Electronics and Electrical Communications Engineering Department

Graduation Project

Electronic Water Flow Measurement

By

Botros Saied Botros
Hazem Atef Ibraheem
Khaled Abd-Allah Moussa
Mohamed Mamdooh Ibraheem
Tameem El-Sayed Mohamed

Supervisor	Head of Department	Dean
Dr. Eng. Salah Diab **Dr. Eng. Amir Salah El-Safrawy**	**Dr. Eng. Osama Zahran**	**Dr. Eng. Ayman El-Sayed**

Menoufia University

Faculty of Electronic Engineering

Department of Electronics and Electrical Communication Engineering

Graduation Project

Electronic Water Flow Measurement

Supervised by:

Dr. Eng. Salah Diab

Dr. Eng. Amir Salah El-Safrawi

Amir.hafez@el-eng.menfia.edu.eg

2020/2021

Menoufia University

Faculty of Electronic Engineering

Department of Electronics and Electrical Communication Engineering

Electronic Water Flow Measurement

A graduation project is submitted to the Department of Electronics and Electrical Communication Engineering in partial fulfillment of the requirements for the degree of bachelor of engineering in Communication and Electronic Engineering.

Supervised by:

Dr. Eng. Salah Diab

Dr. Eng. Amir Salah El-Safrawy

Dedication

This humble work presented to you is dedicated to our professors and mentors Dr. Eng. Amir salah El-Safrawi and Dr. Eng. Salah Diab, our professors, our colleagues and our parents.

Acknowledgements

First and foremost, we thank Allah for conciliation in this project.

Second, we would to express out sincerest thanks to our supervisors, teachers and mentors:

Dr. Eng. Salah Diab

Dr. Eng. Amir Salah El-Safrawi

For his support and guidance to us through all the phases of this project.

Finally, we would like to thank our parents for their support and patience with us over the years.

Table of Contents

Table of Figures

Chapter:1 Internet Of Things

1.1 Introduction

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

IoT can also make use of artificial intelligence (AI) and machine learning to aid in making data collecting processes easier and more dynamic.

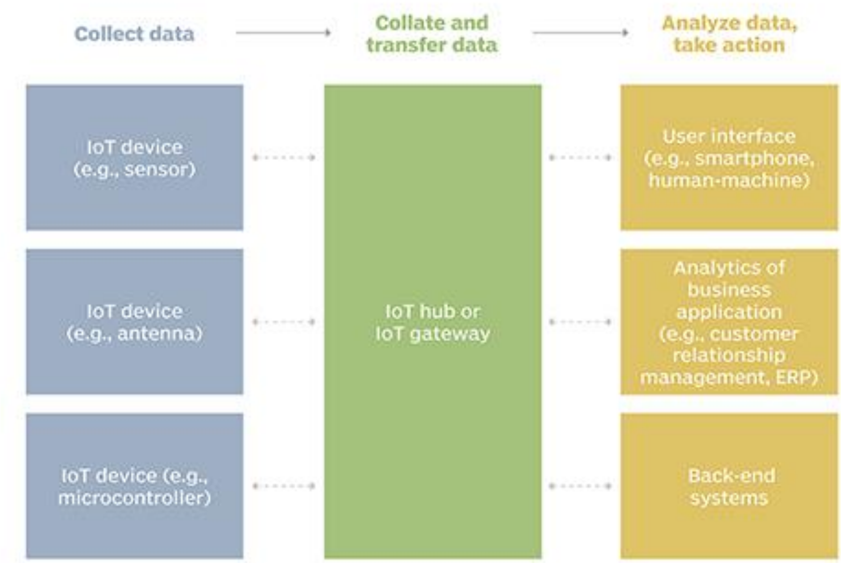


Figure 1 Example of an IoT system

The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations.

IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.

As such, IoT is one of the most important technologies of everyday life, and it will continue to gain traction as more businesses realize the potential of connected devices to keep them competitive.

1.2 History of IOT

The internet of things (IoT) has only recently become ingrained in our everyday life. It surrounds us everywhere we go: connected cars driving on the street, home automation devices located in the house, smart office sensors embedded in the workplace, and fitness trackers worn on our bodies. Altogether, they create a massive ecosystem of 26.66 billion interconnected things, according to Statista, which hold a remarkable influence over societies and economies worldwide. But the world hasn't always been this way. Until 1999, the term "internet of things" didn't even exist. So, how exactly did the internet of things evolve so fast and become such a regular buzzword, and what milestones marked internet of things development globally? In order to answer these questions, let's dive into the roots of this incredible technology.

1.2.1 The brief history of the internet of things

The concept of connected devices itself dates back to 1832 when the first electromagnetic telegraph was designed. The telegraph enabled direct communication between two machines through the transfer of electrical signals. However, the true IoT history started with the invention of the internet—a very essential component—in the late 1960s, which then developed rapidly over the next decades.

1.2.1.1 The 1980s

This might be hard to believe, but the first connected device was a Coca-Cola vending machine situated at the Carnegie Melon University and operated by local programmers.

They integrated micro-switches into the machine and used an early form of the internet to see if the cooling device was keeping the drinks cold enough and if there were available Coke cans.

This invention fostered further studies in the field and the development of interconnected machines all over the world.

1.2.1.2 The 1990s

In 1990, John Romkey connected a toaster to the internet for the very first time with a TCP/IP protocol. One year later, University of Cambridge scientists came up with the idea to use the first web camera prototype to monitor the amount of coffee available in their local computer lab's coffee pot.

They programmed the webcam to take pictures of the coffee pot three times per minute, then send the images to local computers, thus allowing everyone to see if there was coffee available.

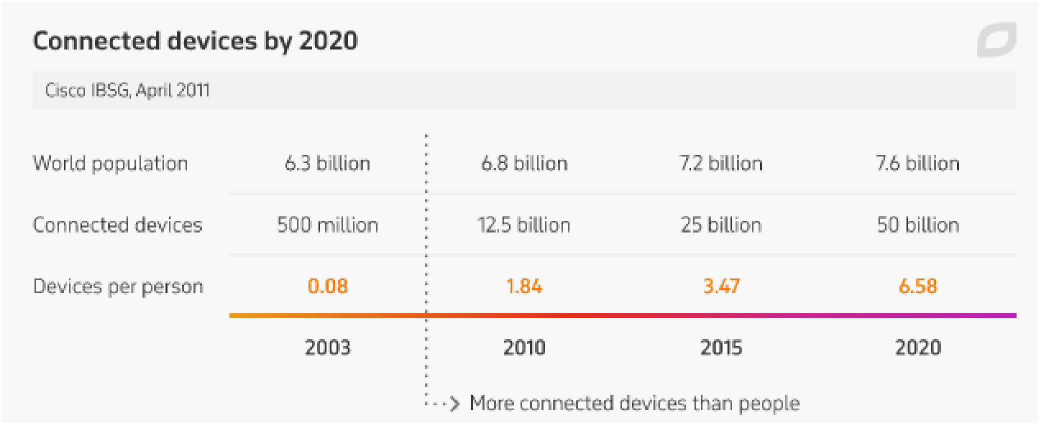
The year 1999 was easily one of the most significant for the IoT history, as Kevin Ashton coined the term "the internet of things." A visionary technologist, Ashton was giving a presentation for Procter & Gamble where he described IoT as a technology that connected several devices with the help of RFID tags for supply chain management. He specifically used the word "internet" in the title of his presentation in order to draw the audience's attention since the internet was just becoming a big deal that time.

While his idea of RFID-based device connectivity differs from today's IP based IoT, Ashton's breakthrough played an essential role in the internet of things history and technological development overall.

1.2.1.3 The 2000s

At the beginning of the 21st century, the term "internet of things" came into widespread use by the media, with outlets like The Guardian, Forbes, and the Boston Globe making mention of it.

Interest in the IoT technology was steadily increasing, which led to the 1st International Conference on the Internet of Things held in Switzerland in 2008, where participants from 23 countries discussed RFID, short-range wireless communications, and sensor networks. Moreover, several major developments fostered the IoT evolution. One was a refrigerator connected to the internet that was introduced by LG Electronics in 2000, allowing its users to shop online and make video calls. Another essential development was a small rabbit-shaped robot named Nabaztag created in 2005 that was capable of telling the latest news, weather forecast, and stock market changes. Even back then the number of interconnected devices surpassed that of people on Earth, according to Cisco.



Connected devices by 2020

Cisco IBSG, April 2011

	2003	2010	2015	2020
World population	6.3 billion	6.8 billion	7.2 billion	7.6 billion
Connected devices	500 million	12.5 billion	25 billion	50 billion
Devices per person	0.08	1.84	3.47	6.58

More connected devices than people

Figure 2 Connected IoT devices time chart

1.2.1.4 The 2010s

The IoT boom was supported by its addition to the Gartner Hype Cycle for emerging technologies in 2011. In the same year, IPv6—a network layer protocol that is central to IoT—was launched publicly.

Since then, interconnected devices have become widespread and commonplace in our everyday lives. Global tech giants like Apple, Samsung, Google, Cisco, and General Motors are focusing their efforts on the production of IoT sensors and devices—from interconnected thermostats and smart glasses to self-driving cars. IoT has found its way into almost every industry: manufacturing, healthcare, transportation, oil & energy, agriculture, retail, and many more. This dramatic shift has us convinced that the IoT revolution is right here, right now.

As of today, IoT platforms maintain a strong hold on their position among the top trends in this year's Gartner Hype Cycle, along with virtual assistants, connected homes, and level 4 self-driving cars. The technology will reach its plateau of productivity in 5–10 years.

1.2.2 A peek into the future of the internet of things

Given this rapid pace of development, IoT will soon dominate the world. In 2019, Gartner predicted that the enterprise and automotive IoT market would grow to 5.8 billion endpoints in 2020, marking a 21% increase from 2019. Everything that can be connected will be connected, thereby forming a comprehensive digital system wherein all devices communicate with people and one another.

Here are several crucial factors spurring this rapid IoT expansion:

- Falling sensor costs
- Falling costs of data collection and storage due to cloud solutions
- Widely expanding internet connectivity
- Increasing computing power
- Increasing smartphone and tablet penetration

Undoubtedly, IoT's rapid growth will fundamentally change the world we live in. Imagine how an interconnected car will access your work schedule and notify colleagues about your being late to the meeting if it hits a traffic jam on the way to work.

Our inevitable interconnected future will certainly bring in a lot of value and exciting opportunities for people. However, it will have its own challenges, too. Let's take a look at what experts think about the future of the internet of things and emerging industry trends.

1.2.3 IoT will become more industry-specific

In the near future, IoT manufacturers will focus on designing solutions for particular industries and industry segments rather than for general needs.

There is a growing demand for specific use cases that help to resolve industry-specific challenges. For example, IoT solutions for remote patient monitoring aimed at reducing costs and improving the quality of patient care.

The global remote patient monitoring market is expected to reach $1.8 billion by 2026, according to Grand View Research.

New areas are also appearing at the intersections between interconnected technologies and various industries:

- Internet of medical things
- Industrial internet of things
- Automotive internet of things
- Smart cities and smart buildings
- Smart agriculture
- Smart retail

1.2.4 IoT will continue to merge with other technologies

However powerful IoT is on its own, it provides far more opportunities when combined with other technologies such as blockchain, artificial intelligence, machine learning, big data, AR/VR, and cloud and edge computing. In the future, there will be far more mixed solutions. For example, the application of blockchain in IoT will help decentralize networks and ensure higher security data transmission between interconnected devices. Blockchain is already a leading IoT trend, and more value is sure to emerge from the blending of these two technologies.

IoT's future is closely linked with AI and machine learning as well. Application examples include the predictive maintenance of interconnected devices, the self-optimization of production processes, and smart home devices that learn your preferences. In the near future, IoT devices will not only report information, but also make autonomous decisions and become smarter on their own by deploying machine learning techniques.

Cloud and edge computing will continue to be integral to IoT data storage in 2019 and beyond, with experts predicting that edge computing will soon gain even more popularity.

1.2.5 Security will remain a blind spot

Despite the efforts of numerous governments to strengthen IoT security regulations and improve protection mechanisms for interconnectivity, data security and privacy problems will never diminish. Cybercriminals use more and more sophisticated tactics in order to find vulnerabilities in connected devices, thereby gaining access to private information.

As a result, consumers and organizations are increasingly concerned about IoT security and see it as the leading barrier to widespread IoT adoption.

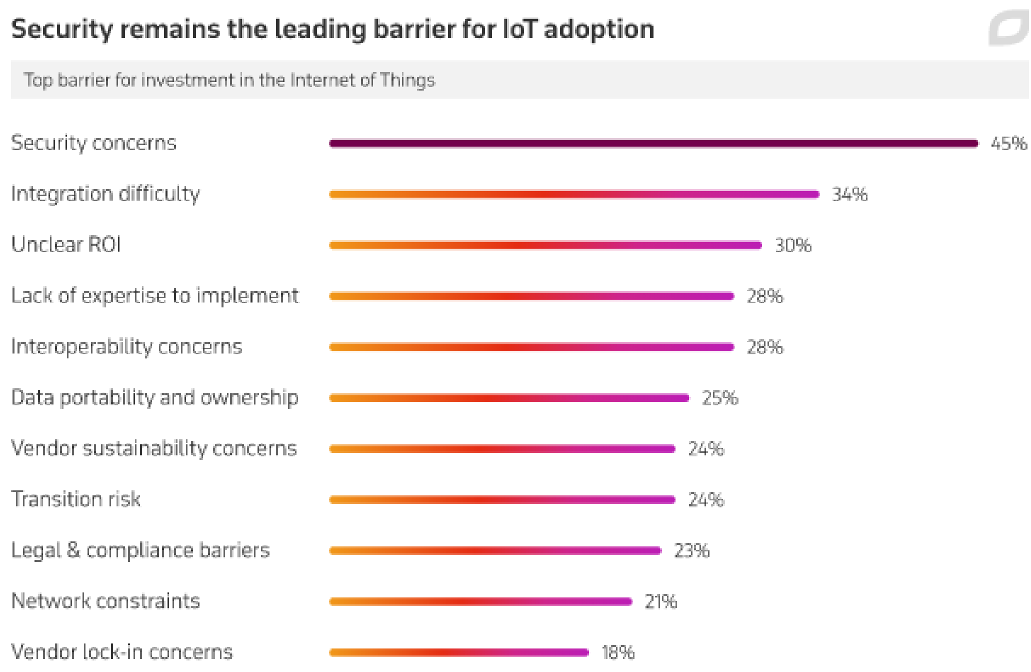


Figure 3 IOT investment barriers

1.3 Trends and characteristics of IOT

The IoT's major significant trend in recent years is the explosive growth of devices connected and controlled by the Internet. The wide range of applications for IoT technology mean that the specifics can be very different from one device to the next but there are basic characteristics shared by most. The IoT creates opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. The number of IoT devices increased 31% year-over-year to 8.4 billion in the year 2017 and it is estimated that there will be 30 billion devices by 2020. The global market value of the IoT is projected to reach $7.1 trillion by 2020.

1.3.1 Intelligence

Ambient intelligence and autonomous control are not part of the original concept of the Internet of things. Ambient intelligence and autonomous control do not necessarily require Internet structures, either. However, there is a shift in research (by companies such as Intel) to integrate the concepts of the IoT and autonomous control, with initial outcomes towards this direction considering objects as the driving force for autonomous IoT. A promising approach in this context is deep reinforcement learning where most of IoT systems provide a dynamic and interactive environment. Training an agent (i.e., IoT device) to behave smartly in such an environment cannot be addressed by conventional machine learning algorithms such as supervised learning. By reinforcement learning approach, a learning agent can sense the environment's state (e.g., sensing home temperature), perform actions (e.g., turn HVAC on or off) and learn through the maximizing accumulated rewards it receives in long term.

