side effects such as disorientation, falls, hospitalization, and even death. Maintaining a balanced fluid intake is essential, especially to the elderly and people with underlying illnesses that affect their ability to regulate fluids. It is suggested that people who are at greater risk for recurrent formation of stones have a high quantity of water. As a result, keeping an eye on fluid intake[6] can help ascertain whether or not enough has been consumed. Numerous accounts exist of efforts to develop tools or systems that can help with monitoring and controlling fluid intake. Certain bottles feature sensors in the middle, most likely made of capacitive sensors, while other bottles have sensors in the base that monitor the amount of fluid being consumed using load or pressure sensors. Accurate water level tracing is crucial for individuals with health concerns.

The two parts of the Smart Bottle are the real container and the Android app. The bottle is equipped with an accelerometer, Bluetooth module, microcontroller, temperature and humidity sensor, and ultrasonic distance sensor. The bottle's water level is determined using an ultrasonic distance sensor. Position feedback is provided to the microcontroller by the accelerometer. The microcontroller gets its input signal from the shift in the bottle cap's position. The state of the bottle—open or closed—can be ascertained using this signal. To communicate with the smartphone application, a Bluetooth module[7] is utilized. Sensor data is received by a microcontroller, which then processes it.

The main challenge a nurse or attendant faces is periodically checking the saline bottle's level. Reversing flow of blood happens when a nurse neglects changing the saline bottle, endangering the patient's life. An Internet of Things-based saline level indicator is suggested as a solution to this issue. The saline bottles is hanging from an anchor at the bottom of a loadcell[8], which is attached at the highest point of the pedestal and used to measure the level of the saline bottle. When the level falls, the sensor transmits its results to the controller. The nurse can keep an eye on the condition of the saline bottle by using a mobile app and IoT to monitor the indicator in the room, which is powered by the controller. Additionally, when the saline bottle's level is emptied, the patient's primary issue is the blood flowing backwards towards it. When the saline level falls, the solenoid valve is adjusted to solve this issue. Caregivers can also monitor each patient's blood oxygen level, pulse rate, and body temperature in order to more accurately track each the patient's health.

There are smartphone apps that monitor our fluid consumption[9] and prompt us to hydrate when we don't meet our goals. Nevertheless, these applications necessitate either a customized container or direct user input. They are unable to account for liquid that has been spilled or drunk by others. We suggest an application that lets the user utilize any container they choose.

It is composed of a load sensor-equipped detachable container base that measures the amount of liquid consumed with each sip, and a machine learning-powered wristwatch that uses accelerometer sensor data and smartwatch algorithms to determine the hand's drinking motion. Any container can be fastened with the detachable base.

Consuming water improves respiratory organ resilience, which is beneficial for health, particularly in the elderly. Elderly people[10], however, are ignorant of the proper ways to drink water, such as the right amount, when to drink it, how often, etc. This study aimed to ascertain older adults' water intake behaviour, types of consumers, current issues, and potential for water consumption. Creating healthcare goods and services that bring together modern technology and youth sentiments should be able to create a positive user experience. Additionally, young people are highly receptive to technology and use the Internet frequently, which may contribute to the acceptance of IoT technology in the medical field.

Ten more years of surprises from the Internet are in store as it evolves into the "Internet of Things" (IoT). You probably already have your PC, smartphone, and possibly even your car's GPS connected to the Internet. [11] In the coming years, everything in your house and office, including the gas, water, and electricity meters, in addition to street lights, sprinkler systems, bathroom scales and tensiometers, and even walls, will be connected to the Internet of Things. These appliances will be improved in a number of ways tomorrow, including not heating your home if a heatwave is predicted, watering your garden automatically only in the event that it doesn't rain, providing emergency roadside assistance, and more. These advancements will improve our quality of life and make better use of natural resources.

Since drinking water is a basic human need, it is also crucial that it be consumed properly. Water bottles with features like temperature sensors, led lights, sanitizers, etc. can help control it by serving as a reminder to people to drink enough water at regular intervals. These characteristics are easily programmable into the bottle thanks to the Internet of Things, making it unique. [12] SUS 304 stainless steel is what's used to make the bottle. Additionally, the bottle's cap has a temperature sensor built into it that shows the fluid's internal temperature. The inclusion of Bluetooth speakers on the bottle's exterior is another fantastic feature that helps individuals create different environments. A range of fluid temperatures within the bottle is indicated by LED lights. Because it can be used for multiple purposes, this bottle is a complete package for the consumer.

Consuming water is essential for human well-being because it provides the body with a variety of vitamins and minerals [13]. Helps to maintain body of a human hydrated. In elderly or aged people, the water helps to strengthen the resilience of the respiratory organs. The advantages of drinking the recommended amounts, times, and frequencies of water are not well known to the elderly. Halite support the body's ability to eliminate wastes and also raise metabolic rates, both of which are beneficial to humans body to combat a variety of illnesses. This article suggest a water-related sustainable business model.

CHAPTER 3

PROPOSED METHODOLOGY

3.1. Hardware and Methods

The suggested methodology's innovation consists of hardware elements such as Wi-Fi modules and sensors. Together, these parts track the amount of water consumed and deliver information about the degree of hydration. The methods included in the solution are:

- **Planning the project and gathering requirements:** Determine the objectives, target market, and project scope. Specify the exact features and functionalities of the Smart Water Bottle, define exact performance and usability requirements, Establish a budget and schedule for the undertaking.

