Environment Management using IoT Based Cost effective, Secured, Smart Sewerage and Air Pollution Monitoring System

BY

Marzan Tasnim Oyshi
ID: 172-25-588

This Report Presented in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Computer Science and Engineering

Supervised By

Dr. Syed Akther Hossain
Professor and Head
Department of Computer Science and Engineering
Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY

DHAKA, BANGLADESH

SEPTEMBER 2019

APPROVAL

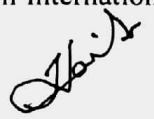
This Project/Thesis titled **"Environment Management using IoT Based Cost effective, Secured, Smart Sewerage and Air Pollution Monitoring System"**, submitted by Marzan Tasnim Oyshi, ID No: 172-25-588 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 13th September 2019.

BOARD OF EXAMINERS

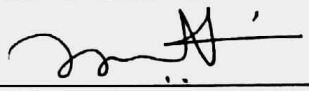
Dr. Syed Akhter Hossain — **Chairman**
Professor and Head
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Internal Examiner

Dr. Md. Ismail Jabiullah
Professor
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University



Dr. Sheak Rashed Haider Noori — **Internal Examiner**
Associate Professor & Associate Head
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University



Dr. Mohammad Shorif Uddin — **External Examiner**
Professor
Department of Computer Science and Engineering
Jahangirnagar University

DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Dr. Syed Akther Hossain, Professor and Head, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

Supervised by:

Dr. Syed Akther Hossain
Professor and Head
Department of Computer Science and Engineering
Daffodil International University

Submitted by:

Marzan Tasnim Oyshi
ID: 172-25-588
Department of Computer Science and Engineering
Daffodil International University

ACKNOWLEDGEMENT

First I express my heartiest thanks and gratefulness to almighty Allah for His divine blessing makes us possible to complete this project successfully.

I fell grateful to and wish our profound our indebtedness to **Dr. Syed Akther Hossain**, Department of Computer Science and Engineering, Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of web development influenced me to carry out this project. His endless patience ,scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism , valuable advice ,reading many inferior draft and correcting them at all stage have made it possible to complete this project.

I would like to express my heartiest gratitude to **Dr. Syed Akhter Hossain, Professor and Head**, Department of Computer Science and Engineering, for his kind help to finish our project and also to other faculty member and the staff of Computer Science and Engineering department of Daffodil International University.

I would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, I must acknowledge with due respect the constant support and patients of my parents.

ABSTRACT

Environment is being badly effected in these days and human are responsible for this. Unplanned urbanization is one of the basic cause of environment pollution and uncountable hassles. The city life in Dhaka gets stuck in the rainy season. Sill countless people are dying for toxic gases while cleaning the underground tunnel for not having any safety kit. Living in a polluted area, breathing toxic gases are the causes to increase deadly diseases like cancer and many more. This research proposes a novel method of real time sewerage monitoring service to determine upcoming blockage with a view to prevent waterlog even before it occurs, a safety kit for underground tunnel workers to detect the inside environment to reduce the death due to toxic gases, air pollution controlling system to detect the amount of emitted toxic gases by specific industry, notify the ministry to take proper steps if the emission keep crossing the threshold. This research also proposes a security model for data security using block chain technology for futerwork and finally proposes the business model for the cost effective solution.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Internet of things (IoT) is one of the most buzzing word in this era. IoT is being able to draw attention and reach out to people as it is allowing sensor nodes equipped with numerous monitoring capacities to have additional facilities in traditional communication. Industry 4.0 came up with the concept of fourth technological revolution, combining basic concepts of Cyber-Physical Systems (CPS), Internet of Things (IoT), Information and Communications Technology (ICT), Enterprise Architecture (EA), and Enterprise Integration (EI). IoT represents a fundamental part in the revelation of Industry 4.0. In recent days IoT has been considered as the technology and economic wave in the global industry.

IoT enables an intelligent network that connects all real life objects to the Internet for the purpose of exchanging information with a view to communicate through the information sensing devices by using mutually agreed protocols. IoT is the connectivity of physical objects to the Internet with a view to monitor and control their behavioral pattern to gain efficiencies and create ultimate new capabilities. According to Arkady Zaslavsky et.al [1] Internet of things is enabling internet to stretch out into the real world and to connect physical objects with the internet. Husni et.al [2] discussed about real life application of IoT and Nava et.al [3] described its scope of being a monitoring system and automation.

This research is connecting IoT with the real world to make it better. It is designed to be implemented in the existing sewerage system and in the garments industry on the context of Bangladesh for its betterment. According to Population of 2017 [4] Dhaka is the home of about 18 million people. Due to having a very poor drainage system the city faces terrible waterlog whenever it rains continuously. Moreover there is no predetermination of upcoming blockage. The only way to reduce waterlog is when the blockage occurs and someone informs the specific authority. According to IPS (Inter Press Service), without taking proper actions 50-60% of Dhaka city might go underwater within 10 years [5]. Clogged drains, channels and manholes are the reason behind of these poor drainage

system. These manholes are being cleaned manually by workers only once in a year and the rest of the time it remains completely covered. This environment contributes to form toxic gases inside the manholes. The dedicated worker goes inside the manhole without having any kind of safeguard. Many of them ends up being dead as a victim of the toxic environment.

Mostly Ammonia (NH3) is responsible for the deathly environment. But this death can be reduced and stopped eventually just by checking the inside environment of a covered manhole from the outside. If the environment is deadly or similar to deadly the worker can keep the manhole uncovered for a while and go inside after a time being. This might take couple of extra time to wait for the cleaner but it will reduce the risk of losing his own life.

Bangladesh is a highly populated country in south Asia. The industry based economy of Bangladesh is 46th largest in the world in nominal terms and 33rd largest by purchasing power parity. According to "CIA WORLD FACTBOOK", the economy of Bangladesh has grown roughly 6% per year since 1996 [6]. The half of total GDP is generated from agriculture and industrial sectors. Garment industry is the backbone of industrial structure of Bangladesh. The industrial production growth rate of Bangladesh is 8.4% and it ranked 7th in country comparison to the world [7]. But this industry is being a great threat to the environment and leading Bangladesh to a very uncertain future.

For IoT solution most of the time designers keeps the security aside, hoping that it could be added later on. But this delay increases the risk of attack. IoT is enabling the concept of connected devices and working with huge amount of real life sophisticated data. This research also focuses on data security in the initial process by using block chain technology.

Environment Management using IoT Based Smart, Cost effective, Secured Sewerage System and Air Pollution Monitoring System using block chain technology aims to focus on predetermination of upcoming blockage to prevent waterlog even before it happens, ensured safety of the workers who perform underground work in tunnels, communication work sites, proposes a method for the solution to control the air pollution using maintaining data security and providing a complete business model.

1.2 Motivation

Environment is being highly polluted all over the world. Waterlog is very common problem in Bangladesh. Being in a tropical region Bangladesh experiences continuous rain in monsoon. It is normal to have rain water on the roads but it is terrible to be in stuck the houses just for excessive waterlog. The condition is getting worst by the time. Garments Industry has played a vital role to upgrade Bangladesh from poor to developing country but this specific unplanned industry has become the ultimate threat to the people by violating environment ecosystem. The global climate is extremely affected by the revolution of industries. Industries are helping us to rise the economic condition but nature is paying the cost. The garment factories emit huge number of toxic elements that get mixed with the environment and effect the environment badly.

It is high time to manage the drainage system and the emission of toxic gases by garments to secure the future of generation.

1.3 Expected Outcome

A smart, secured and cost effective sewerage and air pollution monitoring system that will help to predetermine upcoming blockage, check the hazard condition inside a manhole and to identify the exact industry emitting toxic gases, make them to follow environment rules for a better future.

1.4 Report Layout

The report has been segmented into 5 parts. Chapter 2 focuses on literature review, chapter 3 focuses on research methodology, chapter 4 describes results and finally chapter 5 discusses about limitation and future work.

CHAPTER 2

BACKGROUND

This section of the report presents the background study of the thesis. The study of related works provided valuable inputs in further understanding the thesis.

2.1 Introduction

In the present world IoT is being dedicated to enhance the quality of life by connecting things to the internet and making life better. IoT is stretching its hand in Bangladesh as well. There are a very few implementation. Researchers are doing research to integrate IoT with real world to gain the efficiency. The infrastructure to implement IoT is still limited in Bangladesh. But the infrastructure is being developed and researchers are working on the planning of implementation.

2.2 Literature Review

According to P.P.Ray [8] IoT is permitting users to acquire the best value by connecting devices to internet in health care [9], agriculture [10], industrial manufacturing [11], transportation [12], business [13], e-education [14], logistic [15], retail [16], e-governance [17], smart city [18], assisted living [19] and many more sectors. Gartner [20] states 25 Billion things will be connected to internet and will be in use by 2020. This indicates that there will be connected device more than double of the world population [21]. Smart city allows to be interconnected with the environment by measuring, inferring and understanding the environmental indicators from the existing ecological, natural and urban resources. Smart city combines smart manufacturing, smart health, smart agriculture, smart buildings, traffic management, efficiency management and waste managements. Sewerage Monitoring System connects waste management with a view to develop an effective smart city by adding additional values. Hlodversdottir et.al [22] showed their study was to consider the present and possible future flood hazard in the combined sewer system in Reykjavik city Centre. Nie et.al [23] showed in their research work about the possible outcomes in the Sewerage System, in the present situation, predicted and artificial climate scenarios which contains (1) surface flooding (2) basement flooding and (3) combined sewer overflow were defined to represent the adverse effects of climate change. Weyrauch et.al [24] and Passerat et.al [25] presented the Sewerage System overflow problem scenario and made possible wastewater treatment plant method which was applied to the urban River Spree in Berlin, Germany. Hata et.al [26] aimed to analyze the effect of rainfall events which caused viral load in surface waters impacted by Sewerage System and the reliability of molecular methods for detection of enteric viruses.

Abraham et.al [27] Recent developments in urban storm drainage are reviewed starting with rainfall/runoff processes, followed by discussions of combined sewage, drainage impacts on receiving waters, impact mitigation, hydroinformatics, regulatory programs and conclusions. Chen et.al [28] discussed about the surface flooding by overloaded Sewerage System and demonstrated a new approach to simulate & the result reduce the surface flow more than the traditional model.

Kant et.al [29] discussed about the sensors for Monitoring and diagnosis of air quality. Setiawan et.al [30] discussed about a tool that can measure the air quality. Esquiagola et.al [31] discussed about the use of IoT platform for monitoring indoor air quality. Marques et.al [32] discusses about indoor air quality and the methods of identifying exposure to pollutants and controlling them. Anitha [33] described about detection of empty bin, bin filled with garbage at the maximum level and alerting the specific authority. Smith et.al [34] discussed about the study that reviewed past work in the area of hazard of toxic material buried underground. LeeS. et.al [35] discussed about the hazard condition sharing system in underground tunnel for saving lives of the workers in dangerous events.

