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Smart Protection System for Outdoor Children (SPSOC)

Khaled Al-Hamedi
College of Engineering & Petroleum, Hadhramout University, Mukalla, Hadramaout, Yemen
eng.khaled.alhamedi@gmail.com

Lujain Bamatraf
College of Engineering & Petroleum, Hadhramout University, Mukalla, Hadramaout, Yemen
lojemohammad12@gmail.com

Noof Jaber
College of Engineering & Petroleum, Hadhramout University, Mukalla, Hadramaout, Yemen
nooofty1998@gmail.com

Hala Al-madhi
College of Engineering & Petroleum, Hadhramout University, Mukalla, Hadramaout, Yemen
hala77411@gmail.com

Rasha Bin-Thalab
College of Engineering & Petroleum, Hadhramout University, Mukalla, Hadramaout, Yemen
r.binthalab@hu.edu.ye

ABSTRACT

Many children nowadays face dangers while they are outside their homes. This danger is growing in countries where a civil war is taking place, such as Yemen right now. Parents, on the other hand, want their children to be safe on their way to and from school or any other place. As a result, this paper addresses this issue in order to assist parents in paying attention to their children. The goal of this paper is to create a Smart protection system for outdoor children (SPSOC) to protect children from kidnapping, fire, or even getting lost. Parent sends a text message with keywords such as "LOCATION" using a Global System for Mobile (GSM) technique. The Global Positioning system (GPS) chip is used to determine the location, and the smart device will respond with a text containing the child's real-time accurate location, which, when tapped, will provide directions to the child's location on Google Maps. We also used a gas sensor, which detects if there is a fire, a gas leak, or any odor that is harmful to the child. The child can also use the system to send his location if he feels threatened. The device when conducted showed promised results.

Index Terms – Child Protection System, Internet of Things (IoT), Requirements Model.

1. INTRODUCTION

Infants and children require special attention from their parents both inside and outside the home. This includes things like providing care, guidance, and protection. At home, parents usually look after their children as well as their siblings. Outside the home, a parent usually accompanies their child, but this becomes harder as the child grows older and approaches pre-school or kindergarten age; since young children can easily become lost or be targeted for kidnapping by criminals. When children are away from home - for example, going to school or out with friends - parents can worry about their safety.

The matter is getting more dangerous in countries that suffer from the absence of law and security services in a state of permanent surveillance. Yemeni children are suffering terribly in the crisis [1]. Children in Yemen paid this prices UNICEF Executive Director Henrietta Fore has said “Whenever the conflict in Yemen flares and violence escalates, children are the ones who pay the heaviest price,” [2]. A system or tool is required to make it easier for parents to monitor their children's whereabouts. This system should be simple to use and light enough that a child aged 5 to 9 years old can use it without assistance, and it should be portable enough to accompany the child wherever he or she goes. On the other hand, technology has advanced very quickly in recent years. This means that new tools and techniques can be used to develop better and more efficient systems. This can help us to solve a lot of problems, like creating a child protection and tracking system.

Due to the fact that the number of tracking devices used to locate children in our country, Yemen, is low and prohibitively expensive in relation to the average household's income, this paper intends to construct a simple system out of inexpensive components. The system assists parents in paying attention to and monitoring their children while they are outside. The system employs Global Positioning System/ Global System for Mobile Communication (GPS/GSM) modules, which are technologies that aid in the location of a child, as well as a microcontroller, which aids in their activity and location.

The purpose of this paper is to describe the development of a protection system, called Smart Protection System for Outdoor Children (SPSOC) that is designed to protect children from online harm. The objectives of the paper can be summarized below"

1) Create a requirement model using the Unified Modeling Language (UML) for the SPSOC.
2) Develop a system for the proposed requirement model that has the following tasks:
    a) Locate the child using a GPS module at any time.
    b) Measure the level of pollution in the air using an MQ135 sensor.
    c) Alert parents if something goes wrong with the child using a GSM module.

Next sections of the paper explain how the system works and how it could be implemented. Section 2 of the paper explains the different parts and elements used to build the system. Section 3 looks into other related researches that has been done before. Section 4 outlines the methodology used by the researchers to get the results they wanted to achieve. Section 5 describes how the system's needs are met. Section 6 explains how the system is put into practice. Section 7 contains the results of the researchers' work and their thoughts on it. Finally, Section 8 summarizes the paper's findings and suggests possible future studies.

2. BACKGROUND

In this section, the tools that are needed to construct the proposed system are discussed. These tools are described in more detail, including what they do and how they work.