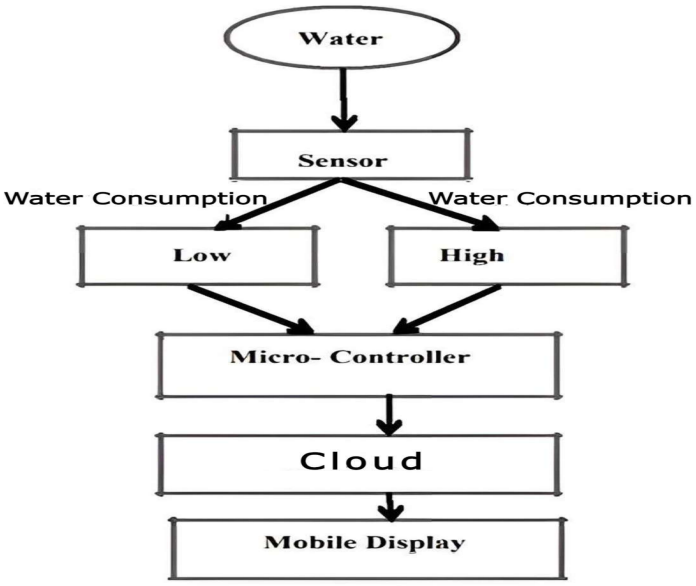

Figure 3.1.1 Block Diagram

- **Selection and Integration of Sensors:** Select the appropriate sensors to monitor the water intake and surrounding conditions. These might include a water bottle, jumper wires, wifi modules, and ultrasonic sensors. Make sure the chosen sensors are accurate, dependable, and energy-efficient to increase the device's battery life.
- **Ultrasonic Sensor:** When measuring the gap between a sensor and an object, an ultrasonic sensor uses sound waves with frequencies higher than what is audible to humans. The device functions by generating an ultrasonic sound wave, which is a high-frequency sound wave, and timing how long it requires for the sound wave to pass through an object and return to its sensor. Following that, the sensor determines the object's distance from it by utilizing the airborne sound speed and the duration of the sound wave's journey to and from the object. Four pins are commonly found on ultrasonic sensors: GND for ground, VCC for power supply, Echo for timing and receiving reflected sound waves, and Trig for triggering

measurements. Trig starts the emission of ultrasonic sound waves, GND serves as the ground reference, and VCC provides electrical power (such as +5V). Echo allows one to measure distance by producing a pulse whose width is equal to the time it takes for sound waves to return from an object. Users can initiate measurements and acquire distance data by connecting Trig and Echo to a control system, and VCC and GND to the power source. The particular sensor models and applications may require different wiring and programming.

Figure 3.1.2 Ultrasonic Sensor

- **ESP8266:** The ESP8266 is a well-liked and extensively utilized microcontroller and Wi-Fi module in the embedded systems and IoT fields. The ESP8266 a small and affordable device for connecting gadgets to local networks or the internet because it combines a microcontroller with integrated Wi-Fi capabilities. The low cost of ESP8266 modules has led to their extensive use in Internet of Things applications and projects. Because the ESP8266 platform is open-source, developers can access and alter its firmware and software, giving it a great deal of customization capability. It has numerous GPIO ports that can be used for both digital and analog input and output in a variety of applications. Since it can communicate via Wi-Fi, the ESP8266 is perfect for Internet of Things applications where devices must exchange data via a wireless network. Power-saving features are provided by the ESP8266, which can be crucial for Internet of Things devices that run on batteries. Many Internet of Things applications, including smart devices, home automation, sensor networks, and remote monitoring, frequently use the ESP8266. By offering a reasonably priced and easily accessible platform for connecting devices to the internet, it has significantly contributed to the growth of the Internet of Things. Because of their capabilities, affordability, and versatility, ESP8266 modules are essential in the Internet of Things world. These modules from Espressif Systems offer a simple and easy way to upgrade a variety of electronic devices with Wi-Fi connectivity. The ESP8266 is a great option for Internet of Things applications because of its small form factor, low power consumption, and compatibility with many different programming languages. With the help

of these modules, developers can link devices to the internet and facilitate data sharing and communication. Their extensive documentation, strong community support, and ecosystem of development tools that simplify the IoT development process are additional factors contributing to their popularity. All things considered, ESP8266 modules are a fundamental component that facilitates IoT development and aids in the general uptake of connected technologies.

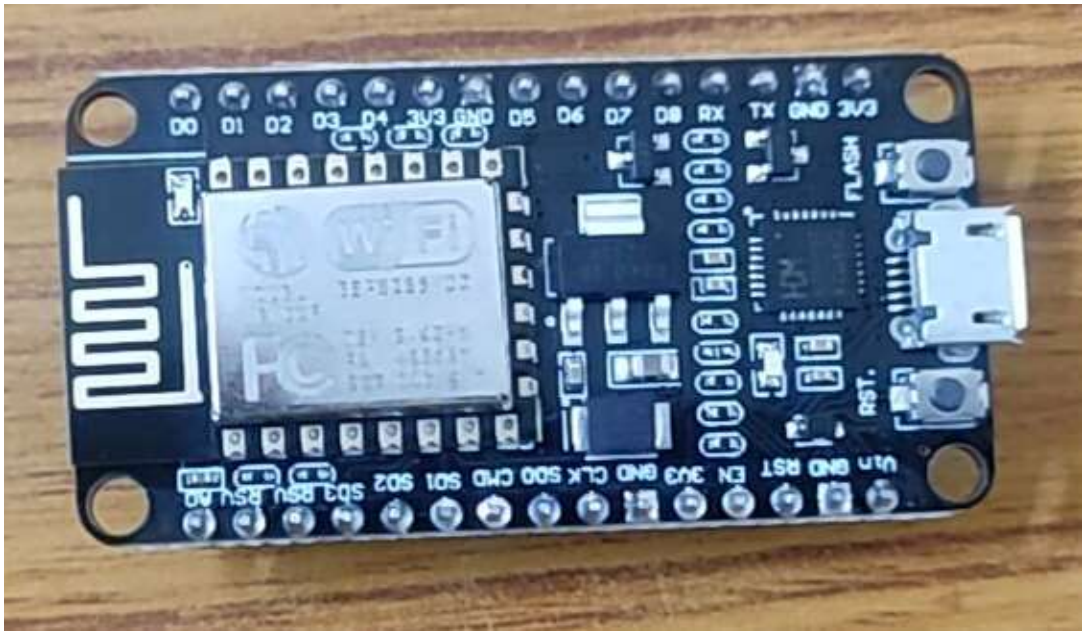

Figure 3.1.3 ESP8266 Module

- **Connection Methods:** Select the connection type that will be utilized to transfer information to a mobile application. Wi-Fi and BLE technology are common choices. For connectivity, the module for Wi-Fi has been used in this project. In this project, the Wi-Fi module for the ESP8266 was used. Construct the hardware components needed to establish a dependable connection with the program.
- **Designing and prototyping hardware:** Construct the Smart Water Bottle's external form while considering components like dimensions, form, and material (like glass, stainless steel, or BPA-free polymers). Create a functioning prototype to confirm the integration of sensors and connectivity components. To track the water level, we have kept the ultrasonic sensor in the water bottle cap in the prototype. Verify that the bottle is simple to clean, maintain, and refill.