IoT intelligence can be offered at three levels: IoT devices, Edge/Fog nodes, and Cloud computing. The need for intelligent control and decision at each level depends on the time sensitiveness of the IoT application. For example, an autonomous vehicle's camera needs to make real-time obstacle detection to avoid an accident. This fast decision making would not be possible through transferring data from the vehicle to cloud instances and return the predictions back to the vehicle. Instead, all the operation should be performed locally in the vehicle. Integrating advanced machine learning algorithms including deep learning into IoT devices is an active research area to make smart objects closer to reality. Moreover, it is possible to get the most value out of IoT deployments through analyzing IoT data, extracting hidden information, and predicting control decisions. A wide variety of machine learning techniques have been used in IoT domain ranging from traditional methods such as regression, support vector machine, and random forest to advanced ones such as convolutional neural networks, LSTM, and variational autoencoder.

1.3.2 Network architecture

The Internet of things requires huge scalability in the network space to handle the surge of devices. IETF 6LoWPAN would be used to connect devices to IP networks. With billions of devices being added to the Internet space, IPv6 will play a major role in handling the network layer scalability. IETF's Constrained Application Protocol, ZeroMQ, and MQTT would provide lightweight data transport.

Fog computing is a viable alternative to prevent such a large burst of data flow through the Internet. The edge devices' computation power to analyze and process data is extremely limited. Limited processing power is a key attribute of IoT devices as their purpose is to supply data about physical objects while remaining autonomous. Heavy processing requirements use more battery power harming IoT's ability to operate. Scalability is easy because IoT devices simply supply data through the internet to a server with sufficient processing power.

1.3.3 Complexity

In semi-open or closed loops (i.e. value chains, whenever a global finality can be settled) the IoT will often be considered and studied as a complex system due to the huge number of different links, interactions between autonomous actors, and its capacity to integrate new actors. At the overall stage (full open loop) it will likely be seen as a chaotic environment (since systems always have finality). As a practical approach, not all elements in the Internet of things run in a global, public space. Subsystems are often implemented to mitigate the risks of privacy, control and reliability. For example, domestic robotics (domotics) running inside a smart home might only share data within and be available via a local network. Managing and controlling a high dynamic ad hoc IoT things/devices network is a tough task with the traditional networks architecture, Software Defined Networking (SDN) provides the agile dynamic solution that can cope with the special requirements of the diversity of innovative IoT applications.

1.3.4 Size considerations

The Internet of things would encode 50 to 100 trillion objects, and be able to follow the movement of those objects. Human beings in surveyed urban environments are each surrounded by 1000 to 5000 trackable objects. In 2015 there were already 83 million smart devices in people's homes. This number is expected to grow to 193 million devices by 2020. The figure of online capable devices grew 31% from 2016 to 2017 to reach 8.4 billion.

1.3.5 Space considerations

In the Internet of Things, the precise geographic location of a thing—and also the precise geographic dimensions of a thing—will be critical. Therefore, facts about a thing, such as its location in time and space, have been less critical to track because the person processing the information can decide whether or not that information was important to the action being taken, and if so, add the missing information (or decide to not take the action). (Note that some things in the Internet of Things will be sensors, and sensor location is usually important.) The GeoWeb and Digital Earth are promising applications that become possible when things can become organized and connected by location. However, the challenges that remain include the constraints of variable spatial scales, the need to handle massive amounts of data, and an indexing for fast search and neighbour operations. In the Internet of Things, if things are able to take actions on their own initiative, this human-centric mediation role is eliminated. Thus, the time-space context that we as humans take for granted must be given a central role in this information ecosystem. Just as standards play a key role in the Internet and the Web, geo-spatial standards will play a key role in the Internet of things.

1.3.6 A solution to "basket of remotes"

Many IoT devices have the potential to take a piece of this market. Jean-Louis Gassée (Apple initial alumni team, and BeOS co-founder) has addressed this topic in an article on Monday Note, where he predicts that the most likely problem will be what he calls the "basket of remotes" problem, where we'll have hundreds of applications to interface with hundreds of devices that don't share protocols for speaking with one another. For improved user interaction, some technology leaders are joining forces to create standards for communication between devices to solve this problem. Others are turning to the concept of predictive interaction of devices, "where collected data is used to predict and trigger actions on the specific devices" while making them work together.

1.4 IOT architecture and enabling technologies

IoT system architecture is often described as a four-stage process in which data flows from sensors attached to “things” through a network and eventually on to a corporate data center or the cloud for processing, analysis and storage. In the Internet of Things, a "thing" could be a machine, a building or even a person.

1.4.1 IOT architecture

IoT system architecture is often described as a four-stage process in which data flows from sensors attached to "things" through a network and eventually on to a corporate data center or the cloud for processing, analysis and storage. In the Internet of Things, a "thing" could be a machine, a building or even a person.

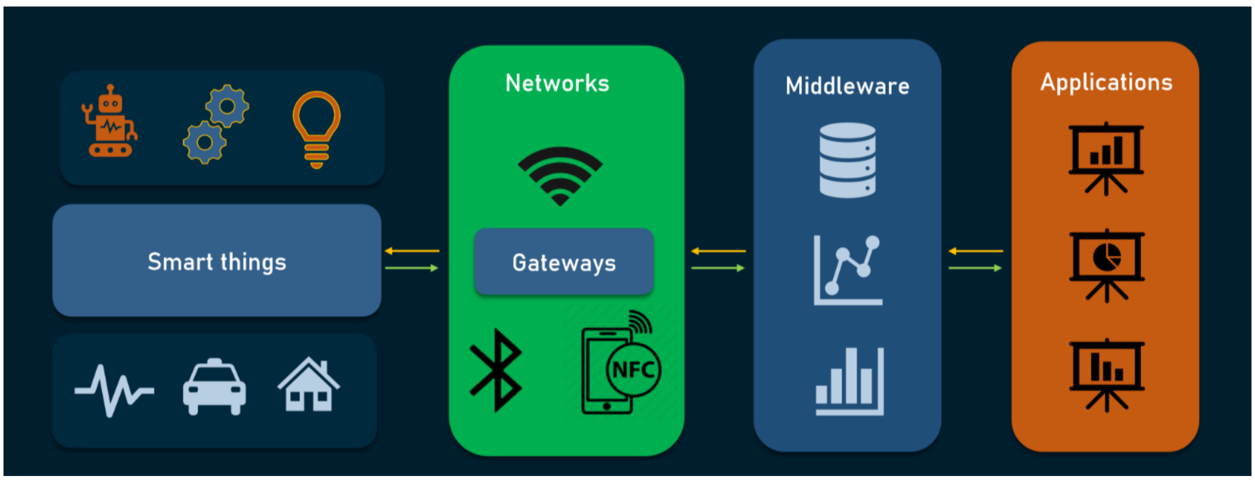


Figure 4 IOT architecture building block

1.4.1.1 Hardware layer

Hardware layer is the first layer in IoT architecture, it can be also called user-end layer, as the components present in this layer are customer end devices. This layer is also called perception layer. It includes sensors, other hardware like embedded systems and RFID readers and the tags. The interconnection between the physical and digital world is done by the sensors There by collecting the data that is to be processed. The type of sensors used in a network will be purely based on the purpose that is to be served. There are many types of sensors like body sensors, vehicle telemetric sensor, environment sensor etc. The sensors convert the measured physical property into the signal that can be understood by an instrument.

1.4.1.2 Network layer

All the devices and components of hardware layer are connected and form network layer. All the data collected will be sent to the central processing server through network layer. This layer has the highest prominence in IoT architecture. That is the reason the effect of attacks will be high in this layer. If one gains control over this layer, they can control, manage and manipulate all the components and data in the network. This layer has to support connectivity and communication using several communication protocols, interfaces, channels and information management.

1.4.1.3 Middleware layer

This layer is also called as processing layer. The data from the hardware layer reaches this layer passing through network layer. This layer reserves, examines and process the large amount of data received. Management and decision support are the two main functions of this layer. Various database management systems are used in this layer for data retrieval and storage. By employing technologies such as cloud computing, big data we can achieve interoperability in this layer.

1.4.1.4 Application layer

Based on the information processed in the middleware layer, the applications are managed in this layer. Various applications like smart home, smart hospital and smart transportation includes this layer. This layer provides the application specific services to the user. Many technologies like augmented reality, virtual reality, are used to connect intelligent applications, between IoT and users. Business layer: The Business layer is also called commercial layer because the usage of this layer is more for commercial purposes. Visualization of the processed data is the main function of this layer. This layer creates executive reports, flowcharts, different types of graphs for business purposes.

1.4.2 Enabling technologies for IOT

IoT primarily exploits standard protocols and networking technologies. However, the major enabling technologies and protocols of IoT are RFID, NFC, low-energy Bluetooth, low-energy wireless, low-energy radio protocols, and LTE-A. These technologies support the specific networking functionality needed in an IoT system in contrast to a standard uniform network of common systems.

1.4.2.1 RFID

RFID (Radio-Frequency Identification) enables identification of things by computer system. The information is transmitted without device contact, just by using radio frequency. These are also called as electronic tags. Due to the prominence created by IoT, every single object or device is given RFID tags. RFID tags are attached to automotive, and also in shopping malls. It automatically scans all details and sends to a particular destination. So the world is made smarter. Wi-Fi: The main intention of Wi-Fi protocol was to replace Ethernet using wireless communication over unlicensed bands and to provide off-the-shelf. Wi-Fi has IP addressability, and it can be easily understood, so it serves as a separate gateway.

1.4.2.2 ZigBee

Zigbee is the technology of transferring the data over wireless networks. So the power consumption issue can be addressed by using Zigbee. Since the nodes are distributed it can be controlled remotely. It is cost effective and simple compared to blue-tooth and WPAN. The frequency used is 2.4Giga hertz worldwide. ZigBee gateways are used to integrate the devices into the system.

1.4.2.3 4G LTE

In IoT, 4G technology is most popularly used technology. 4G technology is consequent of 3G and 2G. 4G technology has a capacity of handling speeds till 1 giga-bytes per seconds. Long-term Evolution (LTE) uses orthogonal frequency division multiplexing as its radio access technology together with advanced antenna technologies and is based on GSM and HSPA technologies used by earlier-generation mobile networks.

1.4.2.4 Big data

Big data is the information gathered by the devices like sensors and actuators connected over internet. Fetching the data is as important as storing the data. Big data analytics make use of some complex algorithms and patterns to find the data of our interest. Managing large amount of data has become a big challenge. One should be able to leverage the data in an effective manner to reap the benefits. So if IoT is the heart, then big data would be the blood.

1.5 Government regulation on IOT

One of the key drivers of the IoT is data. The success of the idea of connecting devices to make them more efficient is dependent upon access to and storage & processing of data. For this purpose, companies working on the IoT collect data from multiple sources and store it in their cloud network for further processing. This leaves the door wide open for privacy and security dangers and single point vulnerability of multiple systems. The other issues pertain to consumer choice and ownership of data and how it is used. Though still in their infancy, regulations and governance regarding these issues of privacy, security, and data ownership continue to develop. IoT regulation depends on the country. Some examples of legislation that is relevant to privacy and data collection are: the US Privacy Act of

1974, OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data of 1980, and the EU Directive 95/46/EC of 1995.

Current regulatory environment: A report published by the Federal Trade Commission (FTC) in January 2015 made the following three recommendations:

- Data security – At the time of designing IoT companies should ensure that data collection, storage and processing would be secure at all times. Companies should adopt a "defense in depth" approach and encrypt data at each stage.
- Data consent – users should have a choice as to what data they share with IoT companies and the users must be informed if their data gets exposed.
- Data minimization – IoT companies should collect only the data they need and retain the collected information only for a limited time.

However, the FTC stopped at just making recommendations for now. According to an FTC analysis, the existing framework, consisting of the FTC Act, the Fair Credit Reporting Act, and the Children's Online Privacy Protection Act, along with developing consumer education and business guidance, participation in multi-stakeholder efforts and advocacy to other agencies at the federal, state and local level, is sufficient to protect consumer rights.

A resolution passed by the Senate in March 2015, is already being considered by the Congress. This resolution recognized the need for formulating a National Policy on IoT and the matter of privacy, security and spectrum. Furthermore, to provide an impetus to the IoT ecosystem, in March 2016, a bipartisan group of four Senators proposed a bill, The Developing Innovation and Growing the Internet of

Things (DIGIT) Act, to direct the Federal Communications Commission to assess the need for more spectrum to connect IoT devices.

Approved on 28 September 2018, Senate Bill No. 327 goes into effect on 1 January 2020. The bill requires "a manufacturer of a connected device, as those terms are defined, to equip the device with a reasonable security feature or features that are appropriate to the nature and function of the device, appropriate to the information it may collect, contain, or transmit, and designed to protect the device and any information contained therein from unauthorized access, destruction, use, modification, or disclosure,"

Several standards for the IoT industry are actually being established relating to automobiles because most concerns arising from use of connected cars apply to healthcare devices as well. In fact, the National Highway Traffic Safety Administration (NHTSA) is preparing cybersecurity guidelines and a database of best practices to make automotive computer systems more secure

A recent report from the World Bank examines the challenges and opportunities in government adoption of IoT. These include:

- Still early days for the IoT in government
- Underdeveloped policy and regulatory frameworks
- Unclear business models, despite strong value proposition
- Clear institutional and capacity gap in government AND the private sector
- Inconsistent data valuation and management

- Infrastructure a major barrier
- Government as an enabler
- Most successful pilots share common characteristics (public-private partnership, local, leadership)

1.6 Criticism, problems and controversies of IOT

1.6.1 Platform fragmentation

The IoT suffers from platform fragmentation, lack of interoperability and common technical standards a situation where the variety of IoT devices, in terms of both hardware variations and differences in the software running on them, makes the task of developing applications that work consistently between different inconsistent technology ecosystems hard. For example, wireless connectivity for IoT devices can be done using Bluetooth, Zigbee, Z-Wave, LoRa, NB-IoT, Cat M1 as well as completely custom proprietary radios – each with its own advantages and disadvantages; and unique support ecosystem.

The IoT's amorphous computing nature is also a problem for security, since patches to bugs found in the core operating system often do not reach users of older and lower-price devices. One set of researchers say that the failure of vendors to support older devices with patches and updates leaves more than 87% of active Android devices vulnerable.

1.6.2 Data storage

A challenge for producers of IoT applications is to clean, process and interpret the vast amount of data which is gathered by the sensors. There is a solution proposed for the analytics of the information referred to as Wireless Sensor Networks. These networks share data among sensor nodes that are sent to a distributed system for the analytics of the sensory data.

Another challenge is the storage of this bulk data. Depending on the application, there could be high data acquisition requirements, which in turn lead to high storage requirements. Currently the Internet is already responsible for 5% of the total energy generated, and a "daunting challenge to power" IoT devices to collect and even store data still remains.

1.6.3 Security

Security is the biggest concern in adopting Internet of things technology, with concerns that rapid development is happening without appropriate consideration of the profound security challenges involved and the regulatory changes that might be necessary. Most of the technical security concerns are similar to those of conventional servers, workstations and smartphones. These concerns include using weak authentication, forgetting to change default credentials, unencrypted messages sent between devices, SQL injections, Man-in-the-middle attacks, and poor handling of security updates. However, many IoT devices have severe operational limitations on the computational power available to them. These constraints often make them unable to directly use basic security measures such as implementing firewalls or using strong cryptosystems to encrypt their communications with other devices - and the low price and consumer focus of many devices makes a robust security patching system uncommon.

Rather than conventional security vulnerabilities, fault injection attacks are on the rise and targeting IoT devices. A fault injection attack is a physical attack on a device to purposefully introduce faults in the system to change the intended behavior. Faults might happen unintentionally by environmental noises and electromagnetic fields. There are ideas stemmed from control-flow integrity (CFI) to prevent fault injection attacks and system recovery to a healthy state before the fault. Internet of Things devices also have access to new areas of data, and can often control physical devices, so that even by 2014 it was possible to say that many Internet-connected appliances could already "spy on people in their own homes" including televisions, kitchen appliances, cameras, and thermostats. Computer-controlled devices in automobiles such as brakes, engine, locks, hood and trunk releases, horn, heat, and dashboard have been shown to be vulnerable to attackers who have access to the on-board network. In some cases, vehicle computer systems are Internet-connected, allowing them to be exploited remotely. By 2008 security researchers had shown the ability to remotely control pacemakers without authority. Later hackers demonstrated remote control of insulin pumps and implantable cardioverter defibrillators.