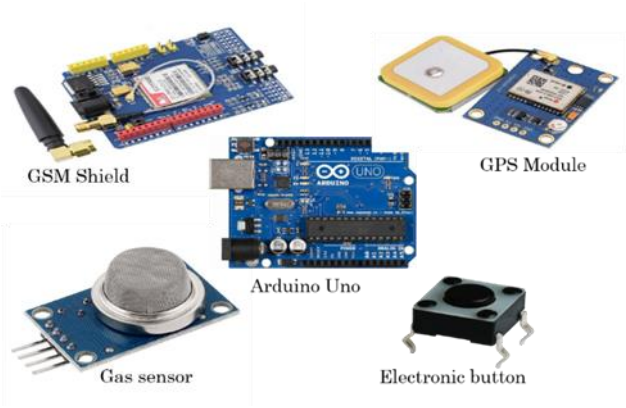

Figure 1 SPSOC Components

Figure 1 displays the main components used to construct the proposed system. These components include an Arduino Uno, a GSM Shield, and a GPS module. Each component is unique in the way it supports and contributes to the overall functioning of the proposed system.

2.1. Hardware Components

Arduino Uno: It is an open-source electronic board created by Arduino.cc [3]. It has digital and analog input and output pins, which allow it to be connected to other circuits and expansion boards (called shields) [4]. It has 14 digital input/output pins, 6 analog input/output pins and can be programmed using a type B USB cable and the Arduino IDE software. It is compatible with voltage between 7 and 20 volts, but can be powered with a 9-volt battery or a USB cable.

2.2. GSM Shield

GSM Shield [5] is a piece of hardware designed to allow an Arduino board to connect to the internet using the GPRS (General Packet Radio System) wireless network. To use the GSM Shield you need to physically attach it to an Arduino board, then insert

a SIM card from a provider that is capable of using GPRS. Finally, you need to follow the given instructions to start controlling devices over the internet.

2.3. GPS

GPS is a system that uses a trilateration method to calculate the exact location of a specific point on the planet [6]. This means that a GPS receiver [7], which is a device containing a small processor and an antenna, can use signals from satellites to determine how far away it is from them. Trilateration is a process that is similar to triangulation which involves measuring angles. When the antenna detects signals from four or more satellites, it receives information from them, such as the time and data, which it then uses to determine its position and time with a high degree of accuracy.

2.4. Gas sensor

Gas sensors are devices that are used to detect the presence of certain gases or vapors, such as those emitted from volatile organic compounds or odors, as well as humidity. In this paper, we are looking at a specific type of gas sensor called MQ135 sensor [8] [9].

2.5. Toggle switch

A toggle switch is an electrical component that can be used to turn a machine on or off. They can be found in many different types of electrical applications, and they also go by other names such as joystick switches or toggle power switches.

2.6. Software tools

We used Proteus and Arduino IDE to write and simulate code. Arduino IDE [10] is an open-source software platform used for programming and creating small-scale interactive electronic devices. The Arduino IDE is a program that lets you write code in different programming languages. It converts the code into a file composed of hexadecimal numbers that can be loaded into an Arduino board, which is a small computer. This program was released on September 2022 and is available on Windows, Mac, and Linux [11]. Proteus [12] is a computer program used by electrical and mechanical engineers. It allows users to create schematic diagrams and blueprints which are needed in the production of printed circuits. It was created by Lab center Electronics and also includes a 2D CAD drawing feature [13].

3. RELATED WORK

This section is about prior projects that have been done on the protection system by giving a summary of what other studies have been done and what knowledge experts in the field have gained from these studies.

Several approaches were developed to utilize Internet of Things (IoT) [14] techniques in order to solve the child protection problem. IoT is a type of technology that is used to collect data from connected objects, such as sensors and devices. IoT is a term used to describe objects that are connected to the internet and have the capability to interact and exchange data. This means people and organizations can communicate with each other remotely, and complex tasks that involve data and decision-making can be automated. The IoT has progressed a lot, and it's now being used in organizations to better manage their business processes [15].

The authors in [16] proposed a system utilizing the Raspberry Pi 3 computer to create a child safety wearable device. Three separate sensors-- a 'pi camera', a 'pulse sensor', and a 'sound sensor'-- gather various types of data which is then transmitted to the parents' smartphones via an intermediary device called a GSM shield. This collected data includes images and the child's current GPS location. In the study by the authors in [17], they created a wearable smartwatch designed to help increase the security of women. The smartwatch is equipped with a sensor that detects the heartbeat of the user. If the user is suddenly attacked, their heartbeat will increase rapidly, triggering the alarm sound on the watch. Once the alarm sound has been activated, the watch will automatically make calls to a few contacts registered on the watch, as well as the closest police station. This way, the police can get to the right place quickly, thanks to the GPS location of the smartwatch. SWay [18] is a project created in the Hackerster.io community to tackle the issue of child protection. It can be used to track a child's location through GPS and immediately let their parents know via email if they wander off the path they were given by their parents. This means parents can feel more secure knowing that their child has arrived safely at school and home, as well as if they are running late.