Figure 3.1.4 Smart Water Bottle

- **Create an application:** The smartphone app should be user-friendly and compatible with Android. Integrate the app with the Smart Water Bottle's sensors and networking features to receive and interpret real-time data. Provide tools for tracking past data, creating customized recommendations, and setting hydration goals. Reminders that adapt should be put into place based on user activity levels, weather conditions, and individual preferences. While safely storing user data, provide privacy controls and options for data sharing.

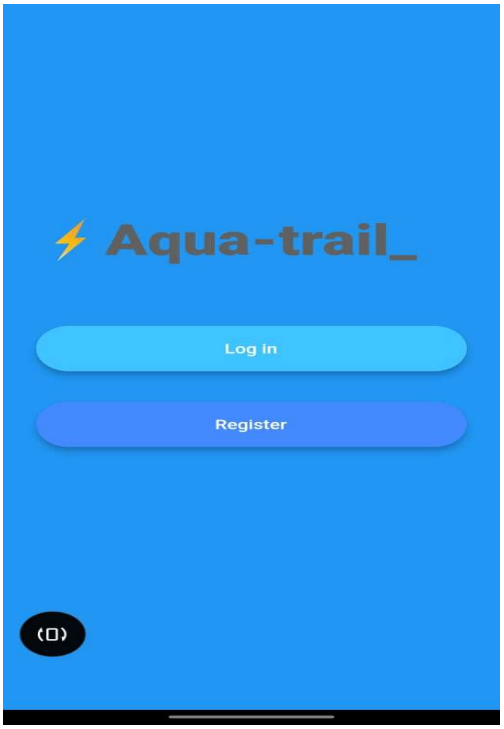

Figure 3.1.5 Mobile Application

3.2. Modules

Several crucial steps are involved in creating a smart water bottle. First, create a bottle that measures the amount of water consumed with built-in sensors. Attach these sensors to a microcontroller that handles data collection and processing. Transmit hydration data to a smartphone app via Bluetooth or Wi-Fi. The app tracks daily goals, sends reminders to drink water, and shows real-time data on water consumption. Install a system that uses rechargeable batteries for prolonged use. Add attributes like simple cleaning and a leak-proof design. Test and improve the product iteratively, taking user comments on usability and aesthetics into account. The finished product is a smart water bottle that encourages better health and wellness by keeping users hydrated.

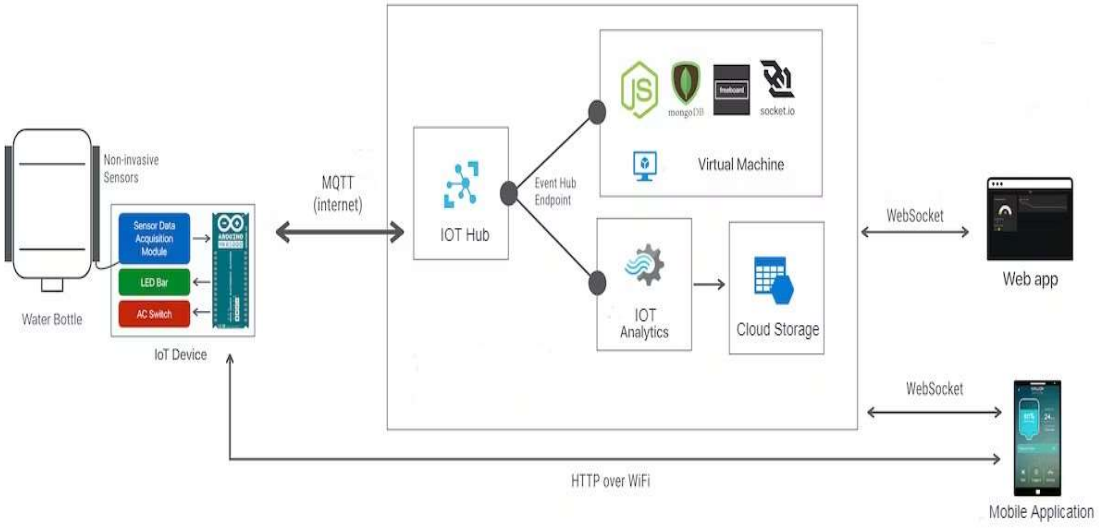

Figure 3.2 Architecture Diagram

The innovation proposed in this article deals with three stages in the development of smart water bottle:

- **Input Stage:** The input stage involves the connection of ultrasonic sensor and WiFi modules. This innovation uses the ESP8266 module because of its low cost and low power consumption, which is crucial if the device runs on batteries. The four pins on the ultrasonic sensor are connected to the Wi-Fi Module. The Vcc pin on the ultrasonic sensor is connected by the jumper wires in the 3v3 pin in the Wifi Module. The electric supply required by the ultrasonic sensor is provided by the 3v3 pin on Wifi module. The GND on ultrasonic sensor is connected with the GND on Wifi Module which serves as ground

reference. Trigpin is an input pin in the ultrasonic sensor which can be connected to any one of the pins like D5, D6, D7 on the Wifi module. A microcontroller or control system pulses the Trig pin for a brief period of time, usually 10 microseconds, to begin measuring distance. This pulse is sent to the Trig pin, and the sensor responds by emitting an ultrasonic sound wave—commonly called a "ping." As the sound wave moves through the atmosphere, it collides with nearby objects. The ultrasonic sensor also has an additional input/output pin called the Echo pin. The sound wave is released, and the sensor waits for it to return after bouncing off an object and returning to it as an echo. The duration of the pulse produced by the Echo pin when an echo is detected is proportionate to the time it took for the sound wave to reach the object and back.