Broring et.al [36] introduced an ecosystem of IoT architecture with five interoperability patterns. Roblek et.al [37] presented a conceptual study of "Industry 4.0" by focusing Internet of Things. Tapashetti et.al [38] presented a prototype for monitoring indoor air quality by measuring the concentration of CO and HCHO gases, and notifies the user when the gases reach to the threshold.

Ju et.al [39] discussed about a generic business model framework for IoT business through literature analysis and interviews. Schladofsky et.al [40] described about the identification of different stakeholders of BIG IoT ecosystems and and analyzes how these stakeholders can enhance their existing business models. Bucherer et.al [41] discusses about value and revenue creation in the Inter-net of Things. Kim [42] proposed a new business model of IoT open market that facilities information sharing, and the requirements for ensuring security as well as the standardization of open markets. Silva et.al [43] aims to provide a generic Business Model for IoT testbeds that can provide guidance and be adapted by owners. Fuller et.al [44] discussed about the business models and the opportunity of its value creation. Weinberger et.al [45] discusses about IoT business models in greater detail about how the IoT affects industrial processes. Wikström et.al [46] points out the diversity of business models in project business and their inclination in order to span organizational levels. Chan [47] discussed about collaborating partners, value network and the sources of value co-creation rooted in the layer model of digitalized objects integrating IoT strategy. Leminen et.al [48] described a framework for scrutinizing different types of IOT business models. Yamakami [49] proposed a framework of IoT-empowered business model engineering using a 3-dimensional approach. Mika et.al [50] highlights on designing ecosystem business models for the IOT, including the diversity of objects, the immaturity of innovation, and the unstructured ecosystems. Metallo et.al [51] discussed about the

advancing the theoretical understanding of critical factors for the value creation process in the IoT based organizations and the way to offer interesting implications for management theory and practice.

According to the research study by Hewlett-Packard Enterprise [51] around 80% of things in IoT fail to require passwords of a sufficient complexity and length, 70% enable an intruder to identify valid user accounts through account listing, 70% use network services that are unencrypted and around 60% raise security concerns with the user interfaces.

According to Hwang [53] IoT technology has opened up the security threats which is closely related to our non-virtual lives and they can directly influence physical security risk. Xu et.al [54] provided an impetus for the development of IoT CAD security technique. Zhang et.al [55] discusses about general information security background of IoT and the challenges that IoT would be encountered by. Farooq et.al [56] analyzes the security issues and challenges and delivers a well-defined security architecture as a confidentiality of the user's privacy and security. Riahi et.al [57] proposed a systemic approach of security in IoT and explored the role of each actor and its interfaces with the other key actors of the proposed scheme. Babar et.al [58] provided a security model based on overview, analysis and taxonomy of security and privacy challenges in IoT. Dorri et.al [59] presented a case study of security and privacy concern of a smart home and proposed a BC-based smart home framework for the security and privacy concern using block chain technology. Mahmoud et.al [60] presented a survey on Internet of Things based on layered IoT architecture and IoT security issues. Miettinen et.al [61] proposed a system which capable of identifying the types of devices being connected to an IoT network automatically.

2.3 Primary Documentary

According to size of the population Bangladesh is extremely limited. Dhaka has been termed as 4th polluted city in the world according to Daily Star 2014 and the condition is getting worse each and every day. Air pollution and water pollution are the serious health hazards among all the pollutions. According to Department of Environment (DOE), the National Ambient Air Quality Standards is given bellow:

Table 1.1. National Ambient Air Quality Standers

Land use Category	**8 Hours average Concentration in µg/m3**			
	CO*	NO2*	SPM*	SO2*
Industrial/Mixed use	5000	100	500	120
Commercial/Mixed use	5000	100	400	100
Residential/Rural Use	2000	80	200	80
Sensitive Use*	1000	30	100	30

**Sensitive areas include national monuments, health resorts, hospitals, archeological spots, and educational institutions. Source: Department of Environment (DOE), 1997.*

But the current status of Dhaka city has already exceeded the threshold limit. The current status of Dhaka city is given bellow where *P denotes as Permissible and *C denotes as Concentration.

Table 1.2. Current Status of Dhaka City

Location at Dhaka City	**CO**		**NO2**		**SPM**		**SO2**	
	P	**C**	**P**	**C**	**P**	**C**	**P**	**C**
Gulistan	5000	33200	100	500	400	1332	100	800
Jatrabari		67000		500		4667		1300
Pantho Path		85100		500		2666		900
Mohakhali		69300		500		2111		1200

* CO – Carbon Monoxide

* NO2 – Nitrogen Dioxide

* SPM – Suspended Particulate Matter

* SO2 – Sulfur Dioxide

According to the research work on “Industrial Pollution in Bangladesh” the main sources of air pollution have been identified as –

- Burning of Fossil Fuel
- Industrial Discharge
- Emission from Vehicles

The research work results industries emission as an alarming source of environment pollution. If the specific industry gets identified, it is possible to take proper steps to force industries to emit toxic disposals in a threshold point.

This research aims to develop a model by which real-time prediction of flooding in Bangladesh sewerage system can be measured and proposes a model to identify the exact industry emitting excessive toxic gasses and make them to follow environment rules. It includes hazard condition sharing system to identify the inside environment of a closed manhole from outside. This research comes up with a business model to ensure the affordability and finally it proposes a model for the data security. The entire research needs to perform all the steps described in research methodology.

2.4 Research Summary

This research aim to introduce a prototype of sewerage monitoring system and will propose a model to control air pollution for garments industry using IoT technology. It will offer predetermination of upcoming blockage hazard condition sharing system and air pollution controlling system keeping the budget and security measurements in mind. The development of prototype needs to follow specific steps. The steps will be discussed in the research methodology.

2.5 Research Challenges

Current infrastructure of Bangladesh is the main challenge to implement the IoT solution. For real-life implementation we are planning to use wifi as the internet connectivity. But city wifi is not available at this moment. But the government has taken the initiate to avail city wifi soon. Maintaining proper data security is the second challenge here. It needs to perform more research to ensure the data security. Cost optimization the third challenge of this research.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

As mentioned in literature review, the prototype of IoT based Smart Sewerage, Hazard Condition Sharing and Air Pollution Controlling System (SSHCSAPCS) needs to follow some specific steps. The very first step for IoT solution is problem identification. IoT solutions focuses on two types of problems. One is must needed to be solved and the other is value addition. These solutions needs proper field work to identify the exact reasons behind causing problems. This field work leads to the further process from choosing sensors to data representation. The workflow is represented in Figure 3.1

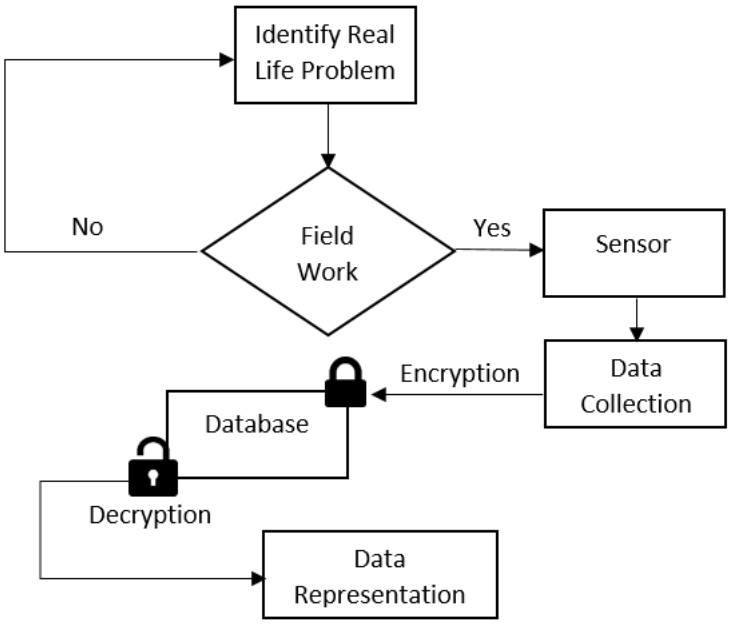


Figure 3.1: Workflow of IoT based SSHCSAPCS

Waterlog, death of underground cleaner and air pollution are burning existing problems in Bangladesh. This research includes required solution and value addition together. To perform field work we have visited Dhaka WASA, Bangladesh Water Development Board, Abid Textile mills and worked with Datasoft Systems Bangladesh Ltd. WASA stands for Water Supply and Sewerage Authority and WASA is responsible for water supply and

sewerage disposal throughout Dhaka city. Bangladesh Water Development Board is a government agency responsible for surface water and underground management of Bangladesh. Datasoft Systems Bangladesh Limited is a CMMI (Capability Maturity Model Integration) level/5 rated software company that works with automation and IoT solutions. To visit Dhaka WASA and Bangladesh Water Development Board, we had to get the appointment via proper channel. After getting the appointment we had a primary discussion and finally we could visit the construction and maintenance area of sewer system. Before visiting the areas we thought the main reason behind the death of the cleaners is CO2 (carbon monoxide) but according to the organizations the main reason is NH3. Primarily, we thought every area has a fixed number of manholes but after the fieldwork we came to know that the number of manholes depends on the density of the population of the respected area. Working with Datasoft Systems Bangladesh Limited helped us a lot to know about the mechanism and the working principles of IoT projects. The entire fieldwork guided us to a more effective solution. We have selected our sensors based on the field work. Ultrasonis sensor has been used here for measuring water height and MQ135 has been used for detecting NH3,NOx, alcohol, Benzene, smoke,CO2 ,etc. We have collected our data from the environment using the sensors. Collected data has been encrypted and stored in the database. Finally the decrypted data has been used for data representation. The encryption and decryption has been done using block-chain technology. To get the final output, used needs to login to the website using their own user ID and password.

3.2 Segmentation

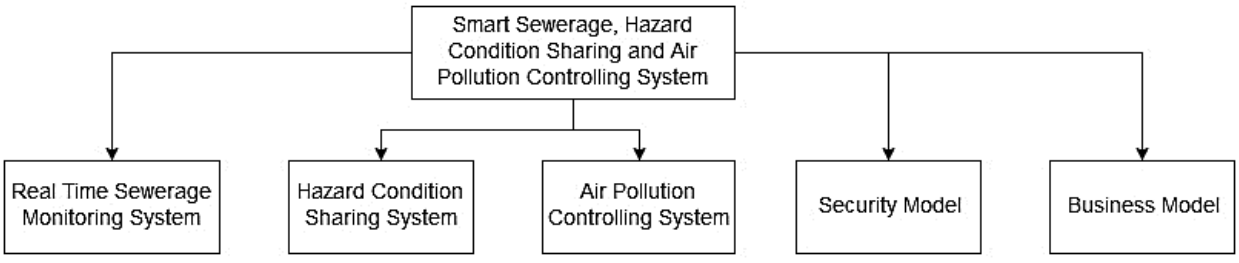


Figure 3.2. Segmentation of IoT based SSHCSAPCS

Figure 3.2 describes about the segmentation of IoT based SSHCSAPCS. The entire research has been segmented in five different parts. Real time monitoring system provides the current water height of different manholes and alerts the authority about upcoming blockage. Hazard condition sharing system allows the facility to check the inside environment of a closed manhole externally to provide safety of the underground tunnel workers. Air pollution controlling system will detect the specific industry emitting excessive toxic gases and inform the ministry. The security model provides the data security model. Finally the business model provides the value proposition, customer segmentation, customer relationship, channel, revenue stream, key resources, key partners, key activities and cost structure.