Poorly secured Internet-accessible IoT devices can also be subverted to attack others. In 2016, a distributed denial of service attack powered by Internet of things devices running the Mirai malware took down a DNS provider and major web sites. The Mirai Botnet had infected roughly 65,000 IoT devices within the first 20 hours. Eventually the infections increased to around 200,000 to 300,000 infections. Brazil, Colombia and Vietnam made up of 41.5% of the infections. The Mirai Botnet had singled out specific IoT devices that consisted of DVRs, IP cameras, routers and printers. Top vendors that contained the most infected devices were identified as Dahua, Huawei, ZTE, Cisco, ZyXEL and MikroTik. In May 2017, Junade Ali, a Computer Scientist at Cloudflare noted that native DDoS vulnerabilities exist in IoT devices due to a poor implementation of the Publish–subscribe pattern. These sorts of attacks have caused security experts to view IoT as a real threat to Internet services.

The U.S. National Intelligence Council in an unclassified report maintains that it would be hard to deny "access to networks of sensors and remotely-controlled objects by enemies of the United States, criminals, and mischief makers... An open market for aggregated sensor data could serve the interests of commerce and security no less than it helps criminals and spies identify vulnerable targets. Thus, massively parallel sensor fusion may undermine social cohesion, if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search." In general, the intelligence community views the Internet of things as a rich source of data.

On 31 January 2019, the Washington Post wrote an article regarding the security and ethical challenges that can occur with IoT doorbells and cameras: "Last month, Ring got caught allowing its team in Ukraine to view and annotate certain user videos; the company says it only looks at publicly shared videos and those from Ring owners who provide consent. Just last week, a California family's Nest camera let a hacker take over and broadcast fake audio warnings about a missile attack, not to mention peer in on them, when they used a weak password"

There have been a range of responses to concerns over security. The Internet of Things Security Foundation (IoTSF) was launched on 23 September 2015 with a mission to secure the Internet of things by promoting knowledge and best practice. Its founding board is made from technology providers and telecommunications companies. In addition, large IT companies are continually developing innovative solutions to ensure the security of IoT devices. In 2017, Mozilla launched Project Things, which allows to route IoT devices through a safe Web of Things gateway. As per the estimates from KBV Research, the overall IoT security market would grow at 27.9% rate during 2016–2022 as a result of growing infrastructural concerns and diversified usage of Internet of things.

1.6.4 Safety

IoT systems are typically controlled by event-driven smart apps that take as input either sensed data, user inputs, or other external triggers (from the Internet) and command one or more actuators towards providing different forms of automation. Examples of sensors include smoke detectors, motion sensors, and contact sensors. Examples of actuators include smart locks, smart power outlets, and door controls. Popular control platforms on which third-party developers can build smart apps that interact wirelessly with these sensors and actuators include Samsung's SmartThings, Apple's HomeKit, and Amazon's Alexa, among others.

A problem specific to IoT systems is that buggy apps, unforeseen bad app interactions, or device/communication failures, can cause unsafe and dangerous physical states, e.g., "unlock the entrance door when no one is at home" or "turn off the heater when the temperature is below 0 degrees Celsius and people are sleeping at night". Detecting flaws that lead to such states, requires a holistic view of installed apps, component devices, their configurations, and more importantly, how they interact. Recently, researchers from the University of California Riverside have proposed IotSan, a novel practical system that uses model checking as a building block to reveal "interaction-level" flaws by identifying events that can lead the system to unsafe states. They have evaluated IotSan on the Samsung SmartThings platform. From 76 manually configured systems, IotSan detects 147 vulnerabilities (i.e., violations of safe physical states/properties.

1.6.5 Design

Given widespread recognition of the evolving nature of the design and management of the Internet of Things, sustainable and secure deployment of IoT solutions must design for "anarchic scalability." Application of the concept of anarchic scalability can be extended to physical systems (i.e. controlled real-world objects), by virtue of those systems being designed to account for uncertain management futures. This hard anarchic scalability thus provides a pathway forward to fully realize the potential of Internet-of-things solutions by selectively constraining physical systems to allow for all management regimes without risking physical failure.

1.6.6 Intentional obsolescence of devices

The Electronic Frontier Foundation has raised concerns that companies can use the technologies necessary to support connected devices to intentionally disable or "brick" their customers' devices via a remote software update or by disabling a service necessary to the operation of the device. In one example, home automation devices sold with the promise of a "Lifetime Subscription" were rendered useless after Nest Labs acquired Revolv and made the decision to shut down the central servers the Revolv devices had used to operate. As Nest is a company owned by Alphabet (Google's parent company), the EFF argues this sets a "terrible precedent for a company with ambitions to sell self-driving cars, medical devices, and other high-end gadgets that may be essential to a person's livelihood or physical safety."

1.6.7 Confusing terminology

The lack of clear terminology is not "useful from a practical point of view" and a "source of confusion for the end user". A company operating in the IoT space could be working in anything related to sensor technology, networking, embedded systems, or analytics. According to Lonergan, the term IoT was coined before smart phones, tablets, and devices as we know them today existed, and there is a long list of terms with varying degrees of overlap and technological convergence: Internet of things, Internet of everything (IoE), Internet of Goods (Supply Chain), industrial Internet, pervasive computing, pervasive sensing, ubiquitous computing, cyber-physical systems (CPS), wireless sensor networks (WSN), smart objects, digital twin, cyberobjects or avatars, cooperating objects, machine to machine (M2M), ambient intelligence (AmI), Operational technology (OT), and information technology (IT). Regarding IIoT, an industrial sub-field of IoT, the Industrial Internet Consortium's Vocabulary Task Group has created a "common and reusable vocabulary of terms" to ensure "consistent terminology" across publications issued by the Industrial Internet Consortium. IoT One has created an IoT Terms Database including a New Term Alert to be notified when a new term is published. As of March 2020, this database aggregates 807 IoT-related terms, while keeping material "transparent and comprehensive."

1.7 IOT adoption barriers

Despite a shared belief in the potential of the IoT, industry leaders and consumers are facing barriers to adopt IoT technology more widely.

1.7.1 Privacy and security concerns

As for IoT, information about a user's daily routine is collected so that the “things” around the user can cooperate to provide better services that fulfill personal preference. When the collected information which describes a user in detail travels through multiple hops in a network, due to a diverse integration of services, devices and network, the information stored on a device is vulnerable to privacy violation by compromising nodes existing in an IoT network.

For example, on 21 October 2016, a multiple distributed denial of service (DDoS) attacks systems operated by domain name system provider Dyn, which caused the inaccessibility of several websites, such as GitHub, Twitter, and others. This attack is executed through a botnet consisting of a large number of IoT devices including IP cameras, gateways, and even baby monitors.

Fundamentally there are 4 security objectives that the IOT system requires:

(1) data confidentiality: unauthorized parties cannot have access to the transmitted and stored data.

(2) data integrity: intentional and unintentional corruption of transmitted and stored data must be detected.

(3) non-repudiation: the sender cannot deny having sent a given message.

(4) data availability: the transmitted and stored data should be available to authorized parties even with the denial-of-service (DOS) attacks.

Information privacy regulations also require organizations to practice "reasonable security".

As each organization's environment is unique, it can prove challenging to demonstrate what "reasonable security" is and what potential risks could be involved for the business. Oregon's HB 2395 also "Requires person that manufactures, sells or offers to sell connected device] manufacturer to equip connected device with reasonable security features that protect connected device and information that connected device collects, contains, stores or transmits] stores from access, destruction, modification, use or disclosure that consumer does not authorize."

1.7.2 Traditional governance structure

A study issued by Ericsson regarding the adoption of Internet of things among Danish companies identified a "clash between IoT and companies' traditional governance structures, as IoT still presents both uncertainties and a lack of historical precedence.

" Among the respondents interviewed, 60 percent stated that they "do not believe they have the organizational capabilities, and three of four do not believe they have the processes needed, to capture the IoT opportunity."

This has led to a need to understand organizational culture in order to facilitate organizational design processes and to test new innovation management practices. A lack of digital leadership in the age of digital transformation has also stifled innovation and IoT adoption to a degree that many companies, in the face of uncertainty, "were waiting for the market dynamics to play out", or further action in regards to IoT "was pending competitor moves, customer pull, or regulatory requirements." Some of these companies risk being 'kodaked' – "Kodak was a market leader until digital disruption eclipsed film photography with digital photos" – failing to "see the disruptive forces affecting their industry" and "to truly embrace the new business models the disruptive change opens up."

Scott Anthony has written in Harvard Business Review that Kodak "created a digital camera, invested in the technology, and even understood that photos would be shared online" but ultimately failed to realize that "online photo sharing was the new business, not just a way to expand the printing business."

1.7.3 Business planning and project management

According to 2018 study, 70–75% of IoT deployments were stuck in the pilot or prototype stage, unable to reach scale due in part to a lack of business planning.

Studies on IoT literature and projects show a disproportionate prominence of technology in the IoT projects, which are often driven by technological interventions rather than business model innovation.

Even though scientists, engineers, and managers across the world are continuously working to create and exploit the benefits of IoT products, there are some flaws in the governance, management and implementation of such projects.

Despite tremendous forward momentum in the field of information and other underlying technologies, IoT still remains a complex area and the problem of how IoT projects are managed still needs to be addressed.

IoT projects must be run differently than simple and traditional IT, manufacturing or construction projects. Because IoT projects have longer project timelines, a lack of skilled resources and several security/legal issues, there is a need for new and specifically designed project processes.

The following management techniques should improve the success rate of IoT projects:

- A separate research and development phase
- A Proof-of-Concept/Prototype before the actual project begins
- Project managers with interdisciplinary technical knowledge

1.8 IOT Vs IOET

The evolution of the global internet has resulted in virtual connections that affect real-world objects and activities.

Everything is connected to everything else, creating a distributed ecosystem that reaches far beyond the interconnectivity of things. This is known as the Internet of Everything.

Though the Internet of Everything arose from the Internet of Things, it has become a dynamically evolving phenomenon that is poised to disrupt the business world.

1.8.1 What is the Internet of Everything?

The Internet of Everything is based on the idea of all-around connectivity, intelligence and cognition.

Unlike computerized devices that rely on intelligent internet connections, any object can be fitted with digital features and connected to a network of other objects, people and processes, with the goal of converting information into actions for new capabilities and experiences.

The Internet of Everything's pillars are:

- Decentralization: Data is processed in numerous distributed nodes, and not within a central system.
- Data input and output: External data can be stored on devices and returned to other components within the network.
- Connection to every technology in digital transformation: The Internet of Everything connects to cloud computing, artificial intelligence, big data, the Internet of Things, machine learning and other vital future technologies.

The constituent elements of the Internet of Everything are:

- People: People offer personal insights through connected devices, such as healthcare sensors and social media, and artificial intelligence, and other technologies analyze the data to discover insights about human concerns and deliver personalized content that's relevant to their needs.

- Things: Things encompass the Internet of Things or the physical objects with sensors that generate data and transfer it through the network.
- Data: Data from devices is raw, but once aggregated and analyzed it can be used for actionable decisions and intelligent solutions.
- Processes: Processes are based on other current technology, such as social networking, machine learning and artificial intelligence to provide relevant information to a particular person. In this way, the Internet of Everything maximizes the potential of big data.

The primary components of the Internet of Everything are hardware, software and services.

1.8.2 Internet of Things vs Internet of Everything

Though they're often intertwined and some aspects of their evolution occurred together, it's important to understand the differences between the Internet of Things and the Internet of Everything.

The primary difference between the Internet of Things and the Internet of Everything are the pillars for the concepts:

- The Internet of Things focuses on physical objects.
- The Internet of Everything focuses on four constituents: people, things, data and processes.

Simply put, the Internet of Things involves the interconnectivity of physical objects and data input and output, while the Internet of Everything is a comprehensive term that refers to the interconnectivity of various technologies, processes and people.

Despite these differences, they share some similarities:

- Decentralization: Both are distributed and don’t operate within a centralised system, giving them independence.
- Security: Distributed systems are vulnerable to cyberattacks and breaches, though decentralization ensures that the entire system and its connected devices aren’t compromised if problems occur in specific areas.

1.8.3 Examples of the Internet of Things and the Internet of Everything

Marketing Cloud is integrated with Honeycomb, Centrica Connected Home’s custom IoT platform, which provides a range of insights into customer journeys and behaviours The Internet of Things has become a part of our daily lives. It includes connected and 'smart' devices, such as:

- Vehicle telematics
- Voice-controlled home assistants
- Fitness trackers
- Air-quality monitors

The Internet of Everything expands on these common uses and offers applications for every industry. Here are some examples:

- Manufacturing can use sensors for predictive maintenance and equipment monitoring to reduce downtime and costs from inefficiencies.

- Municipalities can use smart meters for electricity and water monitoring in residential and commercial buildings to monitor usage and look for ways to reduce costs.
- Logistics companies can use sensors and devices on delivery trucks to optimize delivery schedules and routes for cost reduction and customer satisfaction.

1.9 IOT Applications

The extensive set of applications for IoT devices is often divided into consumer, commercial, industrial, and infrastructure spaces.

A growing portion of IoT devices are created for consumer use, including connected vehicles, home automation, wearable technology, connected health, and appliances with remote monitoring capabilities.

1.9.1 Smart home

IoT devices are a part of the larger concept of home automation, which can include lighting, heating and air conditioning, media and security systems and camera systems.

Long-term benefits could include energy savings by automatically ensuring lights and electronics are turned off or by making the residents in the home aware of usage.

A smart home or automated home could be based on a platform or hubs that control smart devices and appliances.

For instance, using Apple's HomeKit, manufacturers can have their home products and accessories controlled by an application in iOS devices such as the iPhone and the Apple Watch. This could be a dedicated app or iOS native applications such as Siri. This can be demonstrated in the case of Lenovo's Smart Home Essentials, which is a line of smart home devices that are controlled through Apple's Home app or Siri without the need for a Wi-Fi bridge.

There are also dedicated smart home hubs that are offered as standalone platforms to connect different smart home products and these include the Amazon Echo, Google Home, Apple's HomePod, and Samsung's SmartThings Hub. In addition to the commercial systems, there are many non-proprietary, open source ecosystems; including Home Assistant, OpenHAB and Domoticz.

1.9.2 Elder care

One key application of a smart home is to provide assistance for those with disabilities and elderly individuals.

These home systems use assistive technology to accommodate an owner's specific disabilities.

Voice control can assist users with sight and mobility limitations while alert systems can be connected directly to cochlear implants worn by hearing-impaired users.

They can also be equipped with additional safety features.

These features can include sensors that monitor for medical emergencies such as falls or seizures.

Smart home technology applied in this way can provide users with more freedom and a higher quality of life.

The term "Enterprise IoT" refers to devices used in business and corporate settings. By 2019, it is estimated that the EIoT will account for 9.1 billion devices.

1.9.3 Organizational applications

1.9.3.1 Medical and healthcare

The Internet of Medical Things (IoMT) is an application of the IoT for medical and health related purposes, data collection and analysis for research, and monitoring.

The IoMT has been referenced as "Smart Healthcare", as the technology for creating a digitized healthcare system, connecting available medical resources and healthcare services.

IoT devices can be used to enable remote health monitoring and emergency notification systems.

These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers, Fitbit electronic wristbands, or advanced hearing aids.

Some hospitals have begun implementing "smart beds" that can detect when they are occupied and when a patient is attempting to get up.

It can also adjust itself to ensure appropriate pressure and support is applied to the patient without the manual interaction of nurses.

A 2015 Goldman Sachs report indicated that healthcare IoT devices "can save the United States more than $300 billion in annual healthcare expenditures by increasing revenue and decreasing cost."