From another side, there several smart devices are built to help human to keep track his healthy status. Smart devices are digital tools that are designed to make activities such as location tracking, calling and messaging easier. Smart watch companies have developed special smart devices to increase the protection of children. One example is a kid's smartwatch from Gator Group Co [19]. It comes with a SIM card and there is a free app available for both Android and Apple devices. This device allows up to 13 different numbers to be called and allows for two-way voice messages between the app and watch. It also uses GPS tracking to locate the child when they are outdoors and Wi-Fi tracking when indoors and can alert parents if the child leaves a designated area

(geofences). Additionally, a pedometer sensor is included so that healthy activity can be tracked, and an SOS alarm can be triggered which calls 3 emergency contacts if pressed for 3 seconds.

A recent proposed system was created for Malaysian children [20] and uses a smart band with Internet of Things (IoT) technology. The purpose of the band is to track the location of the child, as well as collect data such as temperature, pulse, and respiratory rate. The collected data is compared to certain standards and if the child is in an unusual location or if any abnormal conditions are detected, the device will send out notifications. The authors created a prototype of a wearable device that a child can wear. The device has a button that can be pressed in an emergency situation. When the button is pressed, an alarm will go off and video recording will start. The video recording, along with an emergency alert, will be sent to the parent's mobile app which can be used to monitor the child's condition from any location.

However, the price of these devices is too high for people in developing nations like Yemen, where the average annual income is low. As a result, we proposed SPSOC. The proposed device is being designed to be more accessible to a wide range of people by providing a prototype with one sensor to detect fire or gas leaks and a button that can be pressed by a child in case of emergency. The device also has a GPS module so that the parents will be able to track the location of their child, and they can send messages to verify the location at all times.

4. PORPOSED MODELLING

The methodology is a process of steps or actions that the researchers took in order to complete their study. These steps can help them decide which methods would be best to use in order to answer any questions they are trying to answer. This could involve collecting information from existing sources, like journals, papers, books, reports, or documents, and then analyzing this data to form conclusions. This step is important because it allows readers to evaluate the accuracy and reliability of the research.

To achieve the project's objectives, the steps in this project are guided by the software development life cycle SDLC. The software development life cycle (SDLC) is a framework used by systems engineers and developers to guide their projects [21]. It's made up of several steps which are followed in a specific order and within a set time frame and budget. This process helps software developers produce high-quality systems that meet the needs of their customers. It also helps in connecting more than one traditional system from different software vendors. The steps within the SDLC are shown in Figure 2 from a certain source [22]..

The first step involves clearly defining the problem that the researcher is trying to solve, what their goals are, and the scope of their study. The second step is for the researcher to look through existing sources such as journals, papers, books, reports, and documents in order to collect any relevant data or information that has already been published on that topic. This process is known as a literature survey and it provides an overview of what has already been done in that field. The researchers interviewed people involved in the process of the proposed system in order to get information about the generic requirements for it. This step included looking at the feasibility of the proposed system by evaluating things like how much it would cost and how long it would take to build. They also studied the operation of the system to make sure that it would meet the needs of those using it.

In the design phase of a research project, diagrams are used to show how the components of the system are connected to each other. UML diagrams are used to illustrate the functions and how the project should work. The researchers used Proteus software to create a simulation of the components they were using. They then took the code that was created and uploaded it onto the Arduino, a type of computer hardware, so they could interact it with its connections and use it to track the children Testing is used to check whether the system does what it should correctly and to identify and fix any system problems before actually using it. Testing is performed by developers and users of the system. More information about this step is explained in section 7. Evolution is the process of changing a software system over time. This change is usually triggered by changes in the environment that the software system is operating in. These changes can come in the form of new business requirements, reports of bugs in the system, or changes to the other systems that the software interacts with. As these changes happen, the software needs to be adjusted to keep up with the new environment it is operating in.

SDLC models or methodologies are approaches to managing the various steps involved in software development. Examples of SDLC approaches or models include waterfall (where each step follows from the last one in sequence), spiral (which take a cyclic approach to software development), Agile software development (which relies on continual review & revision of the software), rapid prototyping (which develops a working model quickly in order to test out ideas), incremental (which involves adding additional components to the software over time) and synchronize and stabilize (which involves ensuring the components work together and are stable). [23]

Agile [24] is a popular method of software development that helps companies predict what may happen during the development process. This paper specifically used Agile Scrum [25], an approach that is designed to both give structure to teams and also assign specific roles and timelines for each delivery cycle. By doing this, companies are often able to get the job done faster, lower their

costs, and produce higher quality work. Finally, Agile Scrum is a flexible and open approach that helps to reduce inefficiencies during the project process.