3.2.1 Real – Time Monitoring System

Real-time monitoring system incledes a fixed device for the predetermination of upcoming blockage. For the prototype, a covered bucket has been used. The fixed device has been attached with the cover of the bucket. The fixed device contains Ultrasonic sensor, Servo Motor, FSR (Force Sensitive Resistor) and nodeMCU and a battery for backup power. Without FSR all the components are covered using an air tight box. FSR and Servo Motor have been used here to create a customized valve to protect ultrasonic sensor from dust and water. FSR detects pressure of water and generates signal to turn the valve off and on. If FSR does not feel any pressure of dust or water, it generates signal 0 and the valve remains open using servo motor. Ultrasonic sensor scans the free space inside the manhole and publishes the scanned height to the MQTT Broker. MongoDB subscribes the published message from the MQTT broker. Database stores the encrypted data and the decrypted data of the free space and used space is displayed in the dashboard. The encryption and deception will be discussed in the security model. The conversion of sensor data to free space and used space is calculated using following formula:

$$Blank\ Space = \frac{Full\ Length - Water\ Height}{Full\ Length} \times 100\%$$

Both ultrasonic sensor and database listens to the same topic for publishing and receiving data. On the other hand, if FSR touches the surface of water and feels the pressure, it generates signal 1 and the valve remains closed to distant ultrasonic sensor from dust and

water. In this point blockage message is displayed on the dashboard. The work flow of fixed device has been described in Figure.3.3

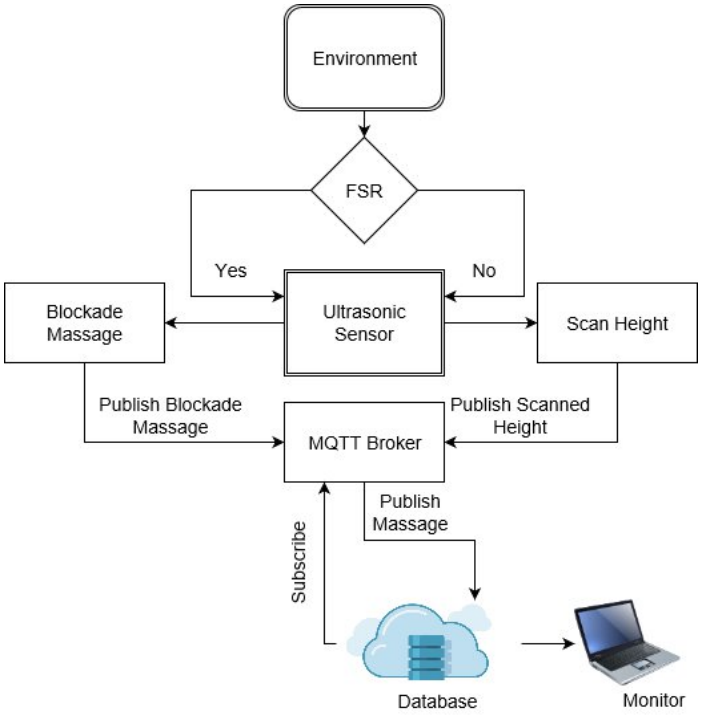


Figure 3.3: Technical Architecture of Fixed Device for Real-Time Sewerage Monitoring Service

In real life, the fixed device will be attached to the cover of a partially sealed manhole. The gateway will be wifi to connect with internet. The device will be turned on using the power of lamp post and the lamp post will be powered by DC current or solar. There will be a battery for backup power. The number of manholes depends on the density of population of the corresponding area. The devices will be installed by sampling the corresponding area. For sampling of this project the entire area will be divided into nodes. Each node indicates a specific location. In fig 4 red circles are marked as nodes. If water level rises suddenly in one node, it is clear that there is blockage in the previous node of the specific node.

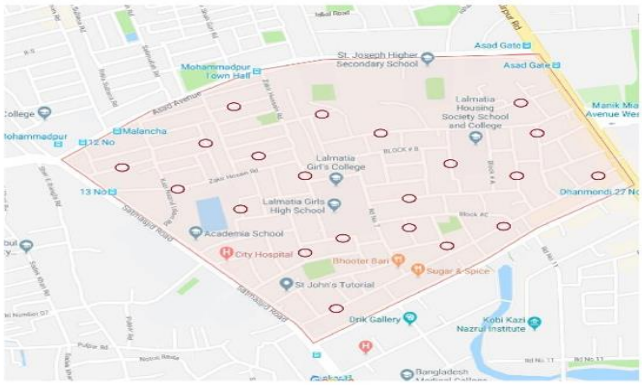


Figure 3.4: Node Samples

As the nodes are divided according to the location, the exact blockage location is detectable by using GSM module. To use the dashboard a user needs to register in the system by providing required information. After registration user can easily access the dashboard and have accurate knowledge of the current situation.

3.2.2 Hazard Condition Sharing System

Hazard condition sharing system includes a portable devices to ensure the safety of the underground tunnel workers. The device combines MQ135 gas sensor, arduino, battery and three LED. MQ135 mainly detects the amount of NH3 (ammonia) in PPM (Parts-per notation, unit of NH3) formed inside the manhole by placing the device over the cover of manholes. The conditions of turning different LED on and off according to the environment is given bellow.

$$\textbf{LED} = \begin{cases} \text{Green; } 0.000<\text{PPM}<0.050 \\ \text{Yellow; } 0.050<\text{PPM}<0.500 \\ \text{Red; PPM}<0.500+ \end{cases}$$

Green LED represents safe environment. Yellow LED represent the presence of ammonia that is harmful for health. Red LED indicates the deadly environment inside the manhole. Cleaners can go inside the manhole without any time delay when the green LED turns on but they have to wait until the yellow or red LED turns to green. The technical architecture of the portable device is shown in Figure 3.5

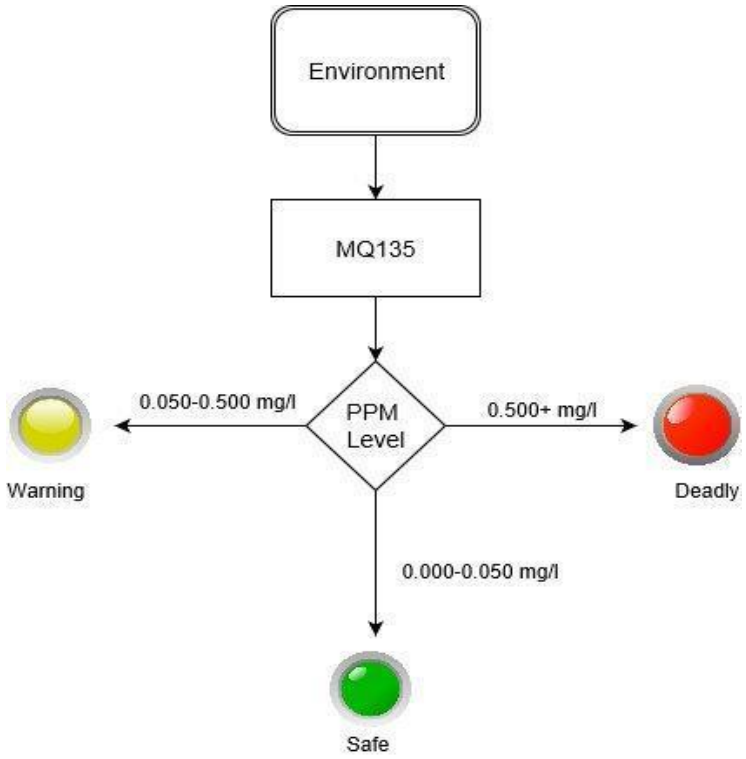


Figure 3.5: Technical Architecture of Portable Device to Determine Toxic Level inside the Manhole

This checking might take some extra couple of time to allow a cleaner to enter the manhole, but this time will work as a safeguard to protect the cleaner from experiencing any deadly environment.

3.2.3 Air Pollution Controlling System

Air Pollution Controlling System for Garments Industry plans to introduce a service that will come up with an IoT Device that will be placed in the exit points of garments, a dashboard for the ministry to keep track of the emission of toxic gases by garments and a user manual. The device will contain

- Microcontroller
- GSM Module
- Battery
- Gas Sensor – MQ135

- Alarm

The proposed system architecture of IoT based air pollution controlling system for garments industry is shown in fig.6.

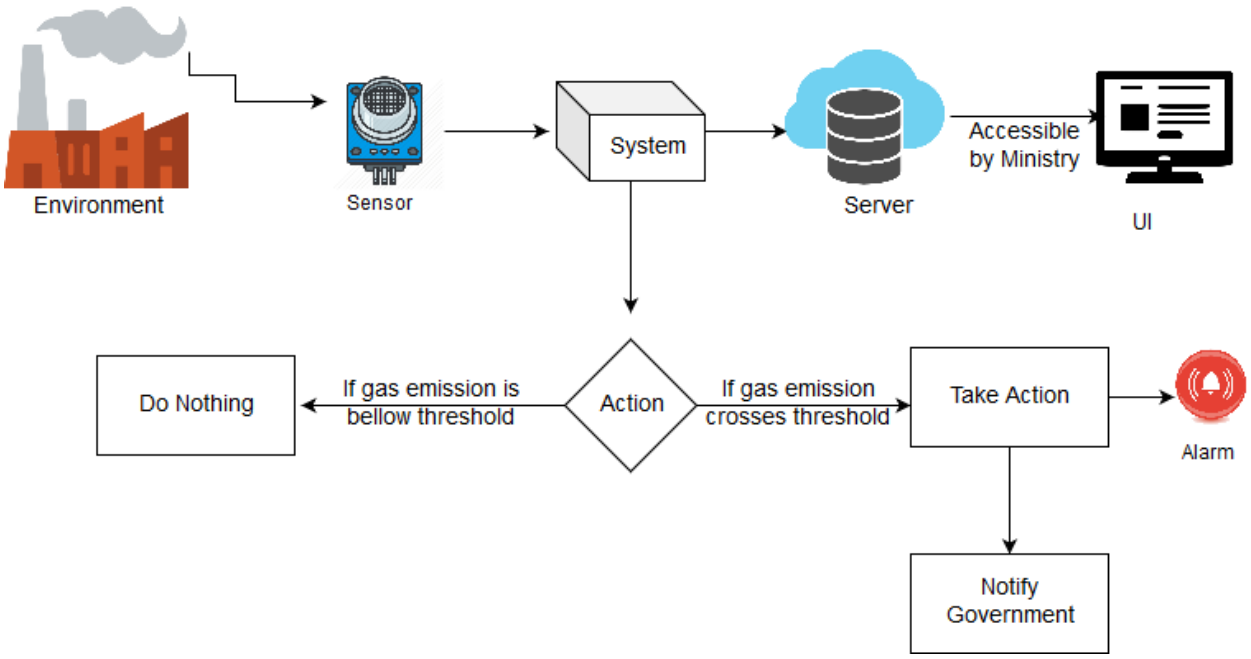


Figure 3.6: Proposed System Architecture of Air Pollution Controlling System

The device will be powered using battery. MQ135 is basically gas sensor and it can detect NH3, NOx, alcohol, Benzene, smoke, CO2, etc. MQ135 will collect data from the environment, compare the toxic levels with the permitted level of emission. Data will be published to the broker, MongoDB will be in the subscribing mode and store the data. Sensor data will be plotted in the dashboard. Here the dashboard will the the user interface and it will be accessible by the ministry itself. Analyzing the data system will take actions accordingly. If the emission is below threshold the system will do nothing but if the emission crosses threshold, it will turn on the alarm. The ministry will be notified immediately via dashboard. Government will be able to send warning and fix certain amount of bill depending on the emission of the toxic gases by the garments. Location of the specific garments will be easily identified using GSM module. The alarm will not be turned off until the industry clears the bill generated by the government.