Moreover, the use of mobile devices to support medical follow-up led to the creation of 'm-health', used analyzed health statistics."

Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well.

These sensors create a network of intelligent sensors that are able to collect, process, transfer, and analyze valuable information in different environments, such as connecting in-home monitoring devices to hospital-based systems.

Other consumer devices to encourage healthy living, such as connected scales or wearable heart monitors, are also a possibility with the IoT.

End-to-end health monitoring IoT platforms are also available for antenatal and chronic patients, helping one manage health vitals and recurring medication requirements.

Advances in plastic and fabric electronics fabrication methods have enabled ultra-low cost, use-and-throw IoMT sensors.

These sensors, along with the required RFID electronics, can be fabricated on paper or e-textiles for wireless powered disposable sensing devices.

Applications have been established for point-of-care medical diagnostics, where portability and low system-complexity is essential.

As of 2018 IoMT was not only being applied in the clinical laboratory industry, but also in the healthcare and health insurance industries.

IoMT in the healthcare industry is now permitting doctors, patients, and others, such as guardians of patients, nurses, families, and similar, to be part of a system, where patient records are saved in a database, allowing doctors and the rest of the medical staff to have access to patient information.

Moreover, IoT-based systems are patient-centered, which involves being flexible to the patient's medical conditions.

IoMT in the insurance industry provides access to better and new types of dynamic information.

This includes sensor-based solutions such as biosensors, wearables, connected health devices, and mobile apps to track customer behavior.

This can lead to more accurate underwriting and new pricing models.

The application of the IoT in healthcare plays a fundamental role in managing chronic diseases and in disease prevention and control.

Remote monitoring is made possible through the connection of powerful wireless solutions. The connectivity enables health practitioners to capture patient's data and applying complex algorithms in health data analysis.

1.9.4 Transportation

The IoT can assist in the integration of communications, control, and information processing across various transportation systems.

Application of the IoT extends to all aspects of transportation systems (i.e. the vehicle, the infrastructure, and the driver or user).

Dynamic interaction between these components of a transport system enables inter- and intra-vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistics and fleet management, vehicle control, safety, and road assistance.

1.9.5 Manufacturing

The IoT can connect various manufacturing devices equipped with sensing, identification, processing, communication, actuation, and networking capabilities.

Network control and management of manufacturing equipment, asset and situation management, or manufacturing process control allow IoT to be used for industrial applications and smart manufacturing.

IoT intelligent systems enable rapid manufacturing and optimization of new products, and rapid response to product demands.

Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IIoT.

IoT can also be applied to asset management via predictive maintenance, statistical evaluation, and measurements to maximize reliability.

Industrial management systems can be integrated with smart grids, enabling energy optimization. Measurements, automated controls, plant optimization, health and safety management, and other functions are provided by networked sensors.

In addition to general manufacturing, IoT is also used for processes in the industrialization of construction.

1.9.6 Agriculture

There are numerous IoT applications in farming such as collecting data on temperature, rainfall, humidity, wind speed, pest infestation, and soil content. This data can be used to automate farming techniques, take informed decisions to improve quality and quantity, minimize risk and waste, and reduce effort required to manage crops.

For example, farmers can now monitor soil temperature and moisture from afar, and even apply IoT-acquired data to precision fertilization programs. The overall goal is that data from sensors, coupled with the farmer's knowledge and intuition about his or her farm, can help increase farm productivity, and also help reduce costs.

In August 2018, Toyota Tsusho began a partnership with Microsoft to create fish farming tools using the Microsoft Azure application suite for IoT technologies related to water management.

Developed in part by researchers from Kindai University, the water pump mechanisms use artificial intelligence to count the number of fish on a conveyor belt, analyze the number of fish, and deduce the effectiveness of water flow from the data the fish provide.

The FarmBeats project from Microsoft Research that uses TV white space to connect farms is also a part of the Azure Marketplace now.

Chapter:2 Water and its measurements

2.1 The importance of water

Water plays an important role in the world economy. Approximately 70% of the freshwater used by humans goes to agriculture.

Fishing in salt and fresh water bodies is a major source of food for many parts of the world. Much of the long-distance trade of commodities (such as oil, natural gas, and manufactured products) is transported by boats through seas, rivers, lakes, and canals. Large quantities of water, ice, and steam are used for cooling and heating, in industry and homes.

Water is an excellent solvent for a wide variety of substances both mineral and organic; as such it is widely used in industrial processes, and in cooking and washing. Water, ice and snow are also central to many sports and other forms of entertainment, such as swimming, pleasure boating, boat racing, surfing, sport fishing, diving, ice skating and skiing.

2.1.1 Water for drinking

The human body contains from 55% to 78% water, depending on body size.

To function properly, the body requires between one and seven liters (0.22 and 1.54 imp gal; 0.26 and 1.85 U.S. gal) of water per day to avoid dehydration; the precise amount depends on the level of activity, temperature, humidity, and other factors.

Most of this is ingested through foods or beverages other than drinking straight water. It is not clear how much water intake is needed by healthy people, though the British Dietetic Association advises that 2.5 liters of total water daily is the minimum to maintain proper hydration, including 1.8 liters (6 to 7 glasses) obtained directly from beverages.

Medical literature favors a lower consumption, typically 1 liter of water for an average male, excluding extra requirements due to fluid loss from exercise or warm weather.

Healthy kidneys can excrete 0.8 to 1 liter of water per hour, but stress such as exercise can reduce this amount. People can drink far more water than necessary while exercising, putting them at risk of water intoxication (hyperhydration), which can be fatal.

The popular claim that "a person should consume eight glasses of water per day" seems to have no real basis in science.

Studies have shown that extra water intake, especially up to 500 milliliters (18 imp fl oz; 17 U.S. fl oz) at mealtime was associated with weight loss Adequate fluid intake is helpful in preventing constipation.

Hazard symbol for non-potable water

An original recommendation for water intake in 1945 by the Food and Nutrition Board of the United States National Research Council read: "An ordinary standard for diverse persons is 1 milliliter for each calorie of food. Most of this quantity is contained in prepared foods."

The latest dietary reference intake report by the United States National Research Council in general recommended, based on the median total water intake from US survey data (including food sources): 3.7 liters (0.81 imp gal; 0.98 U.S. gal) for men and 2.7 liters (0.59 imp gal; 0.71 U.S. gal) of water total for women, noting that water contained in food provided approximately 19% of total water intake in the survey.

Specifically, pregnant and breastfeeding women need additional fluids to stay hydrated.

The Institute of Medicine (US) recommends that, on average, men consume 3 liters (0.66 imp gal; 0.79 U.S. gal) and women 2.2 liters (0.48 imp gal; 0.58 U.S. gal); pregnant women should increase intake to 2.4 liters (0.53 imp gal; 0.63 U.S. gal) and breastfeeding women should get 3 liters (12 cups), since an especially large amount of fluid is lost during nursing.

Also noted is that normally, about 20% of water intake comes from food, while the rest comes from drinking water and beverages.

Water is excreted from the body in multiple forms; through urine and feces, through sweating, and by exhalation of water vapor in the breath.

With physical exertion and heat exposure, water loss will increase and daily fluid needs may increase as well.

Humans require water with few impurities. Common impurities include metal salts and oxides, including copper, iron, calcium and lead, and/or harmful bacteria, such as Vibrio. Some solutes are acceptable and even desirable for taste enhancement and to provide needed electrolytes.

The single largest (by volume) freshwater resource suitable for drinking is Lake Baikal in Siberia.

2.1.2 Water industrial usage

The water industry provides drinking water and wastewater services (including sewage treatment) to households and industry.

Water supply facilities include water wells, cisterns for rainwater harvesting, water supply networks, and water purification facilities, water tanks, water towers, water pipes including old aqueducts. Atmospheric water generators are in development.

Drinking water is often collected at springs, extracted from artificial borings (wells) in the ground, or pumped from lakes and rivers.

Building more wells in adequate places is thus a possible way to produce more water, assuming the aquifers can supply an adequate flow.

Other water sources include rainwater collection. Water may require purification for human consumption. This may involve the removal of undissolved substances, dissolved substances and harmful microbes. Popular methods are filtering with sand which only removes undissolved material, while chlorination and boiling kill harmful microbes. Distillation does all three functions.

More advanced techniques exist, such as reverse osmosis. Desalination of abundant seawater is a more expensive solution used in coastal arid climates.

The distribution of drinking water is done through municipal water systems, tanker delivery or as bottled water. Governments in many countries have programs to distribute water to the needy at no charge.

Reducing usage by using drinking (potable) water only for human consumption is another option. In some cities such as Hong Kong, seawater is extensively used for flushing toilets citywide in order to conserve freshwater resources.

Polluting water may be the biggest single misuse of water; to the extent that a pollutant limits other uses of the water, it becomes a waste of the resource, regardless of benefits to the polluter.

Like other types of pollution, this does not enter standard accounting of market costs, being conceived as externalities for which the market cannot account.

Thus, other people pay the price of water pollution, while the private firms' profits are not redistributed to the local population, victims of this pollution.

Pharmaceuticals consumed by humans often end up in the waterways and can have detrimental effects on aquatic life if they bioaccumulate and if they are not biodegradable.

Municipal and industrial wastewater are typically treated at wastewater treatment plants.

Mitigation of polluted surface runoff is addressed through a variety of prevention and treatment techniques.

2.2 Water associated problems and concerns

water problems:

1. Overuse of water.

2. Water scarcity.

3. Global warming.

4. Groundwater pollution.

5. Natural disasters.

6. Pollution of water.

Global water crisis can be briefly described in these points:

1- 785 million people lack access to clean water. That’s one in 10 people on the planet.

2- Women and girls spend an estimated 200 million hours hauling water every day.

3- The average woman in rural Africa walks 6 kilometers every day to haul 40 pounds of water.

4- Every day, more than 800 children under 5 die from diarrhea 5-caused by contaminated water, poor sanitation, and unsafe hygiene practices.

6- 2 billion people live without access to adequate sanitation.

7- 673 million people defecate in the open.

2.2.1 Water scarcity

Water issues in developing countries include scarcity of drinking-water, poor infrastructure for water access, floods and droughts, and the contamination of rivers and large dams. Over one billion people in developing countries have inadequate access to clean water. Barriers to addressing water problems in developing nations include poverty, climate change, and poor governance.

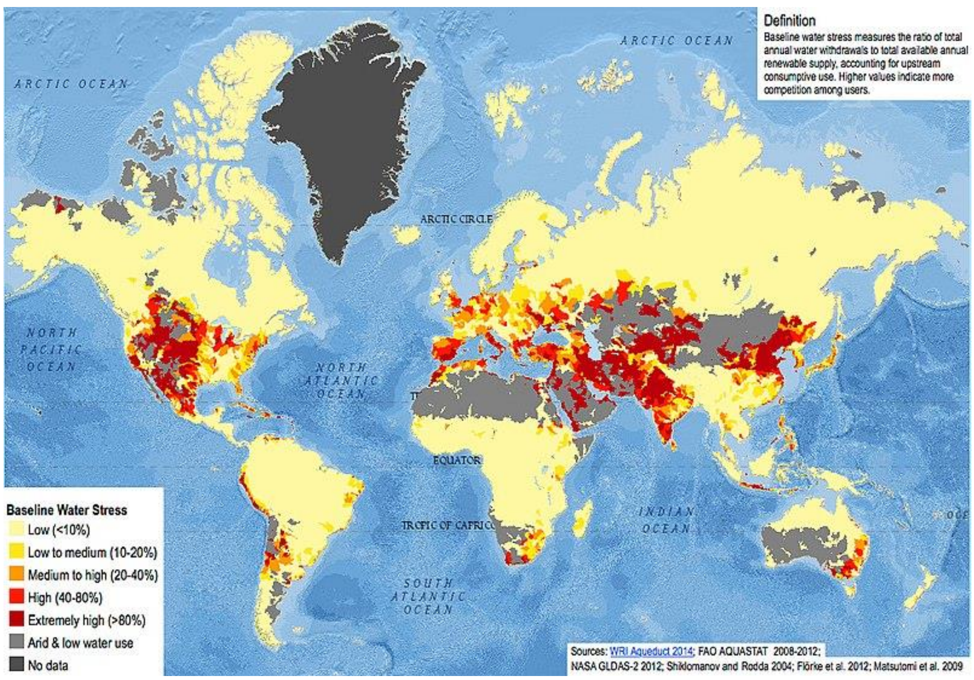


Figure 5 Baseline water stress chart

The contamination of water still remains a huge problem because of the normalization of practices that pollute the quality of water bodies. In developing countries, almost 80% of diseases related with water quality. Open defecation still persists and the associated health risks that come with it such as cholera and malaria remain a nuisance, especially to the vulnerable, in most communities. In developing countries, it is estimated that diarrhea takes the lives of 1.5 million children every year, most of these under the age of five.

Access to freshwater is unevenly distributed across the globe, with more than two billion people live in countries with significant water stress.

Populations in developing countries attempt to access potable water from a variety of sources, such as groundwater, aquifers, or surface waters, which can be easily contaminated. Freshwater access is also constrained by insufficient wastewater and sewage treatment. Progress has been made over recent decades to improve water access, but billions still live in conditions with very limited access to consistent and clean drinking water.

water scarcity is caused by:

1.Rising demand, availability and access:

People need fresh water for survival, personal care, agriculture, industry, and commerce. The 2019 UN World Water Development report noted that about four billion people, representing nearly two-thirds of the world population, experience severe water scarcity during at least one month of the year. With rising demand, the quality and supply of water have diminished.

Water use has been increasing worldwide by about 1% per year since the 1980s. Global water demand is expected to continue increasing at a similar rate until 2050, accounting for an increase of 20-30% above 2019 usage levels.[4] The steady rise in use has principally been led by surging demand in developing countries and emerging economies. Per capita water use in the majority of these countries remains far below water use in developed countries—they are merely catching up.

Agriculture (including irrigation, livestock, and aquaculture) is by far the largest water consumer, accounting for 69% of annual water withdrawals globally. Agriculture's share of total water use is likely to fall in comparison with other sectors, but it will remain the largest user overall in terms of both withdrawal and consumption. Industry (including power generation) accounts for 19% and households for 12%.

The scarcity of fresh water resources is an issue in arid regions around the world but is becoming more common due to overcommitment of resources. In the case of physical water scarcity, there is not enough water to meet demand. Dry regions do not have access to fresh water in lakes or rivers while access to groundwater is sometimes limited. Regions most affected by this type of water scarcity are Mexico, Northern and Southern Africa, the Middle East, India, and Northern China.

Economic water scarcity applies to areas that lack the fiscal resources and/or human capacity to invest in water sources and meet local demand. Water is often only available to those who can pay for it or those in political power, leaving millions of the world's poorest without access. Regions most affected by this type of scarcity are portions of Central and South America, Central Africa, India, and Southeast Asia.