- **Processing Stage:** Following data collection, the data must be transmitted to the cloud (using the WiFi-Module ESP8266) via the MQTT protocol utilizing publish and subscribe messaging transport. The Internet of Things (IoT) is best suited for MQTT, a simple, efficient messaging protocol designed for networks with erratic performance, high latency, or low bandwidth. Through a central broker, clients or devices communicate with one another via the publish-subscribe architecture of MQTT. Publishers target particular topics with messages, and subscribers receive messages from subjects that pique their interest. For Internet of Things (IoT) devices, MQTT guarantees effective data exchange, low overhead, and low power consumption. Because it provides Quality of Service levels for message delivery, it can be used for both asynchronous and synchronous communication, which makes it a popular option for Internet of Things and remote monitoring applications. Whenever there is a discernible change in the bottle's water level, the cloud receives the real-time data that was obtained from the sensor. The Firebase is used as it will also help in the authentication process when it needs to save the credentials of the individual in the cloud.
- **Output Stage:** The user and smart water bottle communicate with each other through a smartphone application. Prior to the user's water consumption being recorded in the firebase, the user must register and sign in to the application. The program will get the information and show the details, such as the amount of water used and the amount left over. Every user's data is stored in Firebase, which is used by the application for firebase authentication. Their hydration level is tracked by the app by retrieving real-time data.

Here is a small and prescribed detail of the project:

Problem:

A lot of people have trouble staying properly hydrated, which can affect their health and general wellbeing. Dehydration can lead to fatigue and impaired cognitive function, among other health issues. A smart water bottle that not only tracks and measures a person's water intake but also allows them to set individualized hydration goals is needed to solve this issue. A system like this should be easy for people to incorporate into their daily lives, providing a convenient and efficient means of maintaining proper hydration levels and enhancing general health and wellbeing.

Solution:

This project aims to develop an intuitive interface makes it simple to monitor and manage smart water bottle. It's common for people to forget to drink enough water. By monitoring its users' water consumption, a smart water bottle could help people stay hydrated. Users of a smart water bottle could be able to monitor their water intake and check their level of hydration even when they are not at home by connecting the bottle to a smartphone app. To guarantee that the user's private information is protected, strong encryption has been implemented.

Benefits:

A smart water bottle ensures we meet our daily hydration goals by accurately monitoring and recording our water intake, among other benefits. aids in the prevention of health problems associated with dehydration, such as headaches, fatigue, and impaired focus. lets us make well-informed lifestyle changes by giving us information and trends about our hydration habits. promotes a healthier lifestyle with little work because it makes tracking and reminders easier. decreases waste from single-use plastic bottles, encouraging sustainability. integrates with mobile applications to make goal-setting and monitoring simple. encourages appropriate hydration, which promotes overall well-being, making it a beneficial addition to daily routines.

Challenges:

There are a number of challenges that need to be addressed which we had faced, smart water bottles are typically more costly. For some prospective users, this expense might be a deterrent to using. The limited availability of smart water bottles in comparison to traditional bottles restricts the options available to consumers who favor a wider selection of brands and styles. Users must remember to charge or replace the batteries on smart bottles on a regular basis to ensure continued functionality, as the batteries may have a limited lifespan. Some of them are:

- **Range:** The typical data transmission distances for IoT devices connected to a network can be used to characterize the network: PAN is short-range, meaning that distances are measured in meters. An example of this would be a wearable fitness tracker that uses Bluetooth Low Energy (BLE) to connect with a mobile app. LAN stands for local area network, and it can cover short- to medium-range networks over hundreds of meters. Examples of these networks include home automation systems and sensors installed inside manufacturing lines that connect wirelessly to a gateway device located inside the same structure. MAN stands for long-range (city-wide), where distances up to a few kilometers are measured. An example of this would be a mesh network topology connected smart parking sensors placed throughout the city. Long-range wireless networks (WAN) are those where the distances are measured in kilometers. An example of this would be the agricultural sensors placed throughout a sizable farm or ranch to keep an eye on the environmental conditions and microclimates throughout the property. The data from the IoT devices should be retrieved by the network and sent to the correct location. It is

necessary to choose a network protocol that fits the range. For WAN applications that need to function over a few kilometers' distance, for instance, BLE should not be used. If it's difficult to send data over the necessary range, think about edge computing. Edge computing analyses data directly from the devices, as opposed to using information coming from a data center that is miles away or another location.

- **Bandwidth:** The capability or speed of data transfer of a networked communication channel is referred to as bandwidth, which is a basic concept in network technology. Calculated over bit per sec, it indicates the maximum amount of data that can be transferred over a network in a specific amount of time. One of the most important metrics for assessing the effectiveness and speed of data transfer within a network is bandwidth. The following are important concepts regarding bandwidth in the field of network technology to grasp: Bandwidth and speed of data transmission are frequently interchangeable terms. More data transmission capacity is indicated by a higher bandwidth, which enables quicker communication between connected devices. The speed at which data can be transmitted or downloaded depends on the quality of the network connection. Bits per second is the common unit of measurement for bandwidth. Kbps is examples of common units. One network connection with 100 Mbps of bandwidth, for instance, can send 100 million bits of information in a second. Bandwidth is frequently divided into both upstream and downstream components, or components. The rate of data transfer from the device used by the user to the network is referred to as downstream bandwidth, and the velocity of data transfer from the networks to the user's device is referred to as upstream bandwidth. The majority of residential internet services have asymmetrical network connections, where the downstream bandwidth is typically greater than the upstream bandwidth. The efficiency of networked services and applications is directly impacted by the available bandwidth. Faster downloads, more fluid streaming of videos, and quicker online activity response times are all made possible by increased bandwidth. On the other hand, a restricted bandwidth can cause slower data transfer rates, which can cause delays and worse performance. A number of factors can influence how much actual bandwidth users experience. The effective bandwidth can be affected by a number of factors, including network congestion, the quantity of individuals using the same network, the caliber of the infrastructure, and the effectiveness of networking hardware. Furthermore, the physical medium—copper cables, fiber optics, wireless channels, etc.—that is utilized for network connections affects the amount of bandwidth that is available. Network latency is the term used to describe the lag or delay in data transmission between two points, whereas capacity measures the capacity of information transfer. For real-time applications wherein timely data delivery is critical, like online gaming or video calling, low latency is essential. Network latency is influenced by a number of other factors, including processing delays and routing efficiency, so high bandwidth by itself does not ensure low latency. The amount of bandwidth needed can change depending on the kinds of applications and users utilizing a network. The ability of a network to support more users or more data demands is referred to as scalability. In order to satisfy the bandwidth demands of growing user bases or changing technological requirements, networks must be built to scale efficiently. The downstream as well as upstream speeds are equal in symmetrical bandwidth. This is typical of business-focused

services where customers require steady download and upload speeds. On the other hand, a lot of home internet providers provide asymmetrical bandwidth, meaning that the upload speed is slower than the download speed.