The workflow of IoT based air pollution controlling system for garments industry is shown in figure 3.7

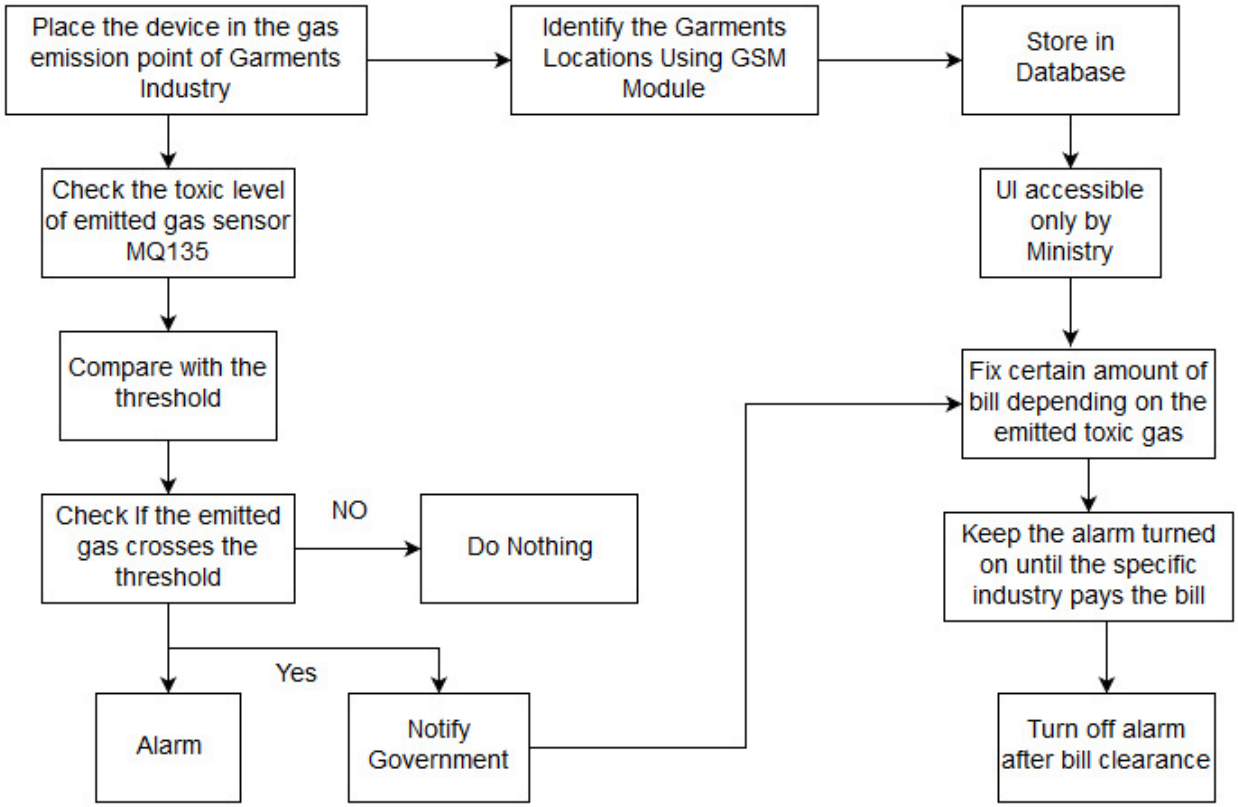


Figure 3.7: Workflow of Air Pollution Controlling System

The device will be powered on using pencil battery. Special casing will be used to protect the device from heat, smoke and dust. End user will be able to use the service via web application and mobile application. To use the service user will need to have specific account by sharing the official details. Without logging in the system, no one will be able to get the service.

3.2.4 Security Model

Security model can be implemented here to secure the data. On the context of SSHCSS, most of the time data will be floating and stored in cloud. If the data is not protected, intruder can access and alter the data. To secure the data block-chain technology has been used here. Block chain is a chain of blocks that contains information. Block-chain is widely used for crypto currency.

However, block-chain can be used to data security as well. This technology is mainly a distributed ledger and open to everyone. Whenever a record is entered in block-chain, it becomes very difficult to change as the blocks are connected with each other like widely shared network. Each block has three components – data, hash and hash of previous block. Block structure is shown in figure 3.8

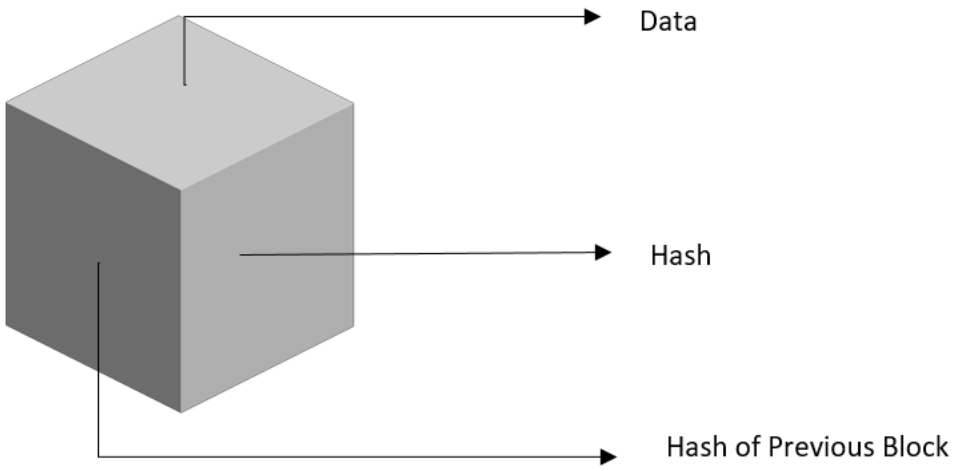


Figure 3.8: Single Block of Block-chain

Data stored inside the block depends on the type of data. For SSHCSAPCS, data will be the sensor data about the free space, used space and water height of corresponding manhole along with the location. Hash of a block defines a block and all that it contains, and it is always unique. Hash is calculated by the time of the creation of a block. Any kind of change inside the block causes the change in hash. Having the hash of previous block crates the chain of blocks and introduces block-chain.

Calculation of hash can be done using different algorithm. We have used SHA-256 for calculating hash of the blocks of SSHCSS. SHA-256 is a Cryptographic Hash Algorithm. SHA-256 generates unique 256-bit (32-byte) signature text for a normal text. For SSHCSS, it generates 32 byte long cipher text against each block by encrypting the sensor data and the blocks together creates the block chain. Data encryption using SHA-256 has been shown in figure.3.9

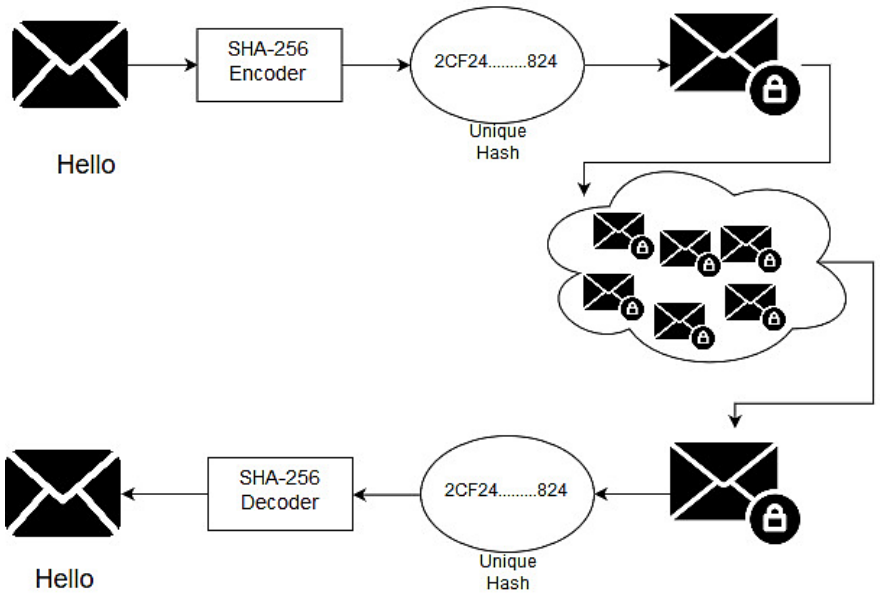


Figure3.9: Data Encryption Using SHA-256

Each block contains hash of its own block and hash of previous block. Previous hash for the first block is always zero. The block chain of SSHCSS is having the hash and previous hash using SHA256 is shown in figure 3.10.

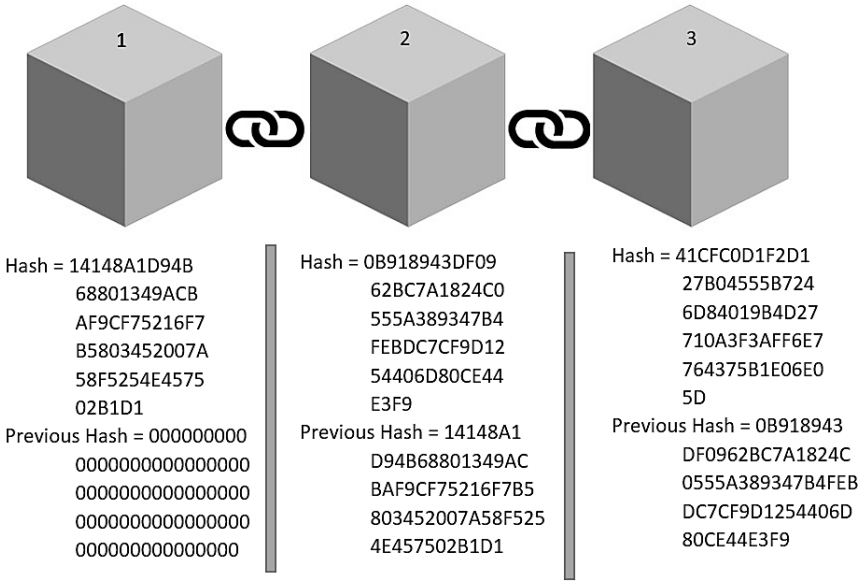


Figure 3.10: Block-chain of SSHCSAPCS

3.2.5 Cost Structure and Business Model

Cost calculation for the prototype and real life differs from each other. We have tried to keep the cost affordable and as minimum as possible. There are some more fraction costs for wires and other tiny equipment which is not counted in the structure. Cost structure for prototype and real life is given in table 3.1 and table 3.2. And finally table 3.3 represents the estimated cost structure for Air Pollution Controlling System.