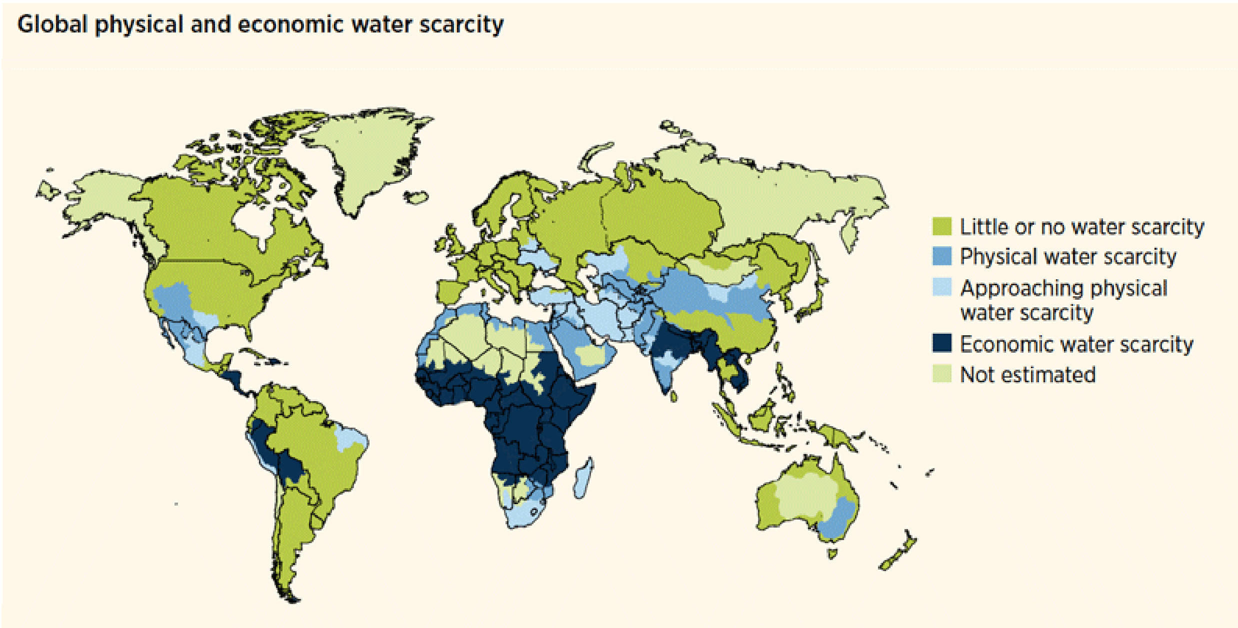


Figure 6 Global physical and economic water scarcity chart

2.Contamination:

After accounting for availability or access, water quality can reduce the amount of water for consumption, sanitation, agriculture, and industrial purposes. Acceptable water quality depends on its intended purpose: water that is unfit for human consumption could still be used in industrial or agriculture applications. Parts of the world are experiencing extensive deterioration of water quality, rendering the water unfit for agricultural or industrial use. For example, in China, 54% of the Hai River basin surface water is so polluted that it is considered un-usable.

Safe water is defined as potable water that will not harm the consumer. It is one of the eight Millennium Development Goals: between 1990 and 2015 to "reduce by half the proportion of the population without sustainable access to safe drinking water and basic sanitation." Even having access to an ‘improved water source’ does not guarantee the water's quality, as it could lack proper treatment and become contaminated during transport or home storage. A study by the World Health Organization (WHO) found that estimates of safe water could be overestimated if accounting for water quality, especially if the water sources were poorly maintained.

Specific contaminants of concern include unsafe levels of biological pollutants and chemical contaminants, including:

- metals, including iron and arsenic
- organic matter
- salts
- viruses
- bacteria
- protozoa
- parasites
- pathogenic microorganisms
- pesticides

2.2.2 Water pollution

Water pollution occurs when harmful substances-often chemicals or microorganisms-contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

causes of water pollution:

Water is uniquely vulnerable to pollution. Known as a “universal solvent,” water is able to dissolve more substances than any other liquid on earth. It’s the reason we have Kool-Aid and brilliant blue waterfalls. It’s also why water is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.

Categories of Water Pollution:

1.Groundwater:

When rain falls and seeps deep into the earth, filling the cracks, crevices, and porous spaces of an aquifer (basically an underground storehouse of water), it becomes groundwater—one of our least visible but most important natural resources. Nearly 40 percent of Americans rely on groundwater, pumped to the earth's surface, for drinking water. For some folks in rural areas, it's their only freshwater source. Groundwater gets polluted when contaminants—from pesticides and fertilizers to waste leached from landfills and septic systems—make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans.

2.Surface water:

Covering about 70 percent of the earth, surface water is what fills our oceans, lakes, rivers, and all those other blue bits on the world map. Surface water from freshwater sources (that is, from sources other than the ocean) accounts for more than 60 percent of the water delivered to American homes. But a significant pool of that water is in peril. According to the most recent surveys on national water quality from the U.S. Environmental Protection Agency, nearly half of our rivers and streams and more than one-third of our lakes are polluted and unfit for swimming, fishing, and drinking. Nutrient pollution, which includes nitrates and phosphates, is the leading type of contamination in these freshwater sources. While plants and animals need these nutrients to grow, they have become a major pollutant due to farm waste and fertilizer runoff. Municipal and industrial waste discharges contribute their fair share of toxins as well. There’s also all the random junk that industry and individuals dump directly into waterways.

3.Ocean water:

Eighty percent of ocean pollution (also called marine pollution) originates on land—whether along the coast or far inland. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities by streams and rivers into our bays and estuaries; from there they travel out to sea. Meanwhile, marine debris—particularly plastic—is blown in by the wind or washed in via storm drains and sewers. Our seas are also sometimes spoiled by oil spills and leaks—big and small—and are consistently soaking up carbon pollution from the air. The ocean absorbs as much as a quarter of man-made carbon emissions.

4.Oil pollution:

Big spills may dominate headlines, but consumers account for the vast majority of oil pollution in our seas, including oil and gasoline that drips from millions of cars and trucks every day. Moreover, nearly half of the estimated 1 million tons of oil that makes its way into marine environments each year comes not from tanker spills but from land-based sources such as factories, farms, and cities. At sea, tanker spills account for about 10 percent of the oil in waters around the world, while regular operations of the shipping industry-through both legal and illegal discharges-contribute about one-third. Oil is also naturally released from under the ocean floor through fractures known as seeps.

The Effects of Water Pollution:

On human health:

To put it bluntly: Water pollution kills. In fact, it caused 1.8 million deaths in 2015, according to a study published in The Lancet. Contaminated water can also make you ill. Every year, unsafe water sickens about 1 billion people. And low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries.

Waterborne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water. Diseases spread by unsafe water include cholera, giardia, and typhoid. Even in wealthy nations, accidental or illegal releases from sewage treatment facilities, as well as runoff from farms and urban areas, contribute harmful pathogens to waterways. Thousands of people across the United States are sickened every year by Legionnaires' disease (a severe form of pneumonia contracted from water sources like cooling towers and piped water), with cases cropping up from California's Disneyland to Manhattan's Upper East Side.

On the environment:

In order to thrive, healthy ecosystems rely on a complex web of animals, plants, bacteria, and fungi—all of which interact, directly or indirectly, with each other. Harm to any of these organisms can create a chain effect, imperiling entire aquatic environments.

When water pollution causes an algal bloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create "dead zones," where waters are essentially devoid of life. In certain cases, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles.

Chemicals and heavy metals from industrial and municipal wastewater contaminate waterways as well. These contaminants are toxic to aquatic life—most often reducing an organism's life span and ability to reproduce—and make their way up the food chain as predator eats prey. That's how tuna and other big fish accumulate high quantities of toxins, such as mercury.

Marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. Much of this solid debris, such as plastic bags and soda cans, gets swept into sewers and storm drains and eventually out to sea, turning our oceans into trash soup and sometimes consolidating to form floating garbage patches. Discarded fishing gear and other types of debris are responsible for harming more than 200 different species of marine life.

Meanwhile, ocean acidification is making it tougher for shellfish and coral to survive. Though they absorb about a quarter of the carbon pollution created each year by burning fossil fuels, oceans are becoming more acidic. This process makes it harder for shellfish and other species to build shells and may impact the nervous systems of sharks, clownfish, and other marine life.

In the next section, we look at some of the important measurements used with water to tackle some of its problems and the devices used for these measurements…

2.3 Water measurement devices

As discussed before, Water pollution is one of the biggest fears for the green globalization. In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time.

IOT provides the capability of monitoring in real time using sensors and for water there are many sensors that provide many useful measurements.

2.3.1 Sensors

a sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics. Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micromachinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement, for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life. There are a wide range of other sensors, measuring chemical & physical properties of materials. A few examples include optical sensors for Refractive index measurement, vibrational sensors for fluid viscosity measurement and electro-chemical sensor for monitoring pH of fluids. Sensors can be used for monitoring water characteristics such as:

- oxidation
- water level

- Chlorine percentage
- PH level
- Turbidity
- Temperature
- Water flow

2.3.1.1 Oxidation sensor

Figure 7 Water oxidation sensor

Global Water's dissolved oxygen sensor is a rugged reliable water oxygen level measuring device. The dissolved oxygen sensors are attached to 25' of marine grade cable, with lengths up to 500 ft available upon request. The dissolved oxygen sensor output is 4-20 mA with a three-wire configuration. The dissolved oxygen sensor's electronics are completely encapsulated in marine grade epoxy within a stainless-steel housing (online version has 1x8 inch PVC pipe nipple, threaded both ends with cap). The dissolved oxygen sensor uses a removable shield and dissolved oxygen element for easy maintenance.

Global Water's PC320 Dissolved Oxygen Controller to use the dissolved oxygen sensor's output to control pumps or alarms. In addition, global Water offers GL500 dissolved oxygen recorder adds recording capabilities to the dissolved oxygen sensor. The GL500 dissolved oxygen recorder connects to the dissolved oxygen sensor's 4-20mA output to record data.

Why Measure DO?

Dissolved oxygen (DO) is the amount of oxygen (O2) dissolved in water. Dissolved oxygen measurements provide one of the best indicators of the health of a water ecosystem, as oxygen is a necessary element for all forms of life, including aquatic life. Oxygen enters water at the water surface through direct exchanges with the atmosphere. It is also produced as a byproduct of plant and phytoplankton photosynthesis. A decrease in dissolved oxygen levels is typically associated with an organic pollutant. Dissolved oxygen is used by plants and animals for respiration, and by aerobic bacteria in the process of decomposition. When organic matter (such as animal waste or improperly treated wastewater) enters a body of water, algae growth increases. As the plant material dies off and decomposes, dissolved oxygen levels decrease. If the water at the surface is not mixed with deeper water layers, the water's dissolved oxygen levels can become stratified. Dissolved oxygen levels can also vary according to the time of day, weather, and temperature. Dissolved oxygen in water can range from 0-18 parts per million (ppm), but most natural water systems require 5-6 ppm to support a diverse population. As dissolved oxygen levels drop below 5.0 mg/L, aquatic life is put under stress. As dissolved oxygen levels decrease, pollution-intolerant organisms are replaced by pollution-tolerant worms and fly larvae. If dissolved oxygen levels fall below 1-2 mg/L for a few hours, large fish kills can result.

2.3.1.2 Water level sensor

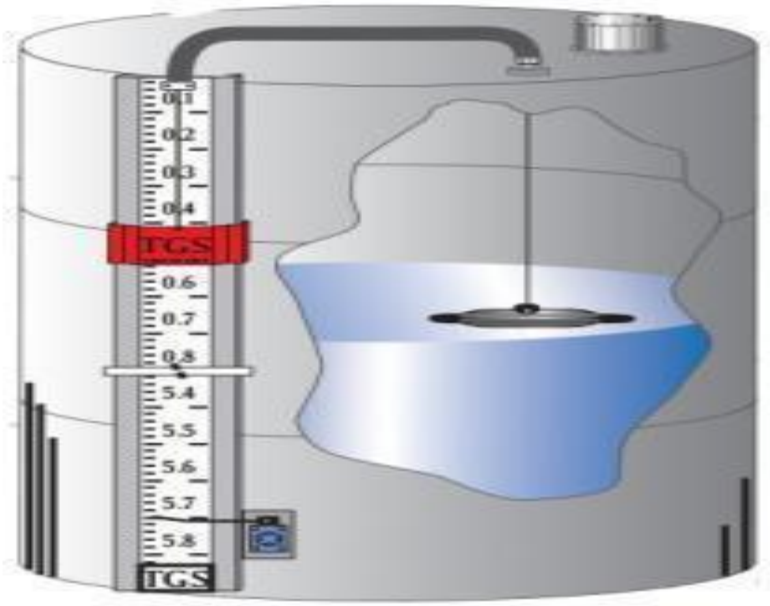


Figure 8 Mechanical water level sensor

Liquid level floats, also known as float balls, are spherical, cylindrical, oblong or similarly shaped objects, made from either rigid or flexible material, that are buoyant in water and other liquids. They are non-electrical hardware frequently used as visual sight-indicators for surface demarcation and level measurement. They may also be incorporated into switch mechanisms or translucent fluid-tubes as a component in monitoring or controlling liquid level.

Liquid level floats, or float switches, use the principle of material buoyancy (differential densities) to follow fluid levels. Solid floats are often made of plastics with a density less than water or other application liquid, and so they float. Hollow floats filled with air are much less dense than water or other liquids, and are appropriate for some applications.

Stainless Steel Magnetic floats are tubed magnetic floats, used for reed switch activation; they have a hollow tubed connection running through them. These magnetic floats have become standard equipment where strength, corrosion resistance and buoyancy are necessary. They are manufactured by welding two drawn half shells together. The welding process is critical for the strength and durability of the float. The weld is a full penetration weld providing a smoothly finished seam, hardly distinguishable from the rest of the float surface.

Liquid level floats can also be constructed with thermoplastic corrosion-resistant materials. These materials include PVC, Polypropylene and PVDF. An example of an application that would require such materials would be if a manufacturer of metal plating and metal finishing lines required continuous level measurement of their chromic acid tanks. Stainless Steel would rapidly corrode in chromic acid, which is why one would have the option to go with a PVDF float, which is a material with great chemical resistance to chromic acid.

Thermoplastic level floats are a great alternative to some other forms of level sensors such as ultrasonic or radar when dealing with corrosive chemical applications. This is because some chemicals create vapor blankets or corrosive fumes inside of tanks. Liquid level floats are unaffected by any foam, vapor, turbulence or condensate inside of the tanks that would normally cause issues with an ultrasonic or radar level sensor.

2.3.1.3 Chlorine percentage sensor

Free chlorine is the most important disinfectant in water treatment due to its easy handling and strong disinfecting effect. Free chlorine sensors are applied in:

1- Drinking water - to ensure sufficient disinfection

2- Food - to provide hygienic bottling and packaging

3- Pool water - to dose disinfectant efficiently

Chlorine dioxide is more and more becoming a disinfectant of choice since it is less corrosive and independent from the pH value. Chlorine dioxide sensors are applied in:

Cooling systems or towers, Drinking water, Wash water for packed vegetables and Desalination plants to prevent ClO_2 from disturbing reverse osmosis

Total chlorine is a good indicator of residual disinfectants in discharge water. The sensors are used in WWTPs:

1- To measure the effluent water's disinfection status.

2- To control reuse of water

Free bromine is often used in applications with seawater because of the unique chemical properties of this medium. Free bromine sensors are applied in:

1- Seawater reuse and process water.

2- Desalination plants.

3- Fish farming - to ensure sufficient wastewater disinfection.

4- Cooling systems characterized by high pH values.

5- Thermal spas.

2.3.1.4 PH level sensor

Figure 9 Water PH level probe sensor

A pH sensor is one of the most essential tools that's typically used for water measurements. This type of sensor is able to measure the amount of alkalinity and acidity in water and other solutions. When used correctly, pH sensors are able to ensure the safety and quality of a product and the processes that occur within a wastewater or manufacturing plant.

In most cases, the standard pH scale is represented by a value that can range from 0-14. When a substance has a pH value of seven, this is considered to be neutral. Substances with a pH value above seven represent higher amounts of alkalinity whereas substances with a pH value that's lower than seven are believed to be more acidic. For instance, toothpaste typically comes with a pH value of 8-9. On the other hand, stomach acid has a pH value of two.

The difference between an alkaline substance and an acidic substance is very important for any company that uses a cooling tower, boiler, manufacturing processes, swimming pool control, and various types of environmental monitoring. The human body has a standard pH level of 7.4, which is essential for the body to run effectively. If the composition of the body every becomes too acidic or overly alkaline, it will look to return to the neutral state.

A pH sensor helps to measure the acidity or alkalinity of the water with a value between 0-14. When the pH value dips below seven, the water starts to become more acidic. Any number above seven equates to more alkaline. Each type of pH sensor works differently to measure the quality of the water. The pH of water can help determine the quality of water. Measuring the pH can also provide indications of pipe corrosion, solids accumulation, and other harmful byproducts of an industrial process.