- **Power Supply:** A power supply is an essential part of electronic devices and systems because it provides the electricity required for them to function. It is in charge of transforming electrical current from a source—like an outlet or battery—into a format that can be used to power electronic components and circuits. Power supplies are essential to the dependable and effective operation of electronic systems. They are available in a variety of forms, each intended for a particular use. In the world of electronics, power supplies are essential because they provide the electrical energy required for a variety of devices to function. Selecting the appropriate solution for a given application and guaranteeing dependable and effective performance in a variety of electronic systems requires an understanding of the various types, features, and factors related to power supplies.

- **Connectivity:** IoT devices don't always have constant connectivity. Certain devices are made to connect on a regular basis. On the other hand, devices may occasionally stop working because of connectivity problems on an unstable network. There are situations when quality of service problems, like handling interference or channel contention on a shared spectrum wireless network, arise. In the event that uninterrupted service is deemed essential for IoT landscape design, designs ought to account for sporadic connectivity and explore all feasible avenues to guarantee it.

- **Compatibility:** It is possible for devices to communicate with one another, with systems, with equipment, and with technology. Interoperability can present difficulties because there are so many distinct devices connected to the Internet of Things. Traditionally, maintaining interoperability on the Internet has involved adopting standard protocols. Industry members agree on standards, which steer clear of numerous alternative designs and directions. Issues with incompatibility, and consequently interoperability, can be avoided with appropriate standards and participants who accept them. Standardization procedures for the Internet of Things occasionally find it difficult to keep up with advancements and modifications. Written and published in accordance with future iterations of standards that are still pending.

- **Security:** A crucial component of information technology, network security aims to protect data's availability, integrity, and confidentiality while it travels across computer networks. Network security is becoming more and more crucial as technology develops and more areas of our lives are linked by networks. The following are important concepts in network security to grasp: Verifying a user's, device's, or system's identity when they try to connect to a network is called authentication. Robust authentication techniques, like multi-factor authentication, biometrics, and username/password combinations, aid in preventing unwanted access. Authorization establishes a user's or device's level of network access after they have been authenticated. In order to guarantee that users have access to only the resources and information required for their tasks, permissions are granted based on roles. The process of transforming information into an encrypted form that is only readable by

those with permission is known as encryption. This guarantees that even in the unlikely event that unauthorized parties obtain the data, they will be unable to decipher or utilize it without the necessary decryption key. A trusted network within a company and an untrusted external network, like the internet, are separated by firewalls. They guard against cyber threats and stop unauthorized access by keeping an eye on and managing network traffic that comes and goes in accordance with pre-established security rules. IDPSs keep an eye on system and/or network activity to spot malicious activity or policy infractions. They offer an extra line of protection against online attacks since they can quickly identify and address security issues. Users can access a secure network remotely by using virtual private networks (VPNs) to create safe, secure connections over the internet. This is essential for protecting the privacy of information sent over open networks, particularly when workers must connect from outside of the company to corporate networks. To keep a network environment safe, complete security measures and processes must be established. These documents provide policies and procedures for safeguarding information, incident response, access controls, user behavior, and other security-related topics. Frequent monitoring and security audits assist in locating weak points, odd behavior, and possible security breaches. Organizations can quickly identify and address security incidents by keeping a close eye on network activity and logs. Keeping network devices, operating systems, and software updated with the newest security patches is essential for fixing vulnerabilities that are known to exist. Maintaining patch levels regularly reduces the possibility of malicious actors exploiting vulnerabilities. Securing individual devices, or "endpoints," that are connected to a network is known as endpoint security. To make sure that endpoints follow security policies, this includes device management, antivirus software, and EDR (endpoint detection and response) solutions. An essential part of network security is educating users about dangers and best practices. Security incidents are frequently caused by human error, and a knowledgeable user base greatly enhances the overall resilience of the network. Even with precautions taken, security incidents can still happen. Organizations can minimize the impact and speed up recovery from security breaches through the implementation of an established incident response plan. Organizations must adhere to specific to an industry regulations and standards in order to guarantee that the security requirements are met. Guidelines for protecting sensitive data are provided by regulatory structures, such as PCI DSS for debit and credit card data and HIPAA for healthcare information. The safety of networks is a constant challenge in today's connected world that calls for a multifaceted strategy. To build a strong defense against the constantly changing landscape of cyber threats, it is imperative to integrate innovations in technology, policies, and user education. It is crucial to maintain a proactive and adaptable network security strategy because cyberattacks are becoming more and more sophisticated.