Scrum is a work methodology that is used to organize tasks and efficiently complete projects. It is divided into three phases. The first phase is outlining the project goals and objectives. This helps to define the main purpose and objectives of the task or project. It also helps to create a plan of how to achieve those goals and objectives. Sprint cycles are short, focused times of development where a part of the project is created in order to complete the project as a whole. At the end of the project, there will be a project closure phase where any leftover documents like user manuals or help frames are finalized and the entire project is evaluated to discover what can be improved next time [22]. For current proposed system, we are going to divide the implementation of each component into its own part. This part (or component) will be worked on and tested, to make sure it functions properly, in one sprint. A sprint is an allotted amount of time for a task or project to be completed.

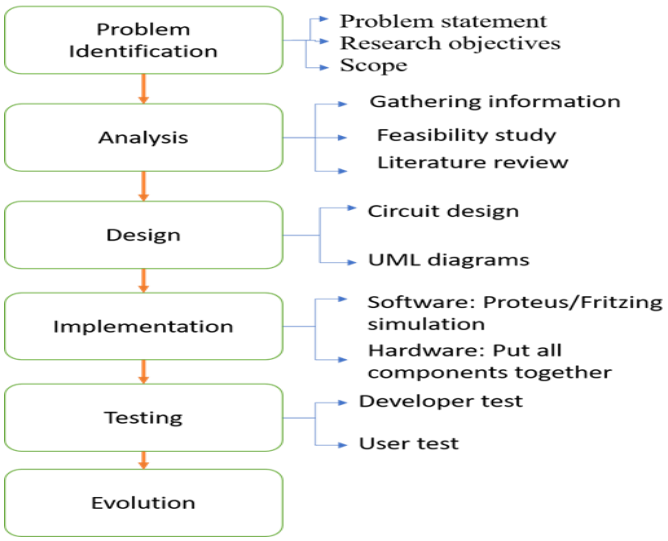

Figure 2 Software Development Life Cycle (SDLC)

5. REQUIREMENT MODEL

To explain the proposed system, we created a flowchart and UML diagrams to provide an outline for the potential solution. We then used simulation software to build a virtual electronic circuit that could follow the instructions outlined in the diagrams. Following subsections discusses each step in- detail.

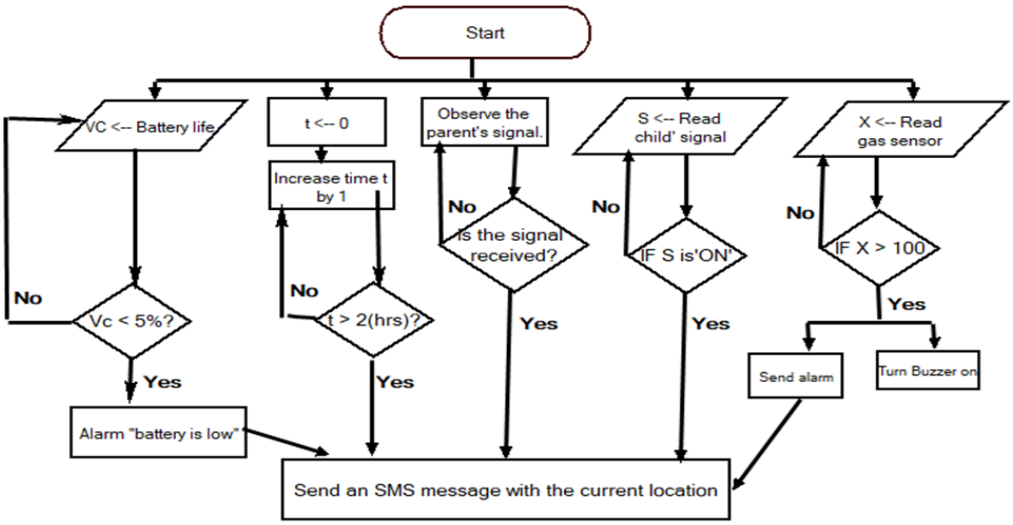

Figure 3 SPSOC Flowchart

5.1. Flowchart

Figure 3 shows how the system works through a series of steps. It shows how the location will be sent to the parents, how harmful gases will be detected and an alert can be sent, and how the parents will be notified when the battery is running low.

5.2. Block Diagram

A block diagram [26] is a visual representation of a system's components and their connections. It is commonly used in engineering to quickly identify and understand where the main parts of a system are located. Figure 4 is a block diagram of SPSOC, which shows an Arduino in the middle and arrows indicating data is being sent between the Arduino and the components on either side.