In an environmental setting, the changing pH could also be an early indicator increasing pollution. If the pH level reaches above 8.5, the water would be considered hard, which would likely cause scale development in boilers and pipes. As aforementioned, there are four main types of pH sensors that you can select from, which include combination sensors, differential sensors, laboratory sensors, and process sensors, each of which is suitable to different applications.

2.3.1.5 Turbidity Sensor

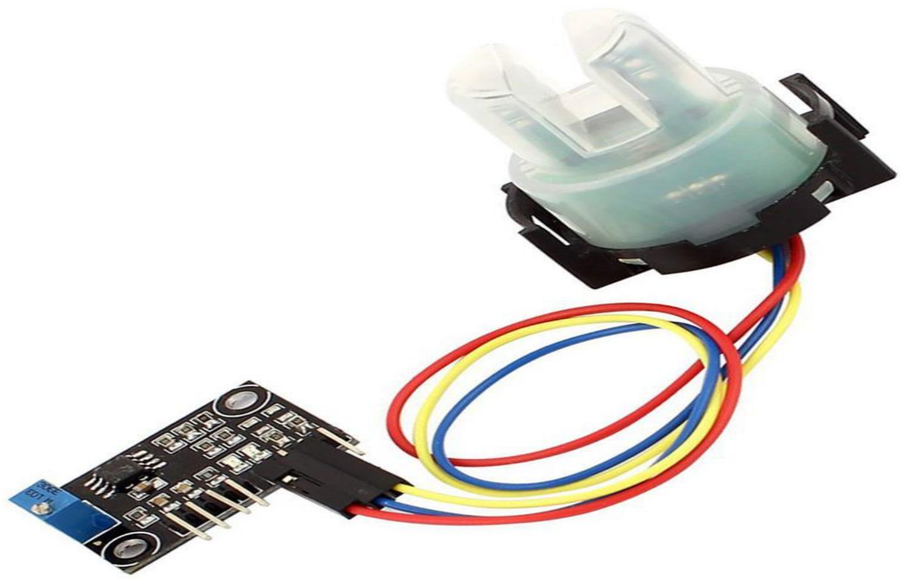


Figure 10 Turbidity sensor

Turbidity is the measurement of water clarity. Suspended sediments, such as particles of clay, soil and silt, frequently enter the water from disturbed sites and affect water quality. Suspended sediments can contain pollutants such as phosphorus, pesticides, or heavy metals. Suspended particles cut down on the depth of light penetration through the water, hence they increase the turbidity -- or "murkiness" or "cloudiness" -- of the water.

High turbidity affects the type of vegetation that grows in water. Turbid water can lend information in regards to the health or well-being of the water body itself. It is important to note that the appearance of high turbidity does not necessarily mean the water body is suffering. However, the level can adversely affect the ecosystem if it changes drastically and maintains that drastic change whereas short term turbid “events” may be temporary and have little overall effect on the system. As with any water quality parameter, it is good to have historic data for any site where turbidity is being monitored so trends can be tracked and the occurrence of an event can be captured. For long-term, in situ continuous monitoring of turbidity, a self-cleaning sensor is usually necessary to avoid fouling of the sensor and maintain accuracy.

Turbidity sensors measure the amount of light that is scattered by the suspended solids in water. As the amount of total suspended solids (TSS) in water increases, the water's turbidity level (and cloudiness or haziness) increases. Turbidity sensors are used in river and stream gaging, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research, and laboratory measurements.

2.3.1.6 Temperature sensor

Figure 11 Water temperature sensor

Resistance thermometers, also called resistance temperature detectors (RTDs), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes. RTDs, which have higher accuracy and repeatability, are slowly replacing thermocouples in industrial applications below 600 °C.

2.4 Water flow measurement sensor

The sensor we are most concerned with is the water flow measurement sensor as it is the main component of this project.

Figure 12 Hall effect water flow meter

Water flow sensor consists of a plastic body, a water rotor, and a hall-effect sensor. When water flows through the rotor, rotor rolls, its speed changes with different rate of flow. And the hall-effect sensor outputs the corresponding pulse signal.

We use a water flow sensor to measure the water flow rate. The water flow rate is the volume of fluid that passes per unit time. People often use water flow sensor for automatic water heater control, DIY coffee machines, water vending machines, etc. There are a variety of flow sensors of different principles, but for makers using Arduino or Raspberry Pi, the most common flow sensor is based on a Hall device. For example, the most classic water flow sensor YF-S402 and YF-S201 rely on Hall sensors.

Water flow sensors are installed at the water source or pipes to measure the rate of flow of water and calculate the amount of water flowed through the pipe. Rate of flow of water is measured as liters per hour or cubic meters.

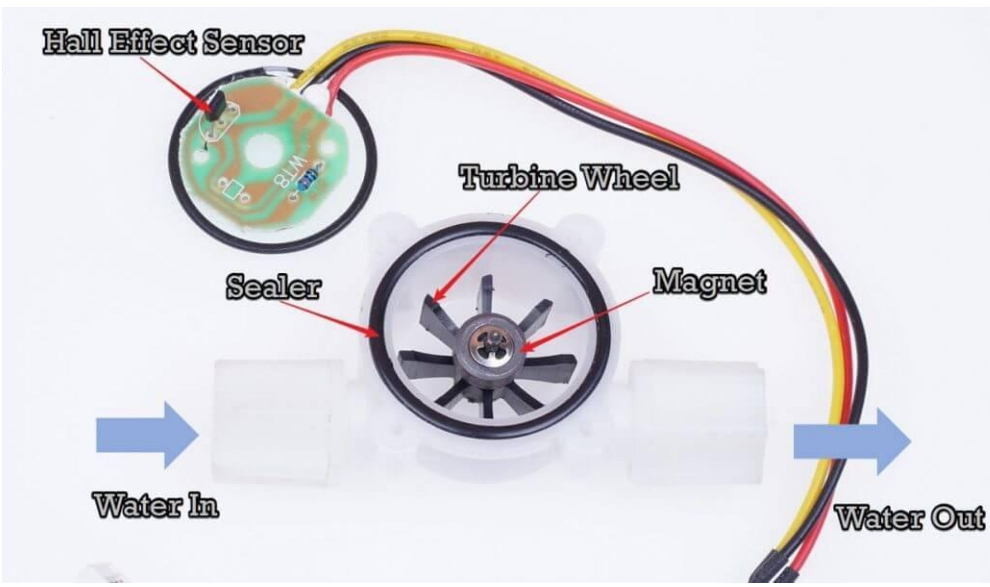


Figure 13 Water sensor internal architecture

Water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a hall effect sensor is present the sense and measure the water flow.

When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect sensor. Thus, the rate of flow of water can be measured.

The main working principle behind the working of this sensor is the Hall effect. According to this principle, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor. This induced voltage difference is transverse to the electric current.

When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor and displayed on the LCD display.

The water flow sensor can be used with hot waters, cold waters, warm waters, clean water, and dirty water also. These sensors are available in different diameters, with different flow rate ranges.

These sensors can be easily interfaced with microcontrollers like Arduino. For this, an Arduino microcontroller board for processing, a Hall effect water flow sensor, a 16×2 LCD display, and Breadboard connecting wires are required. The sensor is placed at the water source inlet or at the opening of the pipe.

The sensor contains three wires. Red wire to connect with supply voltage. Black wire to connect to ground and a yellow wire to collect output from Hall effect sensor. For supply voltage 5V to 18V of DC is required.

Its applications:

Water flow sensors can measure the rate of flow of water either by measuring velocity or displacement. These sensors can also measure the flow of water like fluids such as measuring milk in a dairy industry etc…

There are various types of water flow sensors available based on their diameter and method of measuring. A cost-effective and most commonly used water flow sensor is Paddlewheel sensor. It can be used with water-like fluids.

For the type of applications where a straight pipe is not available for inlet, Positive displacement flow meter is used. This type of water flow sensor can be used for viscous liquids also.

For working with dirty water and wastewater which may be conductive, Magnetic flow meter is used. For applications such as sewage water, slurries, and other dirty liquids Ultrasonic flow meters are used.

The LCD display is used to display the measurements. The magnetic hall effect water flow sensor outputs a pulse of every revolution of the rotor. The hall effect sensor present in the device is sealed from water to keep it safe and dry.

Chapter:3 EWFM

In the last chapter of this book, we talk in length about our project, what got us to think of this idea and the steps we went through to make it happen.

3.1 Problem

Egypt has been suffering from severe water scarcity in recent years. Uneven water distribution, misuse of water resources and inefficient irrigation techniques are some of the major factors playing havoc with water security in the country.

Egypt has only 20 cubic meters per person of internal renewable freshwater resources, and as a result the country relies heavily on the Nile River for its main source of water.

The River Nile is the backbone of Egypt's industrial and agricultural sector and is the primary source of drinking water for the population.

Rising populations and rapid economic development in the countries of the Nile Basin, pollution and environmental degradation are decreasing water availability in the country.

Egypt is facing an annual water deficit of around 7 billion cubic metres.

In fact, United Nations is already warning that Egypt could run out of water by the year 2025. According to My Custom Essay experts you can see the information provided below that could be essential for students who write academic papers.

Egypt's population is mushrooming at an alarming rate and has increased by 41 percent since the early 1990s. Recent reports by the government suggest that around 4,700 newborns are added to the population every week, and future projections say that the population will grow from its current total of 101 million to 110 million by the year 2025.

Egypt receives less than 80 mm of rainfall a year, and only 6 percent of the country is arable and agricultural land, with the rest being desert. This leads to excessive watering and the use of wasteful irrigation techniques such as flood irrigation [an outdated method of irrigation where gallons of water are pumped over the crops].

Nowadays, Egypt's irrigation network draws almost entirely from the Aswan High Dam, which regulates more than 18,000 miles of canals and sub-canals that push out into the country's farmlands adjacent to the river.

This system is highly inefficient, losing as much as 3 billion cubic meters of Nile water per year through evaporation and could be detrimental by not only intensifying water and water stress but also creating unemployment.

A further decrease in water supply would lead to a decline in arable land available for agriculture, and with agriculture being the biggest employer of youth in Egypt, water scarcity could lead to increased unemployment levels.

The rapid population increase multiplies the stress on Egypt's water supply due to more water requirements for domestic consumption and increased use of irrigation water to meet higher food demands.

Egypt controls majority of the water resource extracted from the Nile River due to colonial-era treaty, which guaranteed Egypt 90 percent share of the Nile, and prevented their neighbors from extracting even a single drop from the Nile without permission. However, in recent years countries along the Nile such as Ethiopia are taking advantage are gaining more control over the rights for the Nile.

A big challenge is tackling the issue of Ethiopia building a dam and hydroelectric plant upstream that may cut into Egypt's share of the Nile. For some time a major concern for Egypt was Ethiopia's construction of the Grand Ethiopian Renaissance Dam (GERD) in the Blue Nile watershed, which is a main source of water for the Nile River. Construction of the Renaissance Dam started in December 2010, and has the capacity to store 74 to 79 billion cubic meters of water and generate 6,000 megawatts of electricity for Ethiopia a year.

We can conclude from all the information above that Water availability issues in Egypt are rapidly assuming alarming proportions. By the year 2020, Egypt will be consuming 20 percent more water than it has. With its loosening grip on the Nile, water scarcity could endanger the country's stability and regional dominance. It is imperative on the Egyptian government and the entire population of to act swiftly and decisively to mitigate water scarcity, implement water conservation techniques and control water pollution develop plans that would install more efficient irrigation techniques.

With climate conditions expected to get drier and heat waves expected to become more frequent in the MENA region, Egypt cannot afford to neglect the importance of water conservation anymore and must act immediately to augment its natural water reserves.

3.2 Aim

Our aim here is to use the multi-functioning nature of the arduino circuit in this particular project as a representation of IOT usage in solving a wide array of problems in everyday life.

Our project is concerned with the water usage problem, using the information we accumulated in studying sensors in the Wireless Sensor Networks course we took in the first semester of this year, we came across the water flow meter and then used in the circuit that it measures a certain amount of water then displays the measured amount and its cost across four platforms.

First, an LCD that displays the results in real time.

Second, a GSM module that sends a text message with the monthly results to the database of consumers.

Third, a WIFI module that allows us to display results on both a website and a mobile application updating results every week.

All of this facilitates consumer access to let them know how much water they are consuming.

3.3 Objective

The objective of this project is threefold.

First and most importantly is letting the consumer monitor his water usage through multiple platforms to able to control it as our main problem is water scarcity and a fundamental part of solving that problem is letting the people know how much water they are consuming and controlling it.

Second is partially automating the process of reading the water measurements in each house and facility and collecting the bills nation-wide as this project nearly eliminates the need for human clerks to go around each house and manually take a reading, this also helps much in the third element.

Third is reducing the interaction between employees and the people as we have seen through the past year with the COVID-19 pandemic worldwide and its ever evolving restrictions.

3.4 Idea

Figure 14 The presented project

Water Management System is an important part of City Management. Water management involves supplying water according to the real requirement & without wasting Water. Therefore it is very important to measure water flow rate and volume. Without measuring these parameters, Water Management is almost impossible. Also monitoring the Water Volume, Flow Rate & Water Quality remotely using Internet Connectivity has become very essential. Therefore there is a need for Monitoring Water Management System Online.

In this project we made an IoT Based Water Flow Meter using an arduino uno board interfaced with a water flow meter, an ESP8266 WIFI module and a GSM module. We will display the Total volume of water and the total cost in 4*16 LCD display. We will then integrate the hardware with IoT Server. For IoT Server, we will use both the Blynk App and the Blynk website. The water flow rate & volume data can be uploaded to Blynk Server & can be viewed/monitored from any part of the world. The Gsm module will receive data from the arduino and forwards it to the database of mobile numbers in the form of monthly text messages.

3.5 Project

Our project consists of:

1- Arduino uno board.