3.3. Advantages over traditional methods

When it comes to tracking and sustaining hydration, smart water bottles are far superior to conventional, manual techniques. The following are some main advantages:

- **Accurate Tracking:** Sensor technology in smart water bottles provides accurate tracking by measuring the exact amount of liquid consumed, doing away with the estimation and guesswork that are frequently involved in manual methods. Users are guaranteed to receive highly accurate data regarding their level of hydration thanks to these sensors, which calculate the amount of water consumed in real-time. This accuracy is crucial for helping people reach their daily water intake targets, maintain proper hydration, and learn more about their general health. Precise monitoring enhances overall health and facilitates well-informed decision-making by furnishing users with reliable, data-driven insights into their hydration patterns.
- **Data insights:** By providing users with comprehensive information about their hydration patterns, users can make well-informed decisions regarding their lifestyle and health.
- **Consistency:** Smart bottles promote steady hydration throughout the day, lowering the chance of dehydration and the health issues that come with it.
- **Convenience:** Smart bottles make it easier for everyone to monitor and control their hydration levels by streamlining the process.
- **Environmental Impact:** Because they cut down on the usage of single-use plastic bottles, smart water bottles are good for the environment. They reduce the amount of plastic waste and resources used in the production of single-use bottles by encouraging the reuse of the same container. They lessen pollution and the carbon footprint connected to the production and disposal of plastic by reducing plastic waste and production. Furthermore, adopting sustainable practices—like cutting back on single-use plastics—aligns with international initiatives to address environmental problems, making smart water bottles a modest but significant step in the direction of a more sustainable future and less environmental degradation.
- **Health Benefits:** Smart water bottles encourage appropriate hydration, which has several health benefits. They support users in maintaining their recommended daily intake of water, which is critical for general health. Sufficient hydration can enhance concentration, mental performance, and vitality. It promotes healthy skin, helps with digestion, and controls body temperature. Smart bottles lower the chance of headaches, exhaustion, and kidney stones by avoiding dehydration. They promote long-term health by encouraging users to adopt hydration as a regular habit. Additionally, customized hydration plans that meet each user's needs maximize health benefits by making sure that users drink the appropriate amount of water to support their unique lifestyle and well-being objectives.

3.4. Applications

Applications for smart water bottles are numerous and include travel, hospitality, fitness tracking, medical compliance, environmental sustainability, sports performance, and the care of young and old as well as personal health and wellness. In addition to promoting appropriate hydration and lowering plastic waste, they improve wellbeing in a variety of settings.
Smart water bottles have a range of applications:

- **Personal Health:** Assisting people in maintaining ideal levels of hydration, smart water bottles provide significant benefits for personal health. They make sure users meet their daily hydration goals by precisely tracking the amount of water they consume. These gadgets are vital for general wellbeing because dehydration can cause headaches, exhaustion, and a decline in cognitive function. These gadgets provide users the information they need to make health-related decisions, encouraging improved hydration practices and lowering the possibility of dehydration-related problems.

- **Sports and Athletes:** Sports and athlete environments can benefit greatly from the use of smart water bottles. They are essential in ensuring optimal hydration for maximum output and recuperation. During training and competition, athletes can accurately track and control how much water they consume, which helps to ensure that they stay properly hydrated. Certain smart bottles have the ability to recommend the perfect water temperature for particular activities. These gadgets are particularly helpful in endurance sports, where cramping and decreased performance can result from dehydration. Athletes can improve their performance in training and competition, lower their chance of dehydration-related problems, and recuperate from strenuous physical activity more quickly by using smart water bottles. These benefits will ultimately improve their overall health and athletic performance.

- **Children and Elderly Care:** Children's and senior care are two major areas for which smart water bottles are useful. These devices help kids stay properly hydrated, which is important for growth and general wellbeing. Parents and other caregivers can monitor their child's water intake, which helps kids stay hydrated. Smart water bottles are useful for elderly care because they help people stay hydrated, which is especially important for seniors. Health issues in the elderly can result from dehydration. Elderly people's health and quality of life are enhanced when they are properly hydrated, and these bottles help caregivers keep track of their intake.

- **Corporate Wellness:** Corporate wellness initiatives that support employee health and wellbeing are increasingly incorporating smart water bottles. Their goal is to improve productivity and concentration by promoting constant hydration throughout the workday. More productivity and focus among employees benefits employers. Moreover, companies can customize wellness initiatives by using data insights from smart bottles regarding employees' hydration patterns. These hydration aids promote a happier workplace, lower absenteeism due to health issues, and support company sustainability objectives by cutting down on the use of single-use plastic bottles.

CHAPTER 4

RESULTS

The smart water bottle which has been developed has shown a number of ways in improving our life as the results are improved hydration, tracking and monitoring, regular notifications, encouragement for healthy habits etc. A number of studies have shown that smart water bottles can help people drink more water. For example, a 2022 study published in the journal Scientific Reports found that people who used a smart water bottle drank 16% more water per day than those who used a regular water bottle.

Another study, published in the journal Computers in Human Behavior in 2021, found that smart water bottles can help people develop sustainable water drinking habits. The study found that people who used a smart water bottle for 12 weeks continued to drink more water even after they stopped using the bottle.

Smart water bottles are still a relatively new product, but they have the potential to be a valuable tool for people who are trying to stay hydrated and improve their overall health. However, there are a few things to keep in mind when choosing a smart water bottle. We make sure to choose a bottle that is accurate in tracking your water intake. Some smart water bottles have been shown to be more accurate than others.

Comparing a smart water bottle's accuracy to a known amount of water is one method to do so. For example, fill a cup with exactly 8 ounces of water and then pour the water into the smart water bottle. We offer additional features such as temperature tracking, hydration reminders, and goal setting.

Finally, we consider our budget. Smart water bottles that use IoT and Arduino are often more affordable than traditional smart water bottles. This is because Arduino is a low-cost platform that can be used to create a variety of electronic devices. Additionally, there are many open-source Arduino projects available online, which can be used to create a smart water bottle without having to purchase expensive components or software.

A platform consists of the hardware, network, and operating system (OS) on which an application or service runs. It's possible that several apps were originally intended to run on various platforms (hardware, networks, and operating systems). Services and applications must be integrated on a single platform and operating system. Smart objects in IoT networks generate data that is structured as well as unstructured. Structured data is simpler to work with and analyze because of its well-defined structure. However, unstructured data can be more difficult to handle and usually needs to be processed using a completely different set of analytics tools. A virtualized environment, or one that appears to be one to all apps and services, is provided by cloud computing and storage environments. In reality, there may be two or more physical platforms and running environments present.