Table 3.1: Cost Structure for Prototype of Sewerage Monitoring Service and Hazard Condition Sharing System

Fixed Device		
Equipment	**Price ($)**	**Price (BDT)**
Ultrasonic Sensor	1.20	101.39
Servo Motor	1.50	126.74
Force Sensitive Resistor	7.00	591.44
NodeMCU	3.50	295.72
Battery	0.3	25.35
Total	13.50	1140.64
Portable Device		
MQ135	1.69	142.79
Arduino	4.60	388.66
Battery	0.3	25.35
Total	6.59	556.8

Table 3.2: Cost Structure of Sewerage Monitoring Service and Hazard Condition Sharing System (Real Life)

Fixed Device		
Equipment	**Price ($)**	**Price (BDT)**
Ultrasonic Sensor	1.20	101.39
GSM	25.33	2140.18
Solenoid Push Pull	(Customized) 0.50	42.25
Force Sensitive Resistor	(Customized) 0.12	10.14
Battery	0.3	25.35
Total	27.45	2319.31
Portable Device		
MQ135	1.69	142.79
Arduino	4.60	388.66
Battery	0.3	25.35
Total	6.59	556.8

Table 3.3: Cost Structure for Air Pollution Controlling System

SL	**Device**	**Price ($)**	**Price (BDT)**
1	Arduino	6.09	514.56
2	GSM Module	14.59	1232.74
3	Battery	0.99	83.65
4	MQ135	4.12	348.11
5	Alarm	5.79	489.21
Total		31.58	2668.26

Having a business model canvas (BMC) adds the value of a structuralized business plan. BMC combines nine building blocks. According to Joyce et.al [62] BMC is considered as the Triple Layered Business Model Canvas tool to explore sustainability-oriented business model innovation. This model helps to project sustainable growth, budgeting, financial strategy, financial management, resource management and customer management.

Value proposition is the exact value that we want to provide to our clients. SSHCSAPCS provides sewerage blockade predetermination alert by providing real-time monitoring service. This continuous predetermination helps the authority to predict upcoming issues and take actions to reduce waterlog even before it occurs. SSHCSAPCS provides safety service to the underground tunnel workers. Still now manholes are being cleaned manually by human. There are a lot of accidents including death for the toxic environment. But SSHCSAPCS can identify the toxic level of a manhole externally and safe the life of workers. SSHCSAPCS proposes a model to control air pollution by detecting and notifying to the ministry about the exact industry emitting toxic gases over threshold point and to create a window to force them to follow rules or fine them and use the collected money for the development of environment. Another value proposition of SSHCSAPCS is data security using block chain technology.

Customer segmentation helps to identify the group of customers specifically. This segmentation helps to scale the business. The main customer of SSHCSAPCS is government as sewerage and environment are the property of government. Disposal of dust is an important part for garments industry. If the disposal is not clear enough it causes serious problem. Garments industry is out second customer segmentation. Resorts and residential areas also has their own system. They are targeted as our third and fourth customer segment.

Channel mainly indicates to the process to reach to the customers. Specifically the term denotes to distribution channel. Channel for SSHCSAPCS is B2G (Business to Government), B2B (Business to Business) and WASA (Water and Sewer Authority).

Customer relationship is the relationship between customer and the seller. The relationship starts even before selling a product to the specific customer and does not end up after selling

the product. SSHCSAPCS will engage customer by marketing the product. Marketing will include Direct Marketing, Community Marketing, Digital Marketing and Movement Marketing. After engaging the customers to the business, we will provide 24*7 customer service by our customer service team via phone calls, email and sms. We will increase our business using customer to customer service satisfaction. This strategy will be used for the garments industry, resorts and residential area. When one customer will be satisfied using our solution, it will create the customer community and help the business to grow.

Revenue Stream is one of the main important part of BMC. This section mainly discusses about the revenue collection process. The main revenue will be collected by selling the product and installing it. After selling and installation, if client need any modification it will need a certain amount of service charge. Dashboard and maintaining the dashboard is another revenue collection stream here. After running the business for years, it will contain large amount of data that will eventually form big data. By analyzing big data it will be possible to identify areas that are mainly causing blockage and plan further research to reshape that area and create new business opportunity.

Key resource are the resource that have been used to develop products and run the business. Here, our key resources are our partners, channel, equipment and the dashboard. Key partners are our partners in the business. For sustainable business growth, it is important to have the right partner. For a rightful business WASA, City Corporation and Media are the worthy partners. Key activity of SSHCSAPCS is continuous development of our own solution and service and engage more customers for the growth of business. Finally cost structure involves the overall cost for the entire business. Cost structure for SSHCSS includes Equipment Cost, Manufacturing Cost, Maintenance Cost, Revenue Sharing and Salary. Equipment Cost, Manufacturing Cost and Maintenance are the unavoidable cost. Without sharing the revenue with partners it is impossible to continue partnership and without providing salary no one will work to run the business. It is important to keep coworkers happy to have a successful business. The BMC for SSHCSAPC is given in table 6.

Table 3.4: Business Model Canvas for IoT based Smart Sewerage Monitoring, Hazard Condition Sharing and Air Pollution Controlling System

<table>
<tr><th colspan="5">Business Model Canvas</th></tr>
<tr>
<td rowspan="2">7. Key Partners
WASA
City Corporation
Media</td>
<td>8. Key Activities
Continuous Improvement
Customer Engagement</td>
<td rowspan="2">1.Value Proposition
Monitoring Service
Sewerage Blockage Prediction
Reduce Waterlog
Green Environment
Safety Service
Toxic Level Identification
Data Security</td>
<td>4. Customer Relationship
Marketing
Direct Marketing
Community Marketing
Digital Marketing
Movement Marketing
Service Team
Phone call
Email
SMS
Customer to Customer
Customer Community</td>
<td rowspan="2">2. Customer Segment
Government
Garments Industry
Resorts
Residential Complex</td>
</tr>
<tr>
<td>6. Key Resource
Partners
Channel
Equipment
Dashboard</td>
<td>3. Channels
B2G
B2B
WASA</td>
</tr>
</table>

9. Cost Structure	**5. Revenue Stream**
• Equipment Cost • Manufacturing Cost • Maintenance Cost • Revenue Sharing • Salary	• Product Sell • Installation • Dashboard • Maintenance • Big Data • Fines

CHAPTER 4

RESULTS

To test the prototype of SSHCSAPCS, a bucket has been used as a dummy manhole. To detect water height the bucket has been filled with water externally. Ultrasonic sensor from the fixed device, scans the free height of the manhole. It sends the data to the database and the website displays the free space and used space in the dashboard. The space differs with the level of water. If the water crosses the threshold it sends blockage signal to the dashboard. The used space remains green until the dummy manhole is filled with water below threshold. Free space and used space changes its color to yellow and eventually red according to the used space and the availability of free space. The used space and free space is shown figure 4.1 and 4.2 with water level below threshold.

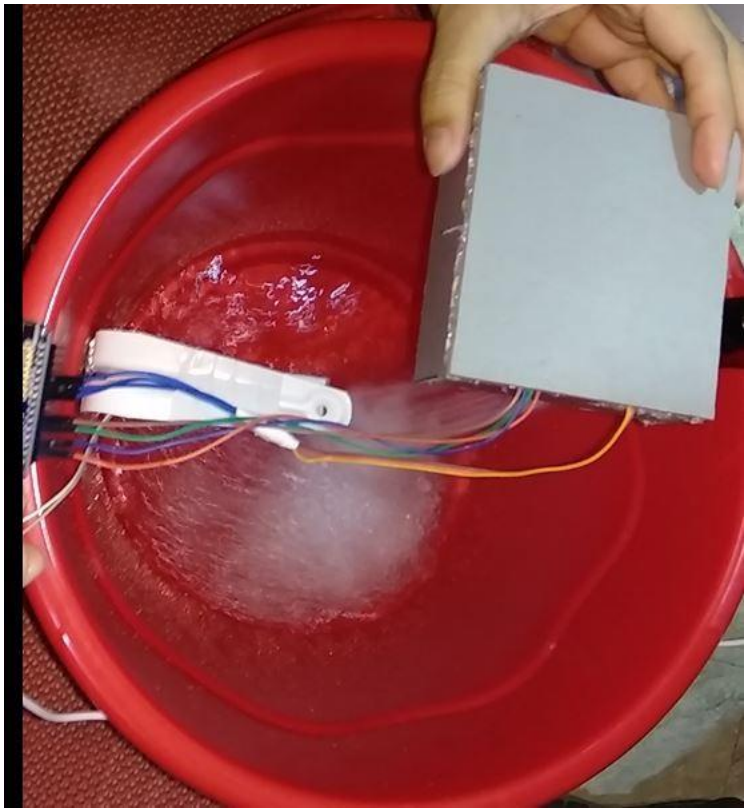


Figure 4.1: Dummy Manhole Partially Filled with Water

Figure 4.2: Free Space and Used Space of the Bucket (Dummy Manhole)

If the water level rises to high and touches the FSR, it feels the pressure and turns off the valve. This valve is used to help the ultrasonic sensor to keep it safe from water and dust. Water height crossing the threshold level is shown in figure 4.3 and 4.4