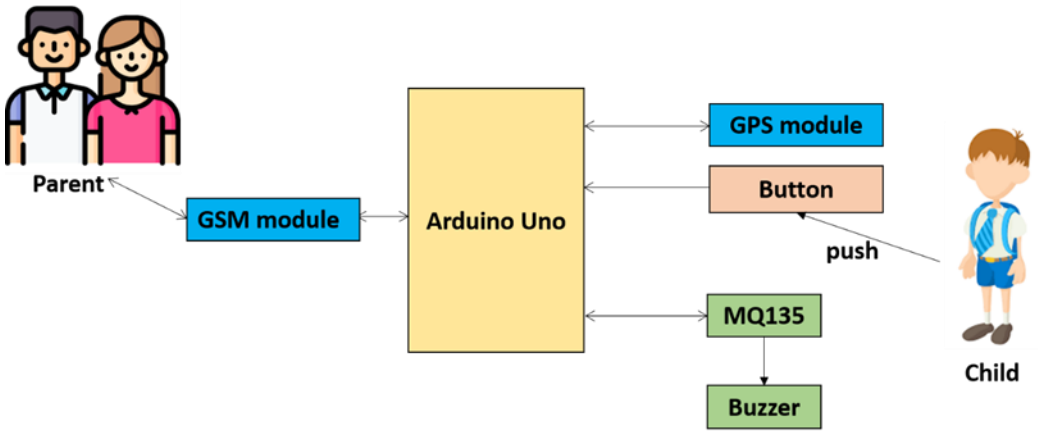

Figure 4 SPSOC Block Diagram

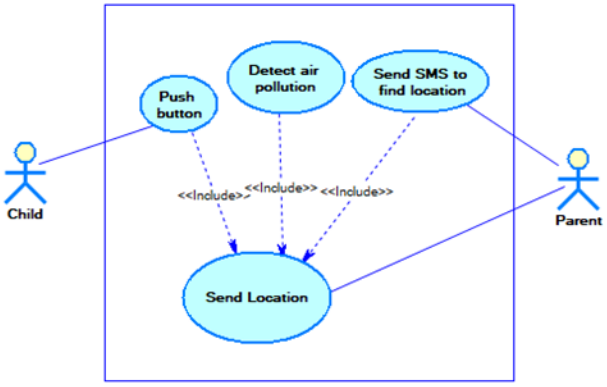

Figure 5 SPSOC Use Cases

5.3. Use Case

A use case [27] is a way of organizing the tasks people might complete when working with a system. It involves looking at all the different ways someone might interact with the system and the different combinations of tasks they might complete to reach a specific goal. Figure 5 shows a set of use cases for SPSOC and how they interact with two "actors" or people involved- a parent and a child.

5.4. Sequence Diagram

Sequence Diagrams [27] are interaction diagrams that describe the steps taken to complete an operation. They depict how objects interact within the framework of a collaboration. Sequence Diagrams are time-focused, and they visually represent the order of the interaction by using the vertical axis of the diagram to represent time, what messages are sent, and when. We show two sequence diagrams for air pollution detection and push button processes in this subsection. Figure 6 shows a sequence diagram for air pollution detection process. The gas sensor constantly reads the levels of gas in the surrounding environment. The obtained data is sent to the Arduino, a type of microcontroller, for comparison. The Arduino only takes action if the gas detected is higher than a

predefined threshold. In that case, a request is made to a GPS module, a tracker that uses satellite signals to determine the precise location of something or someone. This location is then sent to the parent of the child as an SMS message through a GSM module, which is a device used to permit communication via text messages. Similar to Figure 6, Figure 7 depicts the exchange that occurs when a child presses the emergency button to call his parents.