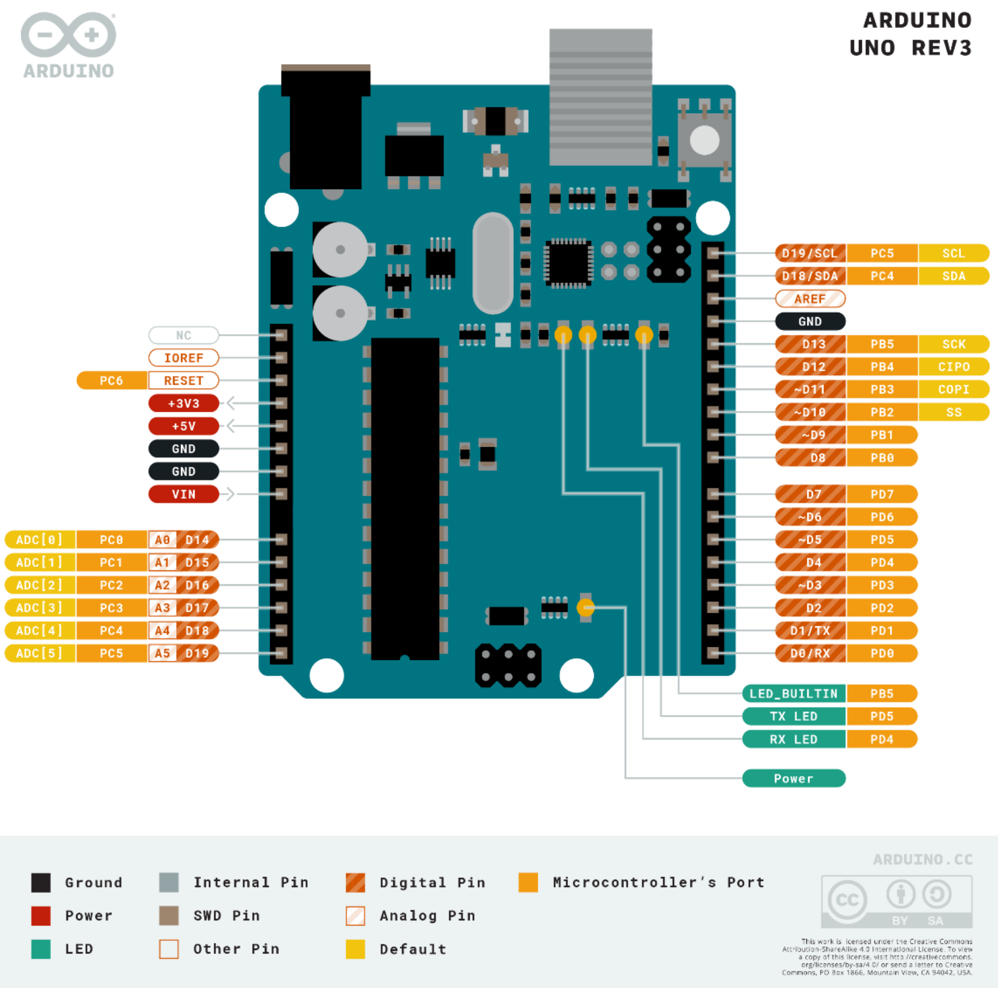


Figure 15 Arduino uno pinout sketch

2- NodeMCU V3 ESP8266 acting as a WIFI module

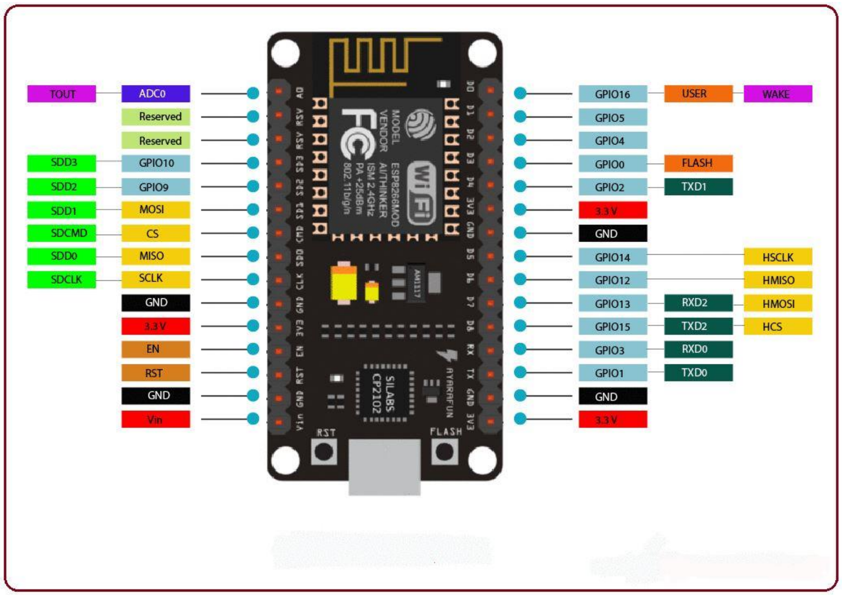


Figure 16 WIFI module pinout sketch

3- Sim800L GSM module

Figure 17 SIM800L chip

4- Alphanumeric 4x16 LCD display

Figure 18 Liquid Crystal Display

5- A power supply

3.5.1 Design and Manufacturing

The first step was designing the circuit using EAGLE computer application to first design a schematic diagram pictured below and then using that schematic diagram to design the PCB board.

The design was five steps:

1- Schematic and board design

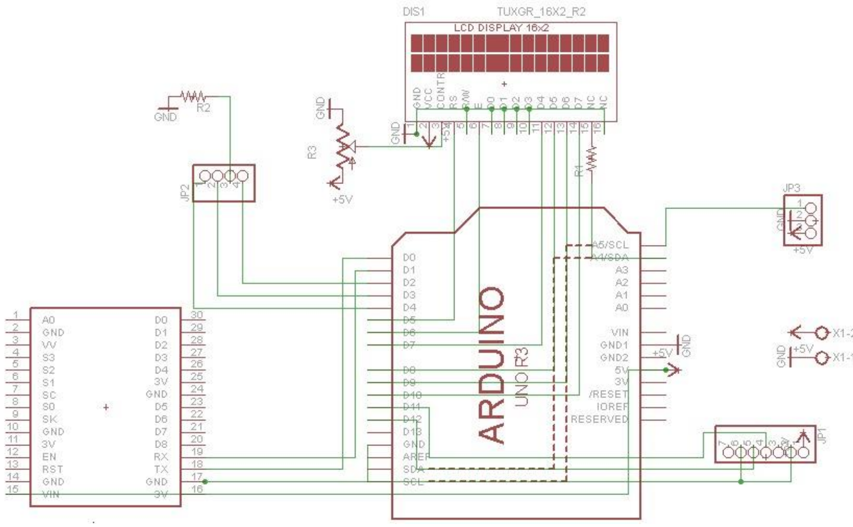


Figure 19 Schematic figure of the circuit

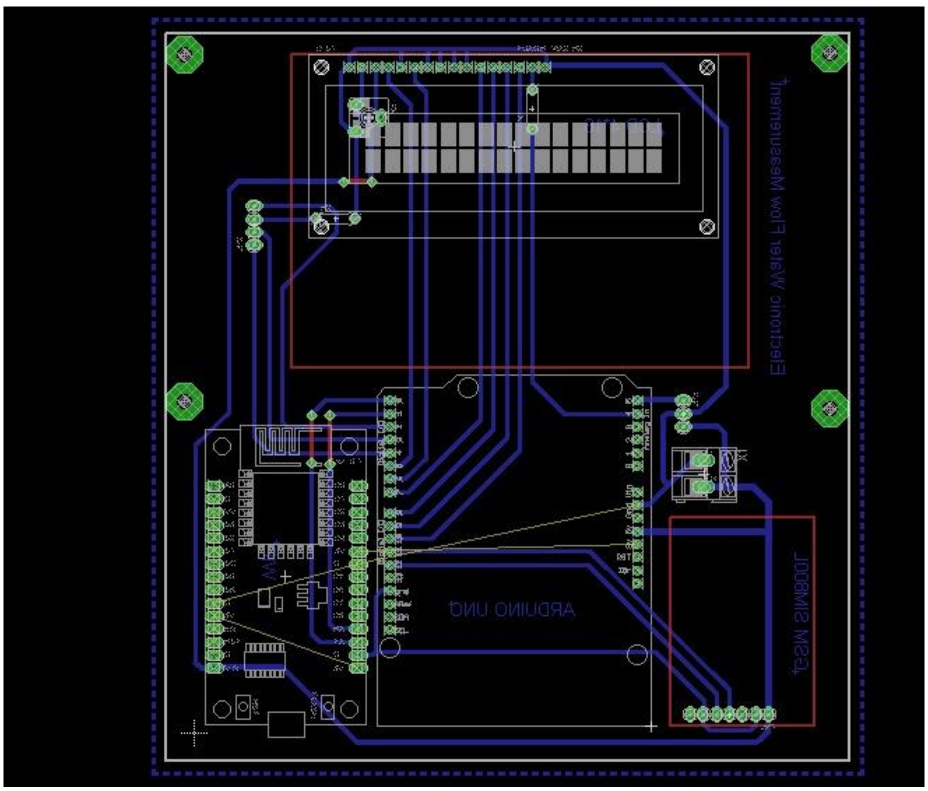


Figure 20 Layout design of the circuit

2- Printing the PCB design onto toner transfer paper

3- Ironing the deign from the paper onto a copper sheet

4- Using Ferric Chloride solution for PCB etching

5- Drilling holes, adding protective coating and mounting our components onto the board.

This is what our PCB board looked like after performing these steps.

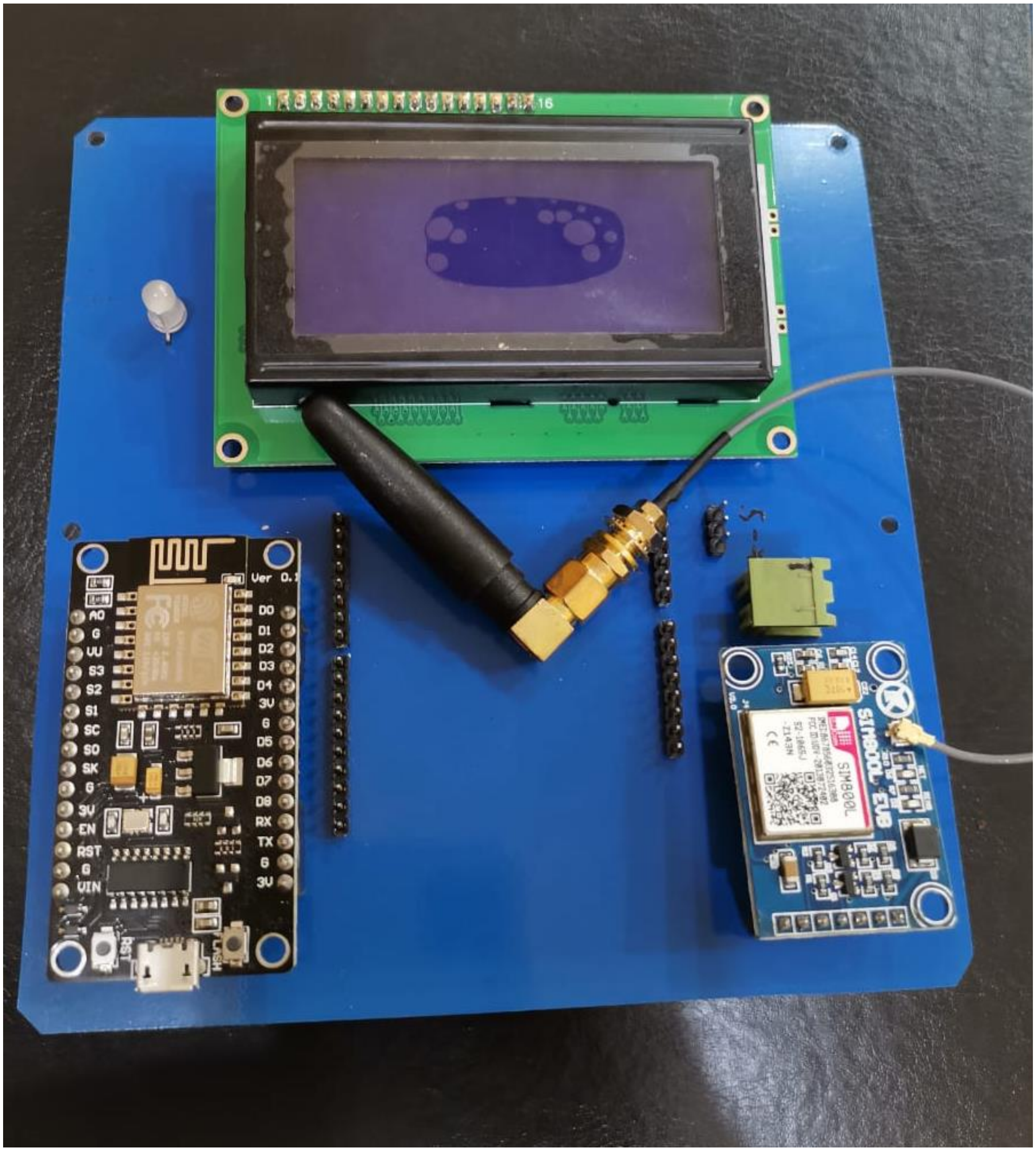


Figure 21 PCB board

3.5.2 Implementing the idea

Since we are dealing with Arduino uno board, we used Arduino IDE to program the Arduino board along with the other components to implement the basic ideas for the project that we have discussed before.

We opted to test individual code files (functions) for the Lcd, GSM, WIFI modules and the flowmeter shown in the figures below and then for the final product combine all of these codes for our purposes.

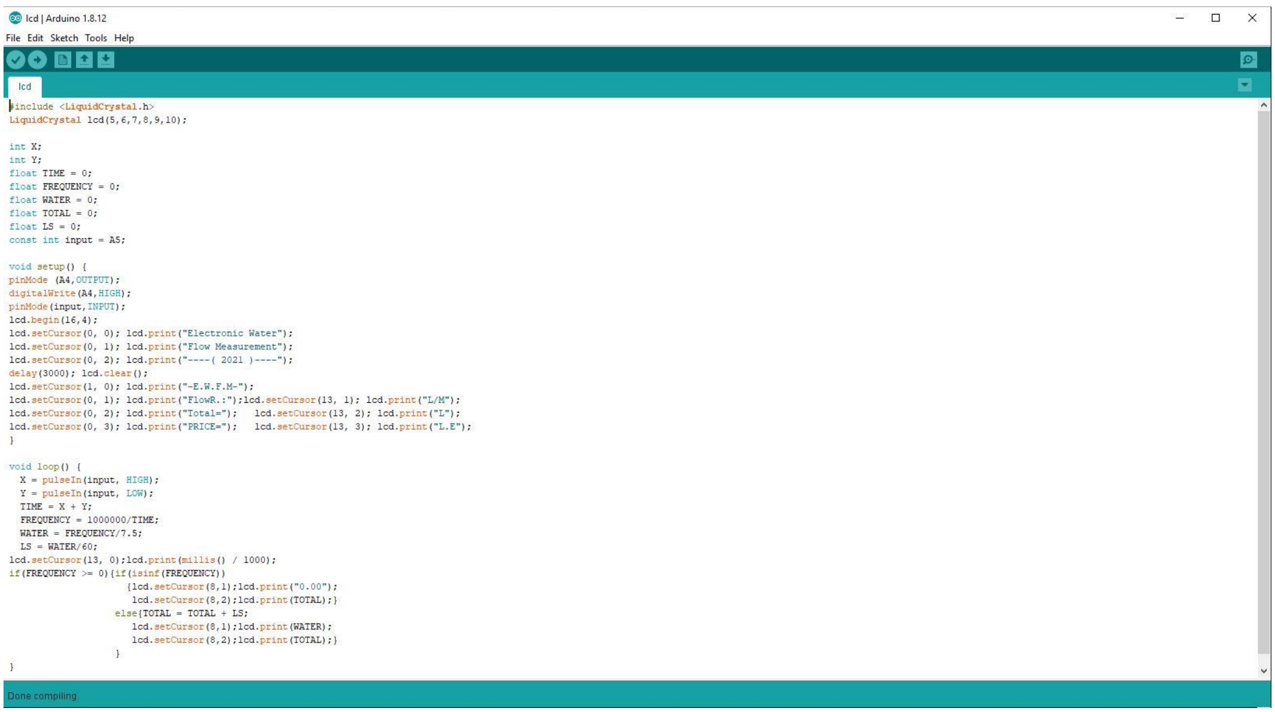


Figure 22 Arduino IDE (LCD code)

Figure 23 Arduino IDE (GSM code)