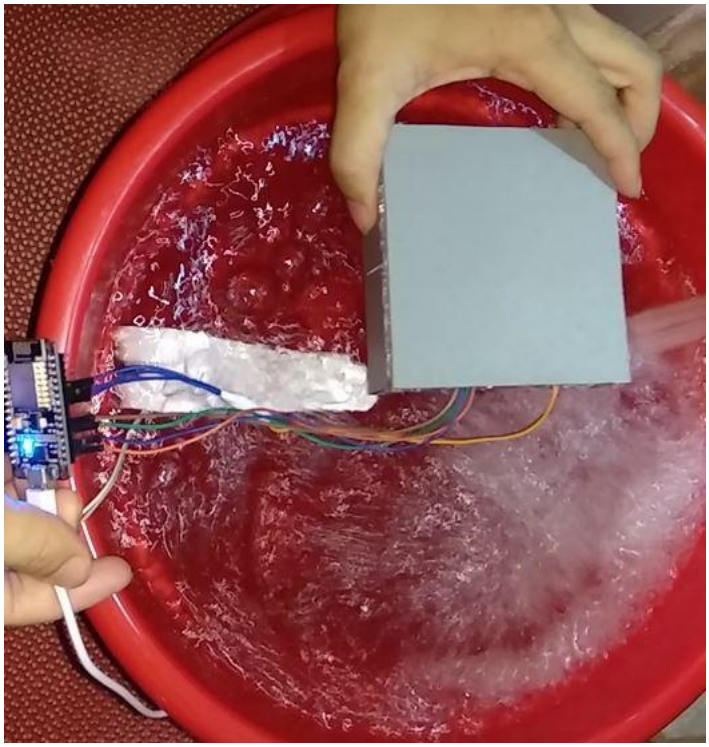


Figure 4.3: Water Level Crossing Threshold

Figure 4.4: Free Space and Used Space Crossing Threshold

Users need to have an account on sewage monitoring system site to have the access. They can check the sensor data along with the node numbers from the history. The node numberings are based on the GPS. These helps to identify the location of respected manhole. Without having the knowledge of the location it is impossible to prevent the blockage. History of nodes allows the user to keep track and identify the location where the probability of occurring waterlog is high. This analysis helps to take further decisions to improve blockage situations. To check hazard condition sharing system, one bucket was fully covered full of garbage that is responsible for forming ammonia gas. When the PPM for ammonia is too high the red LED turns on as the indication of deadly environment. In such environment the RED LED turns on to alert the user. The PPM level of NH3 and the indication of deadly environment is shown in figure 4.5

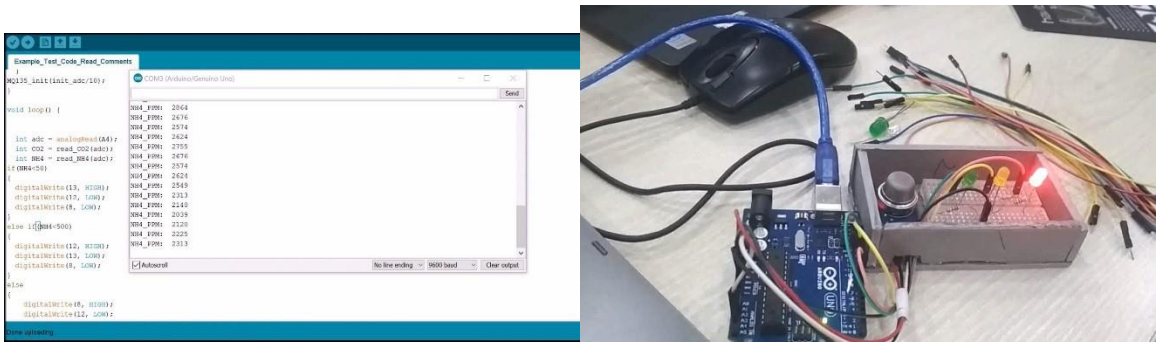


Figure 4.5: PPM Level of Ammonia (NH3) in Deadly Environment

The indications are easy enough to understand for any kind of user. Users do not need to be highly educated to use the devices. They just need to be told the meaning of LED colors and keep in mind that green is safe, yellow is warning and the red is deadly. Just by keeping this information in mind, it will help the users and save them from death.

After keeping the dummy manhole open for couple of time the PPM level decreases. With the decreased PPM level the LED to turns to yellow when the environment is harmful but not deadly. Finally the green LED turns on when the presence of NH3 is bearable. The safest PPM and green LED is shown in figure 4.6

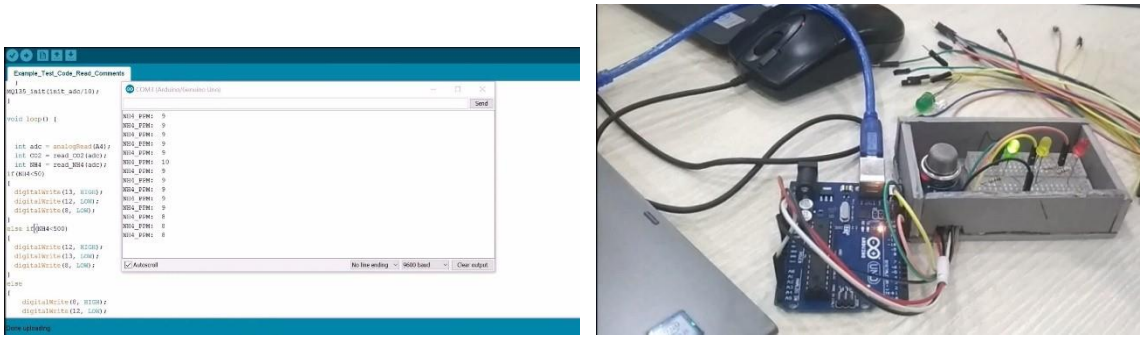


Figure 4.6: PPM level of Ammonia in Safe Environment

The indications are easy enough to understand for any kind of user. Users do not need to be highly educated to use the devices. They just need to be told the meaning of LED colors and keep in mind that green is safe, yellow is warning and the red is deadly. Just by keeping this information in mind, it will help the users and save them from death.

CHAPTER 5

CONCLUSION

Human are the reason behind the unplanned urbanization and the environment disasters. Dhaka city is being one of the top most city which does not follow the standard of living. The city faces terrible waterlog during rainy season, number of people dies due to excessive toxic gases while cleaning the manholes without any safety measurement and the entire country is being forced to breathe toxic air emitted by the garments industries. But this condition is possible to overcome using specific guideline and with the help of technology. It is our responsibility to upgrade our systems and purify our environment for our future generation.

5.1 Limitations

This research determines to solve terrible waterlog in Bangladesh, initially in Dhaka City and the gametes around Dhaka city. It aims to provide a hassle free life to the citizens and a green environment. Obtaining the current architecture of the existing sewerage system was the first challenge here. With the cooperation of Dhaka WASA, Bangladesh Water Development Board and Datasoft Systems Bangladesh Ltd, getting specific idea of existing sewerage system have been possible. Identification of the gas, responsible for deadly environment was another challenge here. Getting access to the garments industry was another challenge. But we could overcome all the challenge.

5.2 Future Work

This thesis aims for real life implementation in near future. In real life implementation sensors and equipment will be changed partially. The partially sealed manholes will be targeted to install fixed devices for monitoring services and Wi-Fi will be used for internet connectivity. It aims to implement block chain for security. The extended plan is to connect lakes, cannels and rivers with the entire system and to introduce automated blockade Clarence for the desired efficiency. This thesis aims to stretch out other fields like automated street light service, automated manhole clearance and other sectors to enhance life style and to save the environment

REFERENCE

[1] Arkady Zaslavsky, Prem Prakash Jayaraman. “The internet of things: Discovery in the internet of things” Researchgate Article, October 2015, DOI: 10.1145/2822529.

[2] Emir Husni, Galuh Boy Hertantyo, Daniel Wahyu Wicaksono, Faisal Hasibuan, Andri Ulus Rahayu, Muhamad Agus Triawan “Applied Internet of Things (IoT): Car monitoring system using IBM BlueMix” Conference: 2016 International Seminar on Intelligent Technology and Its Applications (ISITIA), July 2016, DOI: 10.1109/ISITIA.2016.7828696.

[3] Mauricio Tellez nava, Samy El-Tawab, Mohammad Hossain Heydari “Improving the security of wireless sensor networks in an IoT environmental monitoring system” 2016 Systems and Information Engineering Design Symposium (SIEDS) Conference, April 2016, DOI: 10.1109/SIEDS.2016.7489330.

[4] “Population of 2017” Article, February 10, 2017.

[5] Inter Press Service News Agency “Dhaka Could Be Underwater in a Decade”

[6] Countries of the World. (2019, February 8). Bangladesh Economy 2019. Retrieved from The Dora: https://theodora.com/wfbcurrent/bangladesh/bangladesh_economy.html

[7s] Alam, G. M. (n.d.). ENVIRONMENTAL POLLUTION OF BANGLADESH – IT’S EFFECT AND CONTROL. Retrieved from Bangladesh Environment : http://www.bangladeshenvironment.com/index.php/polution-s/294-environmental-pollution-of-bangladesh-it-s-effect-and-control

[8] P.P. Ray “A survey on Internet of Things architectures” Journal of King Saud University - Computer and Information Sciences, Volume 30, Issue 3, July 2018, Pages 291-319.

[9] Carlos Cambra, Sandra Sendra, Jaime Lloret, Laura Garcia “An IoT service-oriented system for agriculture monitoring” ICC 2017 - 2017 IEEE International Conference on Communications, May 2017, DOI: 10.1109/ICC.2017.7996640

[10] Gabriel Neagu, Stefan Preda, Alexandru Stanciu, Vladimir Florian “A Cloud-IoT based sensing service for health monitoring” 2017 E-Health and Bioengineering Conference (EHB), June 2017, DOI: 10.1109/EHB.2017.7995359

[11] Andrea Melis, Marco Prandini, Laura Sartori, Franco Callegati “Public Transportation, IoT, Trust and Urban Habits” International Conference on Internet Science, September 2016, DOI: 10.1007/978-3-319-45982-0_27

[12] Kleanthis Thramboulidis, Theodoros Foradis, “From Mechatronic Components to Industrial Automation Things: An IoT Model for Cyber-Physical Manufacturing Systems” Journal of Software Engineering and Applications 10(08), June 2016, DOI: 10.4236/jsea.2017.108040

[13] Sok Pal Cho, J.-G. Kim “E-Learning Based on Internet of Things” Journal of Computational and Theoretical Nanoscience 22(11):3294-3298, November 2016, DOI: 10.1166/asl.2016.7937

[14] Martin Fiedler, Stefan Meissner “IoT in Practice: Examples: IoT in Logistics and Health” In book: Enabling Things to Talk, September 2013, DOI: 10.1007/978-3-642-40403-0_4

[15] Naoshi Uchihira, Hirokazu Ishimatsu, Keisuke Inoue “IoT service business ecosystem design in a global, competitive, and collaborative environment” 2016 Portland International Conference on Management of Engineering and Technology (PICMET), September 2016, DOI: 10.1109/PICMET.2016.7806694

[16] Wei Zhou, Frederique Alexandre-Bailly, Selwyn Piramuthu “Dynamic Organizational Learning with IoT and Retail Social Network Data” 2016 49th Hawaii International Conference on System Sciences (HICSS), January 2016, DOI: 10.1109/HICSS.2016.476

[17] Paul Brous, Marijn Janssen “Advancing e-Government Using the Internet of Things: A Systematic Review of Benefits” International Conference on Electronic Government, August 2015, DOI: 10.1007/978-3-319-22479-4_12

[18] Hamidreza Arasteh, Vahid Hosseinnezhad, Vincenzo Loia, Aurelio Tommasetti, Orlando Troisi, Miadreza Shafie-khah, Pierluigi Siano “IoT-based Smart Cities: a Survey” The 16th IEEE International Conference on Environment and Electrical Engineering, (IEEE-EEEIC'16), June 2016, DOI: 10.1109/EEEIC.2016.7555867

[19] Angelika Dohr, Robert Modre-Osprian, Mario Drobics, Dieter Hayn, Günter Schreier “The Internet of Things for Ambient Assisted Living” Seventh International Conference on Information Technology: New Generations, January 2010, DOI: 10.1109/ITNG.2010.104

[20] Gartner Press Release “4.9 Billion Connected "Things" Will Be in Use in 2015”, Barcelona, Spain, November 11, 2014, last accessed July 8, 2018, 14.54.