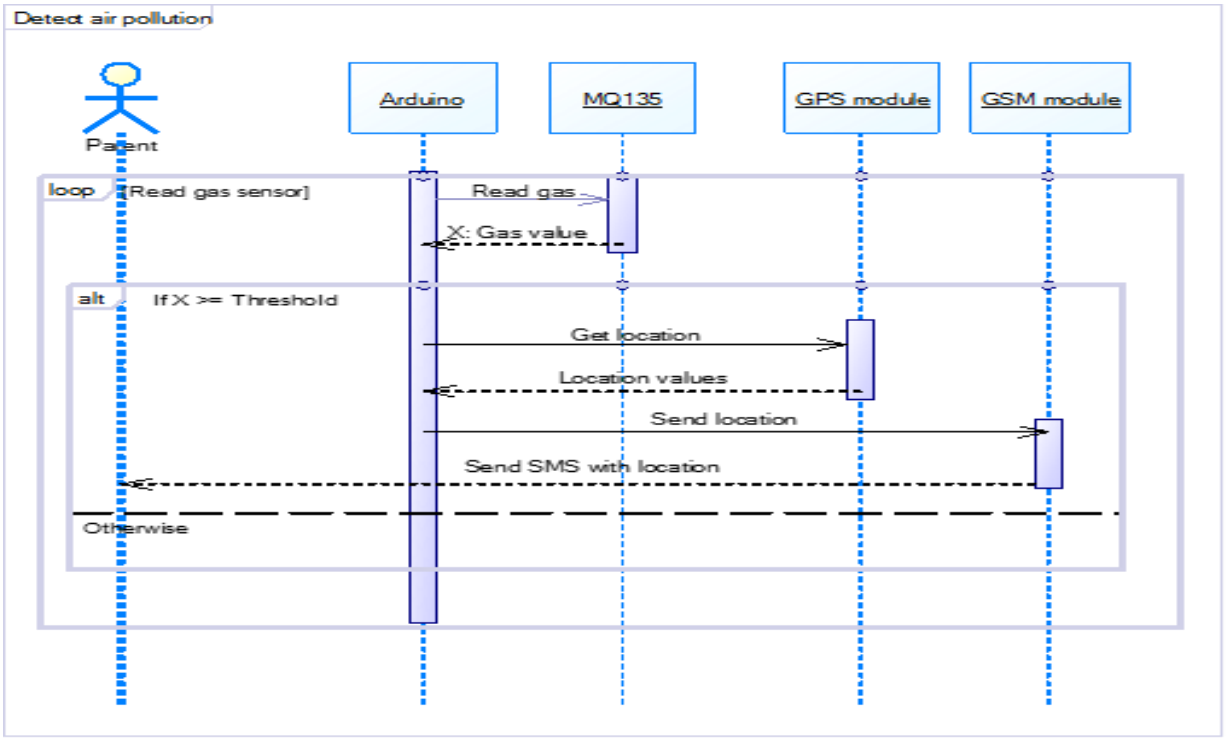

Figure 6 Sequence Diagram for Detect Air Pollution Case

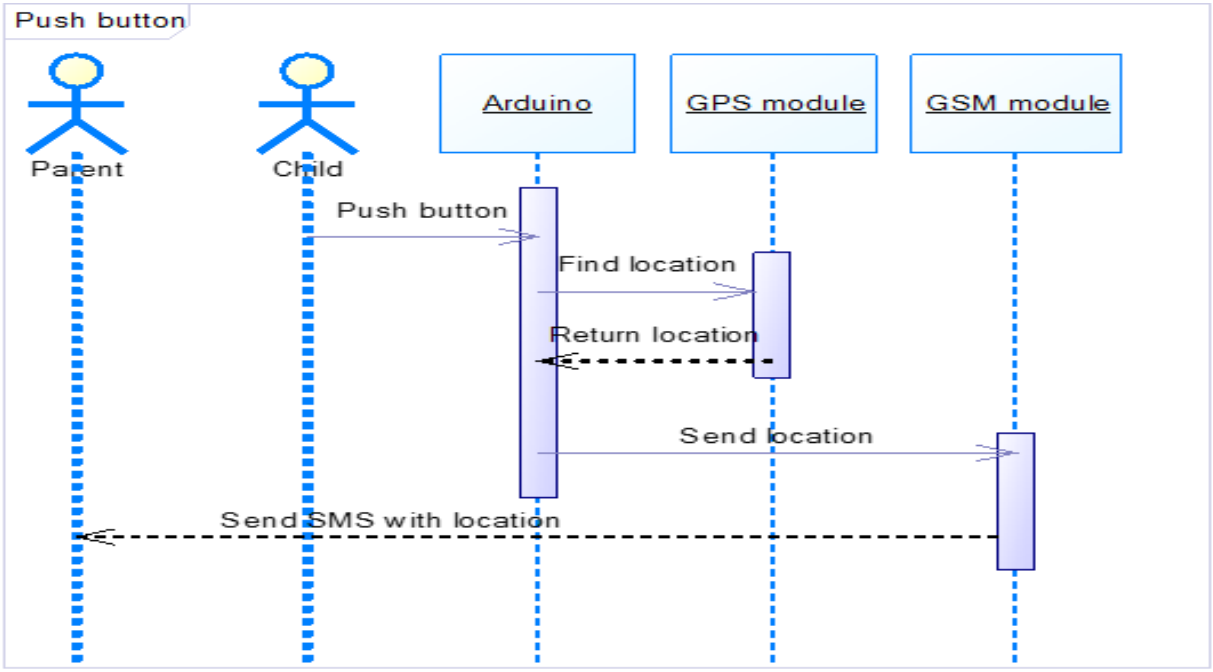

Figure 7 Sequence Diagram for Pushbutton Use Case Experiments

6. EXPERIMENTS

This section provides an overview of the experiments conducted to evaluate the suggested system. First, we'll go over the setup environment, which includes installing project components with a microcontroller. The project components are then tested to ensure their functionality.