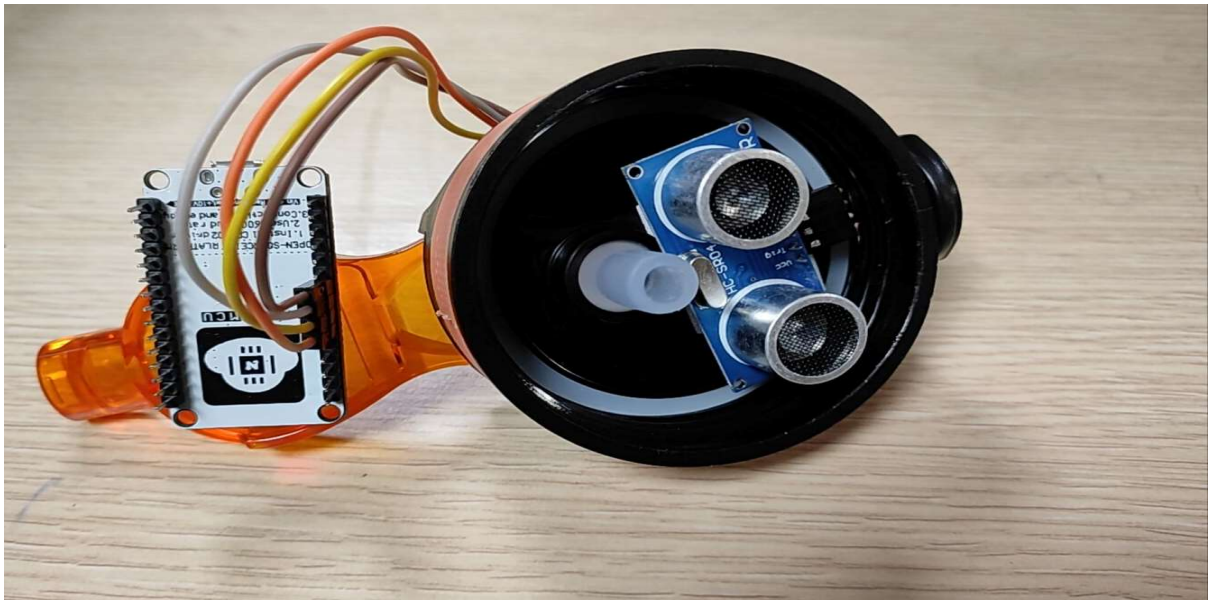

Figure 4. Integration of Sensor and Module

In order to provide real-time data on hydration progress, smart water bottles with sensors and connectivity features (as seen in figure 4) track the amount of water consumed and sync with mobile apps. This provides goals and reminders to users to help them stay hydrated. For an enhanced drinking experience, some smart bottles even have purification and temperature control capabilities. The ultimate result is enhanced wellbeing via optimal hydration, as users learn to be more conscious of how much water they consume, which improves their general health and way of life.

The term "Industrial 4.0" refers to "smart manufacturing" or IIoT (Industrial Internet of Things). For companies that concentrate on managing their supply chains and manufacturing, it integrates massive amounts of data, machine learning, and intelligent digital technologies with physical manufacturing and operations in order to establish an increasingly interconnected and better connected ecosystem.

Even though every business and organization in operation today is unique, The need for connectivity and immediate access to current information across collaborators, products, individuals, and processes is the same issue that confronts them all. That is how Industry 4.0 is being used. Industry 4.0 is not just about investing in new equipment and technology to boost production efficiency—rather, it's about revolutionizing the way the company as a whole functions and grows.

Digital control and sensor data are provided by networked devices. The ultimate goal is to reduce costs and enable quick design, modification, production, and personalization of products in the real world, all while being able to adapt to shifts in the dynamics of the supply chain, customer preferences, demand, and technology.

The goals are to facilitate early stakeholder involvement, vertical and horizontal integration, and autonomous decision-making processes. They also aim to enable real-time asset and process tracking and similarly real-time connected creation of value networks.

CHAPTER 5

CONCLUSION

In conclusion, the AquaTrail project represents a significant step forward in the intersection of technology and health. Through this project, we have successfully designed, developed, and tested a smart water bottle that not only helps individuals stay hydrated but also promotes healthier lifestyles. AquaTrail incorporates a range of features, including hydration tracking, personalized reminders, and compatibility with mobile applications, which provide users with the tools they need to make better choices when it comes to their daily water intake.

Our project has highlighted the potential for technology to enhance our well-being and encourage healthier habits in a world where staying hydrated can be challenging. Smart water bottles that use IoT and Arduino are often more affordable than traditional smart water bottles. This is because Arduino is a low-cost platform that can be used to create a variety of electronic devices. Additionally, there are many open-source Arduino projects available online, which can be used to create a smart water bottle without having to purchase expensive components or software.

Overall, smart water bottles that use IoT and Arduino are a promising technology with the potential to improve people's health and well-being. Here are some specific examples of how these bottles can be used:

- Athletes can use smart water bottles to track their hydration levels during workouts and competitions. This can help them to avoid dehydration and improve their performance.
- People with diabetes can use smart water bottles to track their fluid intake and ensure that they are drinking enough water. This can help to prevent complications from diabetes, such as kidney disease.
- Older adults can use smart water bottles to remind them to drink water throughout the day. This can help to prevent dehydration, which is a common problem among older adults.
- People who live in hot climates can use smart water bottles to track their hydration levels and ensure that they are drinking enough water to stay hydrated. This can help to prevent heatstroke and other heat-related illnesses.

People's approach to staying hydrated is revolutionized by an IoT-based smart water bottle. These water bottles provide real-time monitoring, personalized goals, and reminders by seamlessly integrating technology into the everyday act of drinking water. This encourages the adoption of a more mindful and healthful water consumption routine. The user experience is improved overall by the additional features, such as temperature control and water purification. The culmination is a tool that uses connectivity and data to make proactive and informed hydration choices, thus promoting well-being in addition to satisfying thirst. Thus, the Internet of Things-based smart water bottle is a monument to the revolutionary potential of technology in encouraging healthy lifestyle modifications and enhancing people's general health and well-being.

CHAPTER 6

FUTURE SCOPE

With technology advancing and people becoming more concerned with sustainability and health, the future of smart water bottles appears bright. Exciting advancements in the field of health and technology are expected to arise in the future of smart water bottles. Beyond simple hydration reminders, these bottles have sensors and connectivity built in. Subsequent versions could incorporate sophisticated functionalities such as in-the-moment hydration assessment, customized suggestions according to personal requirements, and integration with wearable technology to provide a comprehensive health monitoring encounter.