[21] Worldometers “World Population: Past, Present, and Future” last accessed July 8, 2018, 15.05.

[22] A.O. Hlodversdottir, B. Bjornsson, H.O. Andradottir, J. Eliasson, P. Crochet, Assessment of flood hazard in combined sewer systems in Reykjavik city centre, Water Sci. Technol. 71 (10) (2015) 1471–1477, http://dx.doi.org/10.2166/wst.2015.119.

[23] L. Nie, O. Lindholm, G. Lindholm, E. Syversen, Impact of climate change on urban drainage systems a case study in Fredrikstad, Norway, Urban Water J. 6 (4) (2008), 323–332, http://dx.doi.org/10.1080/15730620802600924.

[24] P. Weyrauch, A. Matzinger, E. Pawlowsky-Reusing, S. Plume, D. Seggern, B. Heinzmann, K. Schroeder, P. Rouault, Contribution of combined sewer overflows to trace contaminant loads in urban streams, Water Res. 44 (15) (2010) 4451–4462, http://dx.doi.org/10.1016/j.watres.2010.06.011.

[25] J. Passerat, N.K. Ouattara, J. Mouchel, V. Rocher, P. Servais, Impact of an intense combined sewer overflow event on the microbiological water quality of the Seine River, Water Res. 45 (2) (2011) 893–903, http://dx.doi.org/10.1016/j.watres.2010.09.024.

[26] A. Hata, H. Katayama, K. Kojima, S. Sano, I. Kasuga, M. Kitajima, H. Furumai, Effects of rainfall events on occurrence and detection efficiency of viruses in river water impacted by combined sewer overflows, Sci. Total Environ. 468–469 (2014), 757–763, http://dx.doi.org/10.1016/j.scitotenv.2013.08.093.

[27] Abraham, S., Beard, J., and Manijacob, R. (2017), "Remote environmental monitoring using Internet of Things (IoT)" on IEEE Global Humanitarian Technology Conference (GHTC), 19-22 Oct. 2017. DOI: 10.1109/GHTC.2017.8239335

[28] A.S. Chen, J. Leandro, S. Djordjevic, Modelling sewer discharge via displacement of manhole covers during flood events using 1D/2D SIPSON/P-DWave dual drainage simulation, Urban Water J. 13 (2016) 830–840, http://dx.doi.org/10.1080/1573062X.2015.1041991

[29] Rishi Kant, Shantanu Bhattacharya "Sensors for Air Monitoring" In book: Environmental, Chemical and Medical Sensors, December 2017, DOI: 10.1007/978-981-10-7751-7_2

[30] F N Setiawan, I Kustiawan "IoT based Air Quality Monitoring", in article, July 2018, License CC BY 3.0, DOI: 10.1088/1757-899X/384/1/012008

[31] John Esquiagola, Matheus Manini, Arthur Sequeira Aikawa, Leopoldo Yoshioka and Marcelo Knorich Zuffo "Monitoring Indoor Air Quality by using IoT Technology" Conference: XXV International Conference on Electronics, Electrical Engineering and Computing - INTECON 2018, August 2018, DOI: 10.1109/INTERCON.2018.8526380

[31] Benjamin Jones, Constanza Molina “Indoor Air Quality” In book: Reference Module in Earth Systems and Environmental Sciences, December 2017, DOI: 10.1016/B978-0-12-409548-9.10198-8

[32] Marques, G., & Pitarma, R. (2017). Monitoring Health Factors in Indoor Living Environments Using Internet of Things. Recent Advances in Information Systems and Technologies, 785–794. doi:10.1007/978-3-319-56538-5_79

[33] Anitha, A. (2017) “Garbage monitoring system using IoT” IOP Conference Series: Materials Science and Engineering, 263, 042027. DOI:10.1088/1757-899x/263/4/042027

[34] Craig Forsythe Smith, J.J. Cohen, T.E. McKone “Hazard index for underground toxic material” in article, June 1980, DOI: 10.2172/5180369

[35] C.-U. LeeS., W. KimR. And D. Oh “Development of IoT-based smart hazard condition sharing system” in article, August 2015.

[36] Broring, A., Schmid, S., Schindhelm, C.-K., Khelil, A., Kabisch, S., Kramer, D., … Teniente, E. (2017). Enabling IoT Ecosystems through Platform Interoperability. IEEE Software, 34(1), 54–61. doi:10.1109/ms.2017.2

[37] Roblek, V., Meško, M., & Krapež, A. (2016). A Complex View of Industry 4.0. SAGE Open, 6(2), 215824401665398. doi:10.1177/2158244016653987

[38] Tapashetti, A., Vegiraju, D., & Ogunfunmi, T. (2016). IoT-enabled air quality monitoring device: A low cost smart health solution. 2016 IEEE Global Humanitarian Technology Conference (GHTC). doi:10.1109/ghtc.2016.7857352

[39] Jaehyeon Ju, Mi-Seon Kim, Jae-Hyeon Ahn “Prototyping Business Models for IoT Service” December 2016Procedia Computer Science 91:882-890, License CC BY-NC-ND 4.0, DOI: 10.1016/j.procs.2016.07.106.

[40] Werner Schladofsky, Jelena Mitic, Alfred Paul Megner, Claudia Simonato, Luca Gioppo, Dimitris Leonardos, Arne Bröring “Business Models for Interoperable IoT Ecosystems” Conference: Interoperability and Open-Source Solutions for the Internet of Things. Second International Workshop, InterOSS-IoT 2016, DOI: 10.1007/978-3-319-56877-5_6.

[41] Bucherer, E., & Uckelmann, D. (2011). Business Models for the Internet of Things. Architecting the Internet of Things, 253–277. DOI: 10.1007/978-3-642-19157-2_10.

[42] Woo Sung Kim “The Business Model of IoT Information Sharing Open Market for Promoting IoT Service” September 2016, DOI: 10.9716/KITS.2016.15.3.195.

[43] Edgar M. Silva, Pedro Maló “IoT Testbed Business Model” in article, September 2014Advances in Internet of Things 4(4):37-45, License CC BY 4.0, DOI: 10.4236/ait.2014.44006

[44] Charles Baden-Fuller, Vincent Mangematin “Business Models and Modelling Business Models” in article, October 2015Advances in Strategic Management 33: xi – xxii, DOI: 10.1108/s0742-332220150000033013

[45] Markus Weinberger, Dominik Bilgeri, Elgar Fleisch “IoT business models in an industrial context” in article, January 2016at - Automatisierungstechnik 64(9), DOI: 10.1515/auto-2016-0054

[46] Kim Wikström, Karlos Artto, Jaakko Kujala, Jonas Söderlund “Business models in project business” in article, December 2010International Journal of Project Management 28(8):832-841, DOI: 10.1016/j.ijproman.2010.07.001

[47] Hubert C.Y. Chan “Internet of things business models” In book: Internet of Things and Data Analytics Handbook, December 2016, DOI: 10.1002/9781119173601.ch45

[48] Seppo Leminen, Westerlund Mika, Mervi Rajahonka, Riikka Siuruainen “Towards IOT Ecosystems and Business Models” In book: Internet of Things, Smart Spaces, and Next Generation. Lecture notes in Computer Science Volume 7469, Publisher: Springer, Editors: Sergey Andreev, Sergey Balandin, Yevgeni Koucheryavy, January 2012, DOI: 10.1007/978-3-642-32686-8_2

[49] Toshihiko Yamakami “A 3-dimensional view model of IoT-empowered business model engineering towards borderless business reengineering” Conference: 2017 19th International Conference on Advanced Communication Technology (ICACT), January 2017, DOI: 10.23919/ICACT.2017.7890181

[50] Westerlund Mika, Seppo Leminen, Mervi Rajahonka “Designing Business Models for the Internet of Things” in article, July 2014, DOI: 10.22215/timreview/807

[51] Concetta Metallo, Rocco Agrifoglio, Francesco Schiavone, and Jens Mueller “Understanding business model in the Internet of Things industry” in article, February 2018Technological Forecasting and Social Change, DOI: 10.1016/j.techfore.2018.01.020

[52] Hewlett-Packard Enterprise, “Internet of Things research study” 2014, accessed on December 11, 2018 [Online].

[53] Hwang, Y. H. (2015). IoT Security & Privacy: Threats and Challenges. IoTPTS '15 Proceedings of the 1st ACM Workshop on IoT Privacy, Trust, and Security (p. 1). Singapore, Republic of Singapore: ACM New York, NY, USA ©2015. doi:10.1145/2732209.2732216

[54] Teng Xu, J. B. (2014). Security of IoT Systems:Design Challenges and Opportunities. ICCAD '14 Proceedings of the 2014 IEEE/ACM International Conference on Computer-Aided Design (p. 7). San Jose, California: IEEE Press Piscataway, NJ, USA ©2014.

[55] Zhi-Kai Zhang, M. C.-W.-W.-K. (2014). IoT Security: Ongoing Challenges and Research Opportunities. 2014 IEEE 7th International Conference on Service-Oriented Computing and Applications (p. 5). Matsue, Japan: IEEE. doi:10.1109/SOCA.2014.58

[56] M.U. Farooq, M. W. (2015). A Critical Analysis on the Security Concerns ofInternet of Things (IoT). International Journal of Computer Applications (0975 888) (p. 6). ISSN.

[57] Arbia Riahi, Y.C. (2013). A systemic approach for IoT security. 2013 IEEE International Conference on Distributed Computing in Sensor Systems (p.5). Cambridge, MA, USA: IEEE. doi:10.1109/DCOSS.2013.78

[58] Sachin Babar, P. M. (2010). Proposed Security Model and Threat Taxonomy for the Internet of Things (IoT). International Conference on Network Security and Applications. CCIS, volume 89, p. 9. Chennai, India: Springer.