6.1. Setup

GPS is a system used to pinpoint exact locations on earth. It uses satellites and data to measure the latitude and longitude of any place, as well as the exact time according to a global standard called UTC. In SPSOC system, the GPS module is being connected to an Arduino board as part of the installation process. The GPS Module is connected to Arduino's 5V pin and RX/TX pins 10 and 11, respectively. The GSM Module also requires a connection to the Arduino's 5V pin and RX/TX pins 10 and 11, respectively. They both also need the GND pin attached to them. This is indicated in Figure 8 (a) and (b).

The M135 sensor measures the amount of pollution in the air and needs to be connected to an Arduino in order for it to get readings. Figure 8 (c) shows us how the connection between the two should be made. The VCC pin of the sensor needs to be connected to the Arduino's 5V power supply, the GND pin of the sensor needs to be connected to the Arduino's ground, and the analog pin of the sensor, labeled AO, needs to be connected to the Arduino's analog pin A3.

The buzzer is used to alert children and their parents to the spread of gas or low oxygen levels in the air. The connection between the buzzer and the Arduino consists of three steps: connecting the buzzer's VCC (voltage constant current) pin to the Arduino's 5V supply (electricity), connecting the buzzer's GND (ground) to the Arduino's GND (ground), and connecting a resistor (a small component that resists electric current) to pin 2 on the Arduino to adjust the sound the buzzer makes. This is illustrated in Figure 8 (d).

This pushbutton works as an "SOS signal" so that the child can push a button and ask for help in an emergency. Figure 8 (e) shows a schematic drawing of the pushbutton being connected to the Arduino. To do this, the VCC connection on the pushbutton needs to be connected to the 5V port on the Arduino, the GND of the pushbutton connected to the GND of the Arduino, and the remaining end of the pushbutton connected to pin 2. Finally, Figure 9 shows what the whole system looks like once all the components have been connected together.

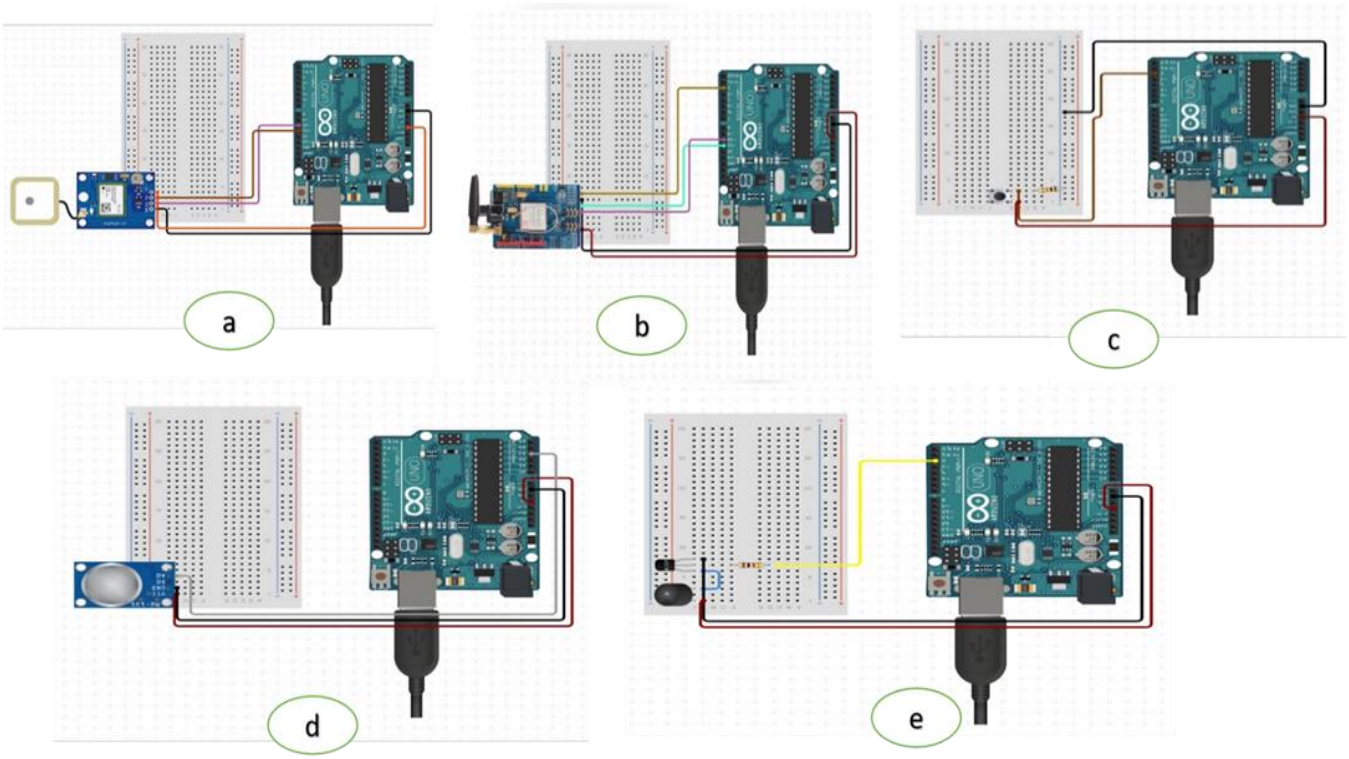

Figure 8: SPSOC Components ‘Connection (a) GPS (b) GMS (c) MQ135 (d) Buzzer (e) Pushbutton