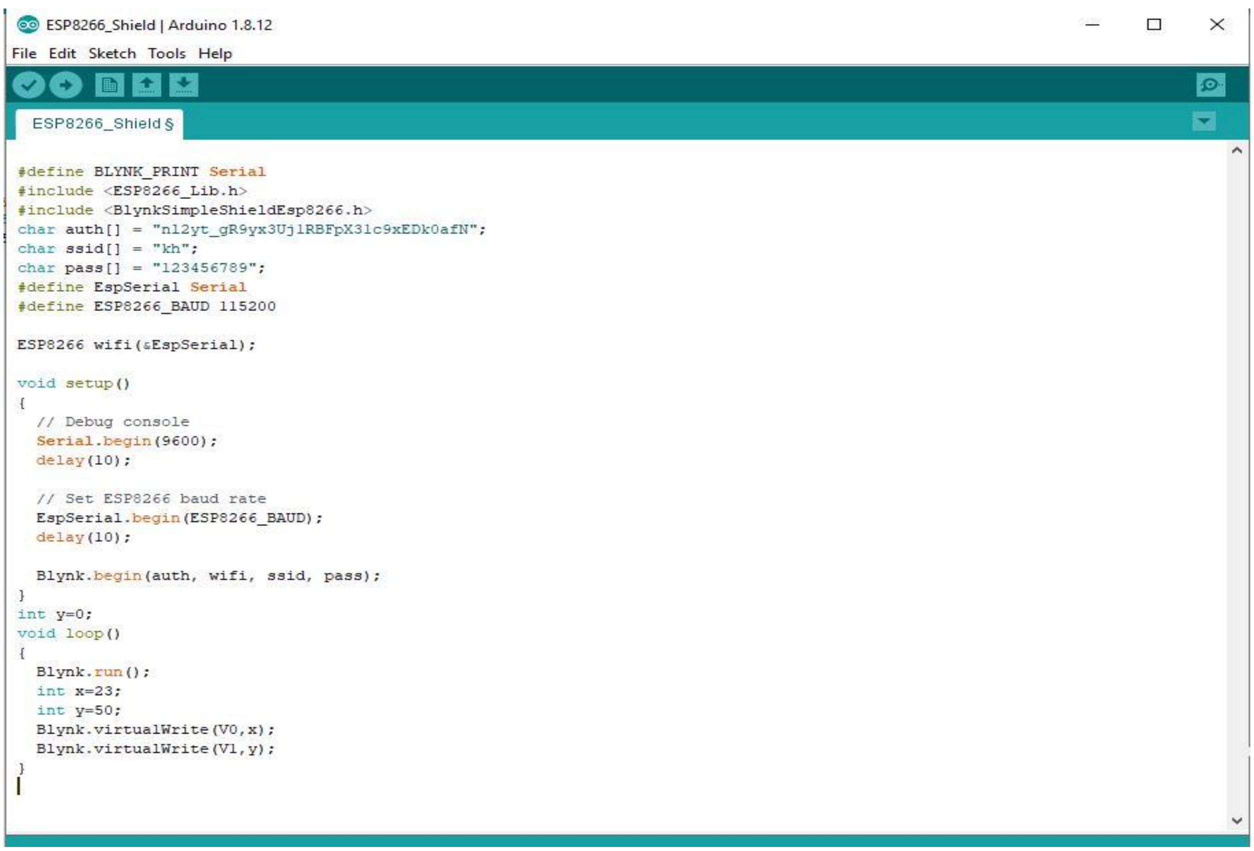


Figure 24 Arduino IDE (WIFI code)

flow | Arduino 1.8.12

```
byte statusLed    = 3;
byte sensorInterrupt = 0;
byte sensorPin       = 2;
float calibrationFactor = 5.5;
volatile byte pulseCount;
float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
unsigned long oldTime;

void setup()
{ Serial.begin(9600);
  pinMode(statusLed, OUTPUT);
  digitalWrite(statusLed, HIGH);  // We have an active-low LED attached

  pinMode(sensorPin, INPUT);
  digitalWrite(sensorPin, HIGH);

  pulseCount        = 0;
  flowRate          = 0.0;
  flowMilliLitres   = 0;
  totalMilliLitres  = 0;
  oldTime           = 0;
  attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
}

void loop()
{
   if((millis() - oldTime) > 1000)    // Only process counters once per second
  {
    detachInterrupt(sensorInterrupt);
    flowRate = ((1000.0 / (millis() - oldTime)) * pulseCount) / calibrationFactor;
    oldTime = millis();
    flowMilliLitres = (flowRate / 60) * 1000;
    totalMilliLitres += flowMilliLitres;


    Serial.print("Flow rate: ");
    Serial.print(int(flowRate));  // Print the integer part of the variable
    Serial.print("L/min");
    Serial.print("\t");
    Serial.print("Output Liquid Quantity: ");
    Serial.print(totalMilliLitres);
    Serial.println("mL");
    Serial.print("\t");       // Print tab space
  Serial.print(totalMilliLitres/1000);
  Serial.print("L");
    pulseCount = 0;
    attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
```

Figure 25 Arduino IDE (Flowmeter code)

The C++ code used for our project that was implemented upon the Arduino board:

```
#include <SoftwareSerial.h>
SoftwareSerial ss(11,12);

#include <LiquidCrystal.h>
LiquidCrystal lcd(5,6,7,8,9,10);

#define BLYNK_PRINT Serial
#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>
char auth[] = "nl2yt_gR9yx3Uj1RBFpX31c9xEDk0afN";
char ssid[] = "kh";
char pass[] = "123456789";
#define EspSerial Serial
#define ESP8266_BAUD 115200
ESP8266 wifi(&EspSerial);

byte sensorInterrupt = 0;
byte sensorPin       = 2;
float calibrationFactor = 5.5;
volatile byte pulseCount;
float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
float price;
unsigned long oldTime;
unsigned long sendTime;
float PPL=3;
void setup() {
  ss.begin(9600);
  EspSerial.begin(ESP8266_BAUD);delay(10);
  Blynk.begin(auth, wifi, ssid, pass);
pinMode (A4,OUTPUT);  digitalWrite(A4,HIGH);
pinMode(sensorPin, INPUT);digitalWrite(sensorPin, HIGH);

  pulseCount        = 0;
  flowRate          = 0.0;
  flowMilliLitres   = 0;
  totalMilliLitres  = 0;
  oldTime           = 0;
  sendTime          = 0;
  attachInterrupt(sensorInterrupt, pulseCounter, FALLING);

lcd.begin(16,4);
lcd.setCursor(0, 0); lcd.print("Electronic Water");
lcd.setCursor(0, 1); lcd.print("Flow Measurement");
lcd.setCursor(0, 2); lcd.print("----( 2021 )----");
delay(3000); lcd.clear();
lcd.setCursor(1, 0); lcd.print("-E.W.F.M-");
lcd.setCursor(0, 1); lcd.print("FlowR.:");lcd.setCursor(13, 1);
lcd.print("L/M");
lcd.setCursor(0, 2); lcd.print("Total=");   lcd.setCursor(13, 2);
lcd.print("mL");
```

```
lcd.setCursor(0, 3); lcd.print("PRICE=");   lcd.setCursor(13, 3);
lcd.print("L.E");
}

void loop() {
  Blynk.run();
  Blynk.virtualWrite(V0,totalMilliLitres);
  Blynk.virtualWrite(V1,price);

  int stime=millis() / 1000;
  lcd.setCursor(13, 0);lcd.print(stime);
  if((millis() - sendTime) > 60000){
                                       lcd.clear();
                                       lcd.setCursor(4, 1);lcd.print("send
SMS.");
                                       sendSMS();
                                       lcd.clear();
                                       sendTime = millis();}
 if((millis() - oldTime) > 1000)
  {
    detachInterrupt(sensorInterrupt);
    flowRate = ((1000.0 / (millis() - oldTime)) * pulseCount) /
calibrationFactor;
    oldTime = millis();
    flowMilliLitres = (flowRate / 60) * 1000;
    totalMilliLitres += flowMilliLitres;

    price =totalMilliLitres*(PPL/1000);
 lcdprint();
    pulseCount = 0;
    attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
  }
}

void lcdprint(){
  lcd.setCursor(1, 0); lcd.print("-E.W.F.M-");
  lcd.setCursor(0, 1); lcd.print("FlowR.:");lcd.setCursor(13, 1);
lcd.print("L/M");
  lcd.setCursor(0, 2); lcd.print("Total=");   lcd.setCursor(13, 2);
lcd.print("mL");
  lcd.setCursor(0, 3); lcd.print("PRICE=");   lcd.setCursor(13, 3);
lcd.print("L.E");
  lcd.setCursor(8, 1); lcd.print(flowRate);
  lcd.setCursor(8, 2); lcd.print(totalMilliLitres);
  lcd.setCursor(8, 3); lcd.print(price);
}
/////////////////////////////////////////////////////////////////
void pulseCounter() {pulseCount++;}
////////////////////////////////////////
void sendSMS(){
 ss.println("AT"); delay(500);
 ss.println("AT+CMGF=1"); delay(500);
 ss.println("AT+CMGS=\"+201062235122\""); delay(500);
 ss.print("consmption: ");delay(500);
 ss.println(totalMilliLitres);delay(500);
 ss.print("cost= ");delay(500);
 ss.print(price); delay(500);
```

```
ss.write(26);}
```

3.5.3 Physical application of the project

By the use of a wooden stand, two glass tanks, pvc pipes and two shutoff valves, we were able to build a contraption that allowed us to physically test the project and present it in its current form.

Figure 26 Physical project apparatus

By connecting the circuit to the power supply, the circuit does not start until the WIFI module latches on the WIFI network.

Once the WIFI modules gets on the network. The circuit starts working and the LCD powers up.

When we open the water valves and the water starts flowing the flowmeter sends the pulses and the Arduino computes them into data that we first display on the LCD in real time.

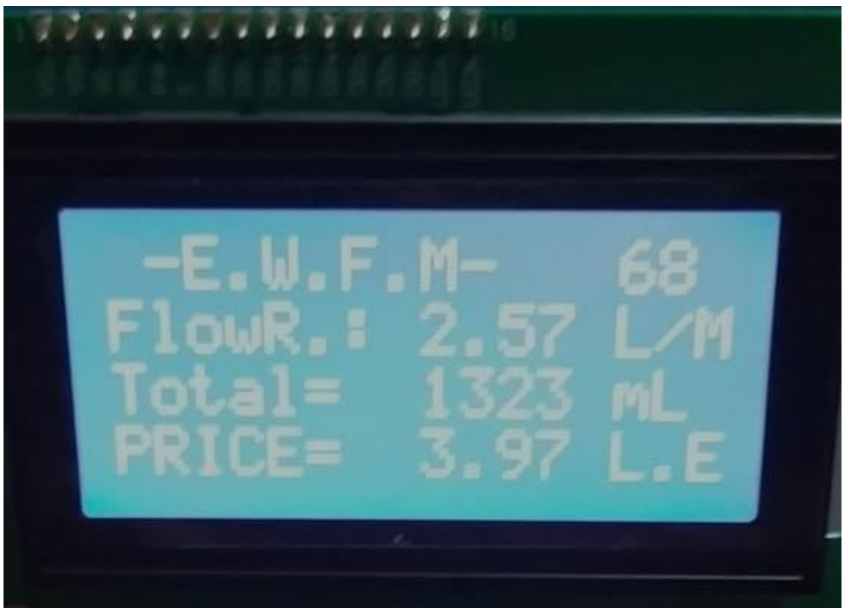


Figure 27Project LCD display

We display 3 things:

1- Flow Rate by liter per minute.

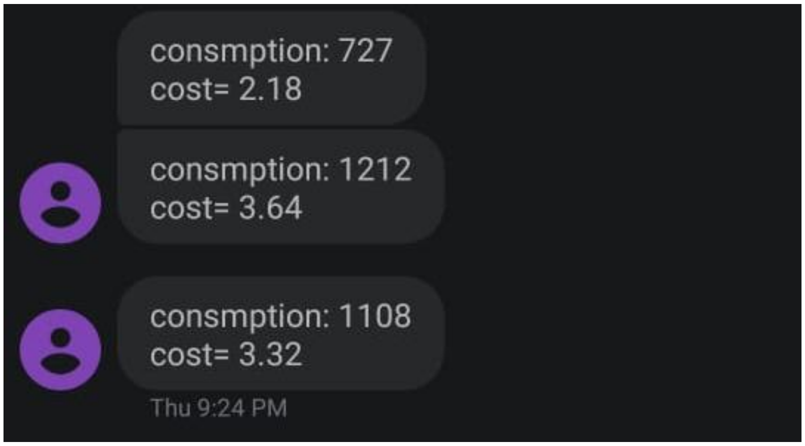
2- Total water volume that has flowed since we started by millileters.

3- Price of the water that has flowed up to this point.

On the upper right corner of the LCD as shown in the figures above there is a timer that counts the seconds since the circuit has started working.

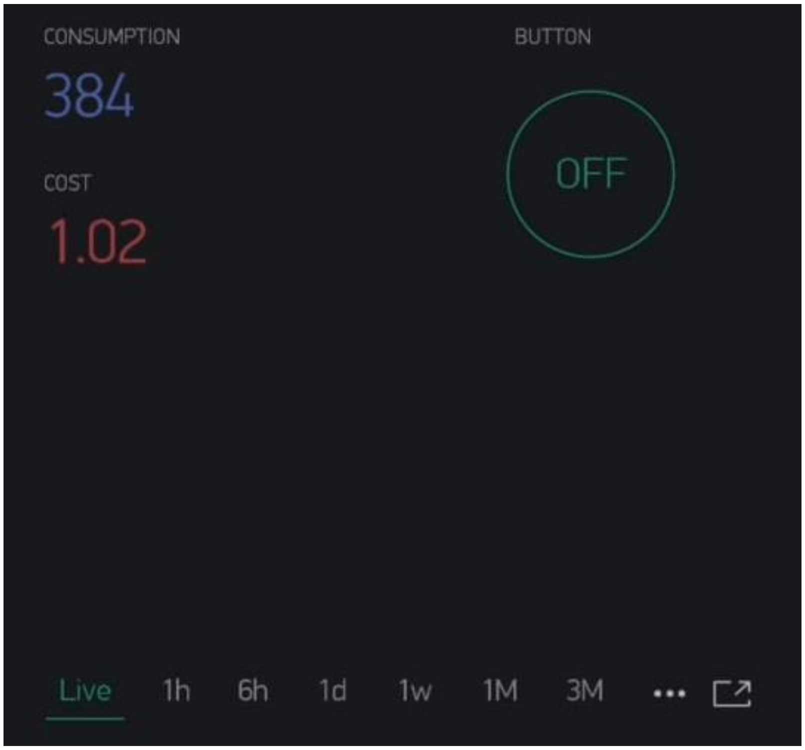
When that timer hits the time interval for the text message, the LCD display lets us know that the text message is being sent right now.

The GSM module sends the text message at every interval containing the total volume of water and its cost up to this point.



While all of this is happening, we use the blync mobile application to display the results in real time also.

It displays the total consumption and the cost just as the information in the text message.



The app can be logged onto from anywhere and still display the live results as the results are uploaded onto the app's web servers so it can be accessed from anywhere in the world.

And that was our project, we hope that we have successfully explained it and displayed it before you.

References

1- Madakam, S., Lake, V., Lake, V., & Lake, V. (2015). Internet of Things (IoT): A literature review. Journal of Computer and Communications, 3(05), 164.

2- Chiang, M., & Zhang, T. (2016). Fog and IoT: An overview of research opportunities. IEEE Internet of things journal, 3(6), 854-864.

3- Farooq, M. U., Waseem, M., Mazhar, S., Khairi, A., & Kamal, T. (2015). A review on internet of things (IoT). International journal of computer applications, 113(1), 1-7.

4- Hassan, Q. F., & Madani, S. A. (Eds.). (2017). Internet of things: Challenges, advances, and applications. CRC Press.

5- Seckler, D., Barker, R., & Amarasinghe, U. (1999). Water scarcity in the twenty-first century. International Journal of Water Resources Development, 15(1-2), 29-42.

6- Pereira, L. S., Cordery, I., & Iacovides, I. (2009). Coping with water scarcity: Addressing the challenges. Springer Science & Business Media.

7- Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., ... & Kanae, S. (2013). A global water scarcity assessment under Shared Socio-economic Pathways–Part 2: Water availability and scarcity. Hydrology and Earth System Sciences, 17(7), 2393-2413.

8- Goel, P. K. (2006). Water pollution: causes, effects and control. New Age International.

9- Mulat, A. G., & Moges, S. A. (2014). Assessment of the impact of the Grand Ethiopian Renaissance Dam on the performance of the High Aswan Dam. Journal of Water Resource and Protection, 2014.

10- Abdelhaleem, F. S., & Helal, E. Y. (2015). Impacts of Grand Ethiopian Renaissance Dam on different water usages in upper Egypt. British Journal of Applied Science & Technology, 8(5), 461-483.

11- Soloman, S. (2010). Sensors handbook. McGraw-Hill Education.

12- Cloete, N. A., Malekian, R., & Nair, L. (2016). Design of smart sensors for real-time water quality monitoring. IEEE access, 4, 3975-3990.

13- BANJARNAHOR, Z. S. (2020). SMART WATER MONITORING INFORMATION SYSTEM. Institut Teknologi Del.

14- https://www.arduino.cc/en/Guide