[59] Dorri, A., Kanhere, S. S., Jurdak, R., & Gauravaram, P. (2017). Blockchain for IoT security and privacy: The case study of a smart home. 2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops) (p. 6). Kona, HI, USA: IEEE. doi: 10.1109/PERCOMW.2017.7917634

[60] Rwan Mahmoud, T. Y. (2015). Internet of Things (IoT) Security: Current Status, Challenges and Prospective Measures. 10th International Conference for Internet Technology and Secured Transactions (ICITST) (p. 6). London, UK: IEEE. Retrieved from 10.1109/ICITST.2015.7412116

[61] Markus Miettinen, A.-R. S. (2017). IOTSENTINEL: Automated Device-TypeIdentification for Security Enforcement in IoT. IEEE 37th International Conference on Distributed Computing Systems (ICDCS) (p. 8). Atlanta, GA, USA: IEEE. Retrieved from 10.1109/ICDCS.2017.283

[62] Joyce, A., & Paquin, R. L. (2016). The triple layered business model canvas: A tool to design more sustainable business models. Journal of Cleaner Production, 135, 1474–1486. doi:10.1016/j.jclepro.2016.06.067

IoT

ORIGINALITY REPORT

30%	23%	17%	25%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Daffodil International University Student Paper	4%
2	Vikki Edmondson, Martin Cerny, Michael Lim, Barry Gledson, Steven Lockley, John Woodward. "A smart sewer asset information model to enable an 'Internet of Things' for operational wastewater management", Automation in Construction, 2018 Publication	2%
3	Submitted to RMIT University Student Paper	1%
4	dspace.library.daffodilvarsity.edu.bd:8080 Internet Source	1%
5	Md. Junayed Siddique, Mohammad Aynul Islam, Fernaz Narin Nur, Nazmun Nessa Moon, Mohd. Saifuzzaman. "BREATHE SAFE: A Smart Garbage Collection System for Dhaka City", 2018 10th International Conference on Electrical and Computer Engineering (ICECE), 2018 Publication	1%

6	onlinelibrary.wiley.com Internet Source	1%
7	aem.asm.org Internet Source	1%
8	iwaponline.com Internet Source	<1%
9	Submitted to CSU, San Jose State University Student Paper	<1%
10	Submitted to Northcentral Student Paper	<1%
11	Submitted to North South University Student Paper	<1%
12	www.intechopen.com Internet Source	<1%
13	designinnovationmanagement.com Internet Source	<1%
14	Regel Gonzalez-Usach, Diana Yacchirema, Matilde Julian, Carlos E. Palau. "chapter 9 Interoperability in IoT", IGI Global, 2019 Publication	<1%
15	Submitted to Colorado Technical University Online Student Paper	<1%
16	Submitted to Study Group Australia	

	Student Paper	<1%
17	Submitted to SUNY, Binghamton Student Paper	<1%
18	Submitted to Laureate Higher Education Group Student Paper	<1%
19	link.springer.com Internet Source	<1%
20	Submitted to University of Canterbury Student Paper	<1%
21	Submitted to University of New South Wales Student Paper	<1%
22	Submitted to University of Witwatersrand Student Paper	<1%
23	www.irjet.net Internet Source	<1%
24	www.tandfonline.com Internet Source	<1%
25	www.econstor.eu Internet Source	<1%
26	Submitted to University of Greenwich Student Paper	<1%
27	libetd.shu.edu.tw Internet Source	<1%

28	aisel.aisnet.org Internet Source	<1%
29	Jongkwon Son, Myung-Eun Kim, Young-Sung Son. "IoT testbed for dynamic management of fine dust in indoor environments", Proceedings of the International Conference on Internet of Things Design and Implementation - IoTDI '19, 2019 Publication	<1%
30	docplayer.org Internet Source	<1%
31	Submitted to University of Applied Sciences Berlin Student Paper	<1%
32	Submitted to University of Liverpool Student Paper	<1%
33	www.science.gov Internet Source	<1%
34	dspace.daffodilvarsity.edu.bd:8080 Internet Source	<1%
35	www.springerprofessional.de Internet Source	<1%
36	www.igi-global.com Internet Source	<1%

37	Luca Scremin, Fabiano Armellini, Alessandro Brun, Laurence Solar-Pelletier, Catherine Beaudry. "chapter 12 Towards a Framework for Assessing the Maturity of Manufacturing Companies in Industry 4.0 Adoption", IGI Global, 2018 Publication	<1%
38	Norman Gwangwava. "chapter 11 Open Product Lifecycle Management (PLM) for Cloud Manufacturing and Cloud-Based Maintenance Integration Using XML", IGI Global, 2018 Publication	<1%
39	insubriaspace.cineca.it Internet Source	<1%
40	Elias G. Carayannis, Manlio Del Giudice, Pedro Soto-Acosta. "Disruptive technological change within knowledge-driven economies: The future of the Internet of Things (IoT)", Technological Forecasting and Social Change, 2018 Publication	<1%
41	Niall P. Dunphy, John E. Morrissey. "chapter 11 Optimization of Construction Supply Chains for Greenhouse Gas Reduction", IGI Global, 2015 Publication	<1%
42	www.coursehero.com Internet Source	<1%

43	www.ijcaonline.org Internet Source	<1%
44	Submitted to University of Technology, Sydney Student Paper	<1%
45	Submitted to Southern New Hampshire University - Continuing Education Student Paper	<1%
46	Submitted to Napier University Student Paper	<1%
47	Submitted to Liverpool John Moores University Student Paper	<1%
48	Aparna Saisree Thuluva, Arne Bröring, Ganindu P. Medagoda, Hettige Don, Darko Anicic, Jan Seeger. "Recipes for IoT applications", Proceedings of the Seventh International Conference on the Internet of Things - IoT '17, 2017 Publication	<1%
49	Pallavi Nehete, Dhanshri Jangam, Nandini Barne, Prajakta Bhoite, Shalaka Jadhav. "Garbage Management using Internet of Things", 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2018 Publication	<1%

50	www2.griffith.edu.au Internet Source	<1%
51	"Future Network Systems and Security", Springer Nature, 2017 Publication	<1%
52	ijsetr.org Internet Source	<1%
53	dspace.bracu.ac.bd Internet Source	<1%
54	timreview.ca Internet Source	<1%
55	borneobulletin.com.bn Internet Source	<1%
56	leafsaversfoundation.wordpress.com Internet Source	<1%
57	Florian Hofer. "Architecture, technologies and challenges for cyber-physical systems in industry 4.0", Proceedings of the 12th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement - ESEM '18, 2018 Publication	<1%
58	Submitted to University of Newcastle Student Paper	<1%

59	www.oalib.com Internet Source	<1%
60	Submitted to Brandenburgische Technische Universität Cottbus Student Paper	<1%
61	Hans Georg Gemünden. "Best papers from IRNOP IX in Berlin", International Journal of Project Management, 2010 Publication	<1%
62	Submitted to Coventry University Student Paper	<1%
63	dblp.dagstuhl.de Internet Source	<1%
64	Submitted to Kingston University Student Paper	<1%
65	Submitted to Columbia College of Missouri Student Paper	<1%
66	Submitted to KTH - The Royal Institute of Technology Student Paper	<1%
67	Submitted to Kaplan International Colleges Student Paper	<1%
68	dblp.uni-trier.de Internet Source	<1%

69	Submitted to University of Maryland, University College Student Paper	<1%
70	www.citeulike.org Internet Source	<1%
71	Lecture Notes in Computer Science, 2012. Publication	<1%
72	aaltodoc.aalto.fi Internet Source	<1%
73	Leonardo Barreto Campos, Carlos Eduardo Cugnasca, Andre Riyuiti Hirakawa, Jose Sidnei C. Martini. "Towards an IoT-based system for Smart City", 2016 IEEE International Symposium on Consumer Electronics (ISCE), 2016 Publication	<1%
74	tel.archives-ouvertes.fr Internet Source	<1%
75	Submitted to De Montfort University Student Paper	<1%
76	bdjobmarket.com Internet Source	<1%
77	dspace.lboro.ac.uk Internet Source	<1%

78	digital.library.unt.edu Internet Source	<1%
79	Jaehyeon Ju, Mi-Seon Kim, Jae-Hyeon Ahn. "Prototyping Business Models for IoT Service", Procedia Computer Science, 2016 Publication	<1%
80	www.jove.com Internet Source	<1%
81	Submitted to University of Wales Institute, Cardiff Student Paper	<1%
82	Submitted to Vaasan yliopisto Student Paper	<1%
83	hal.grenoble-em.com Internet Source	<1%
84	Chan, Hubert C. Y.. "Internet of Things Business Models", Journal of Service Science and Management, 2015. Publication	<1%
85	Submitted to Michigan State University Student Paper	<1%
86	jyx.jyu.fi Internet Source	<1%
87	Submitted to University of Surrey Student Paper	<1%

88	Mohallem, S.V.. "Decreased fertility in mice exposed to environmental air pollution in the city of Sao Paulo", Environmental Research, 200506 Publication	<1%
89	Sachin Babar. "Proposed Security Model and Threat Taxonomy for the Internet of Things (IoT)", Communications in Computer and Information Science, 2010 Publication	<1%
90	Markus Weinberger, Dominik Bilgeri, Elgar Fleisch. "IoT business models in an industrial context", at - Automatisierungstechnik, 2016 Publication	<1%
91	openaccess.city.ac.uk Internet Source	<1%
92	Hyong S. Kim, Ke Wang. "Immutability Measure for Different Blockchain Structures", 2018 IEEE 39th Sarnoff Symposium, 2018 Publication	<1%
93	www.51due.net Internet Source	<1%
94	Submitted to Queensland University of Technology Student Paper	<1%
95	ijsab.com Internet Source	<1%

96	aosc.umd.edu Internet Source	<1%
97	Submitted to Cardiff University Student Paper	<1%
98	ore.exeter.ac.uk Internet Source	<1%
99	depositonce.tu-berlin.de Internet Source	<1%
100	myassignmenthelp.com Internet Source	<1%
101	cyberleninka.org Internet Source	<1%
102	trade.ec.europa.eu Internet Source	<1%
103	Submitted to Arizona State University Student Paper	<1%
104	www.domoritz.de Internet Source	<1%
105	Submitted to Lindenwood University Student Paper	<1%
106	www.m2p2.fr Internet Source	<1%
107	Yu Liu, Kahin Akram Hassan, Magnus Karlsson,	

	Ola Weister, Shaofang Gong. "Active Plant Wall for Green Indoor Climate Based on Cloud and Internet of Things", IEEE Access, 2018 Publication	<1%
108	Submitted to Varsity College Student Paper	<1%
109	Submitted to University of Warwick Student Paper	<1%
110	suppliers.jimtrade.com Internet Source	<1%
111	www.0086cctv.com Internet Source	<1%
112	arxiv.org Internet Source	<1%
113	Submitted to University of Melbourne Student Paper	<1%
114	www.nbmconference.eu Internet Source	<1%
115	trepo.tuni.fi Internet Source	<1%
116	Submitted to Brisbane Grammar School Student Paper	<1%
117	www.lib.ncsu.edu Internet Source	<1%

118	Linmei Nie. "Impacts of climate change on urban drainage systems - a case study in Fredrikstad, Norway", Urban Water Journal, 2009 Publication	<1%
119	IFIP Advances in Information and Communication Technology, 2015. Publication	<1%
120	"Internet Science", Springer Science and Business Media LLC, 2016 Publication	<1%
121	Submitted to Victoria University Student Paper	<1%
122	Submitted to Universiti Teknologi MARA Student Paper	<1%
123	Submitted to University of Lancaster Student Paper	<1%
124	Submitted to BRAC University Student Paper	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		