The hydration reminders on smart water bottles may be automatically adjusted by smart homes as the Internet of Things (IoT) develops, taking into account ambient conditions and individual activity levels. Predictive analytics, which anticipate hydration needs and optimize consumption, may be made possible by the integration of artificial intelligence.

Environmentally friendly designs and materials will probably become the main focus of sustainability. Refills are encouraged by smart bottles, which may also help reduce the amount of single-use plastic waste produced.
Important future scope consist of:

- **Improved Integration:** To provide a comprehensive picture of health and wellbeing, smart water bottles will be more easily integrated with other health-tracking tools and platforms.
- **Advanced Sensors:** As sensor technology advances, more precise water intake measurements and possibly even more health-related data will become available.
- **Quality:** The latest developments in water bottle designs ought to consider the water's quality as well.
- **Environmental Sustainability:** A strong emphasis on sustainability will encourage the creation of eco-friendly designs and materials, lowering the product's environmental impact.
- **Health Monitoring:** Some smart bottles come with extra features for keeping an eye on your electrolyte levels or recommending the best water temperature for a given activity.
- **Increased Adoption:** The use of smart water bottles will increase as people realize how important it is to track their health and stay hydrated.

Even more cutting-edge technology, enhanced personalization, and a greater dedication to sustainability will all be part of the future of smart water bottles, which will ultimately improve user health and wellbeing and leave a smaller environmental impact.

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APPENDIX – 1

- **Actuators:** Actuators are parts or devices that react to signals from controllers or Internet of Things systems by moving physically. This could be any kind of mechanical response, including movement and adjustment.
- **IOT:** Embedded with sensors and software, the Internet of Things (IoT) is a network of interconnected devices that can exchange and gather data.
- **Sensor:** A sensor is a device that measures and detects physical characteristics and then transmits that information to other IoT devices as signals or data.
- **Gateways:** IoT device communication and data exchange are facilitated by gateways, which are devices that link various networks.
- **Cloud Computing:** Utilizing a network of distant servers hosted on the internet for data processing, storing, and management—a technique commonly employed in Internet of Things applications—is known as cloud computing.
- **Edge Computing:** Improving latency in Internet of Things systems through edge computing, which processes data close to the point of generation instead of depending on a centralized cloud.
- **Middleware:** Applications and devices connected to the Internet of Things that serve as abridge to transmit and receive data between one another.
- **Protocols:** Protocols are essential for Internet of Things interoperability because they specify how data is transferred between devices in a network.
- **Security:** The procedures and guidelines put in place to guard against cyberattacks, illegalaccess, and data breaches on IoT networks and devices.
- Interoperability: The capacity of various IoT systems and devices to interact with one another and function as a cohesive unit.
- **Big Data:** Complicated, sizable datasets produced by Internet of Things (IoT) devices thatcall for sophisticated analytics to extract value.
- **Machine Learning:** Algorithms used in machine learning, a branch of artificial intelligence, allow systems to learn from and improve upon data without the need for explicit programming.
- **Application Programming Interface (API):** A collection of guidelines that permit interactivity and communication between various software programs.
- **Firmware:** IoT devices' firmware is embedded software that controls the hardware at a lowlevel.
- **IPv6:** A protocol designed to handle the increasing number of Internet of Things devices, offering a significantly higher number of distinct IP addresses.
- **Smart Grid:** An intelligent electrical distribution system known as a "smart grid" makes use of the Internet of Things to maximize energy production, distribution, and consumption.

APPENDIX – 2

Code:

```
#include <ESP8266WiFi.h>
#include <FirebaseESP8266.h>

#define FIREBASE_HOST "water-level-e63b0-default-rtdb.firebaseio.com"

#define FIREBASE_AUTH "HPpASStII7gBF0LQ1fwOElk1Wn82VYQsS3ZqfPJu"

#define WIFI_SSID "Iotvb"

#define WIFI_PASSWORD "vanshaj123"

FirebaseData firebaseData;

FirebaseAuth auth;

FirebaseConfig config;

int trigPin = D5;
int echoPin = D6;
// Declare global variable to store value int val=0;

void setup() {

pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Serial.begin(115200);

Serial.println("Serial communication started\n\n");

WiFi.begin(WIFI_SSID, WIFI_PASSWORD);

Serial.print("Connecting to "); Serial.print(WIFI_SSID);
while (WiFi.status() != WL_CONNECTED) {

Serial.print(".");
delay(500);
}

Serial.println();
Serial.print("Connected to ");
Serial.println(WIFI_SSID);
Serial.print("IP Address is : ");
Serial.println(WiFi.localIP());
```

```
// Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH); // connect to firebase
config.database_url = FIREBASE_HOST;
config.signer.tokens.legacy_token=FIREBASE_AUTH;    Firebase.begin(&config,
&auth);
Firebase.reconnectWiFi(true);
delay(1000);
}

void loop() {
int pingTravelTime;
float pingTravelDistance;
float dist;
float level;
float vol_left;
float perc;
digitalWrite(trigPin,LOW);
delayMicroseconds(10);
digitalWrite(trigPin,HIGH);
delayMicroseconds(10);
digitalWrite(trigPin,LOW);
pingTravelTime=pulseIn(echoPin,HIGH); delay(25);
pingTravelDistance=(pingTravelTime*765.*5280.*12*2.54)/(3600.*1000000);
dist=pingTravelDistance/2;
level = 26-dist;
vol_left = 39*level;
perc = 30*level/780*100;
Serial.print("Distance to Target is: ");
//Serial.print(dist);
//Serial.print(" cm ");
Serial.print(vol_left);
Serial.print(" ml ");
//Serial.print(perc);
//Serial.println(" % ");
if(isnan(vol_left)){
Serial.print(F("Failed to read from DHT Sensor"));
return;
}
if (Firebase.setInt(firebaseData, "/data", val)) {
Serial.println("Value Uploaded Successfully");
Serial.print("Val = ");
Serial.println(val); Serial.println("\n");
val=vol_left; delay(1000);
}
else {
Serial.println(firebaseData.errorReason());
}
}
```

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