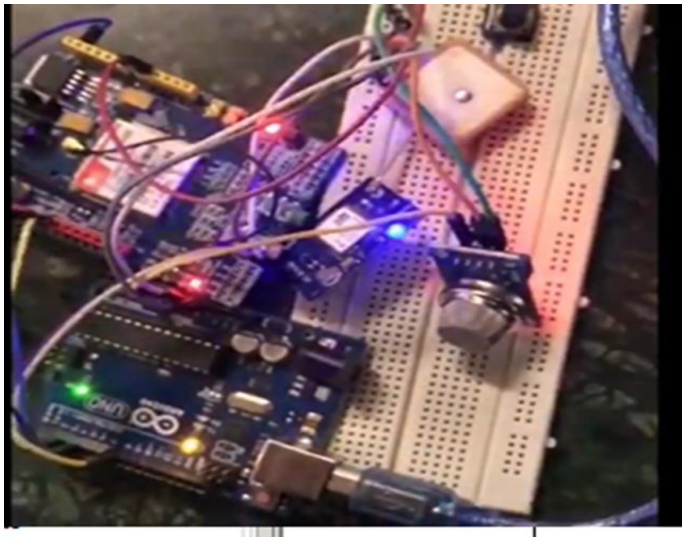

Figure 9 Put All Components Together

7. RESULTS AND DISCUSSION

Firstly, we make sure that all necessary connections are correctly established and the GSM shield is connected to the communication tower, which can be confirmed in Figure 10 (sim handshake). Secondly, there are some functions, such as requesting the child's current location, sending an SOS signal from the child and detecting gas leakage with a MQ135 sensor that will operate independently.

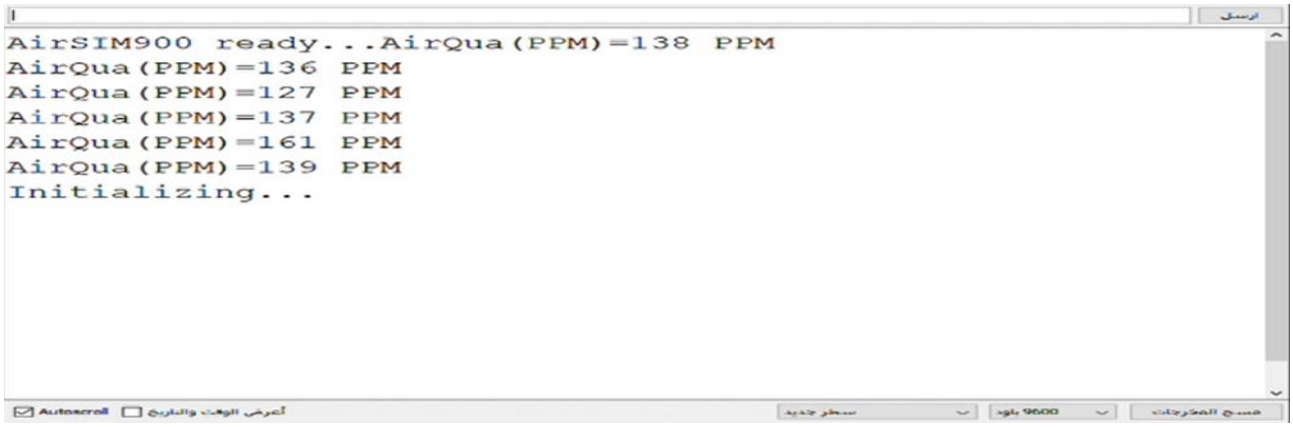

Figure 10 Send Handshake

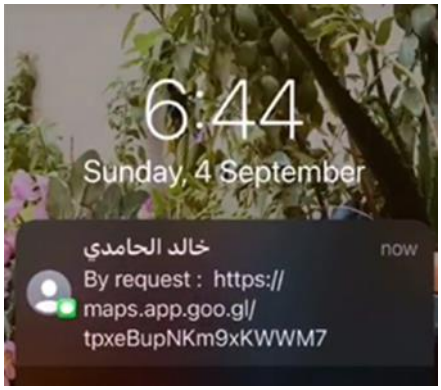

Figure 11 Mobile Message

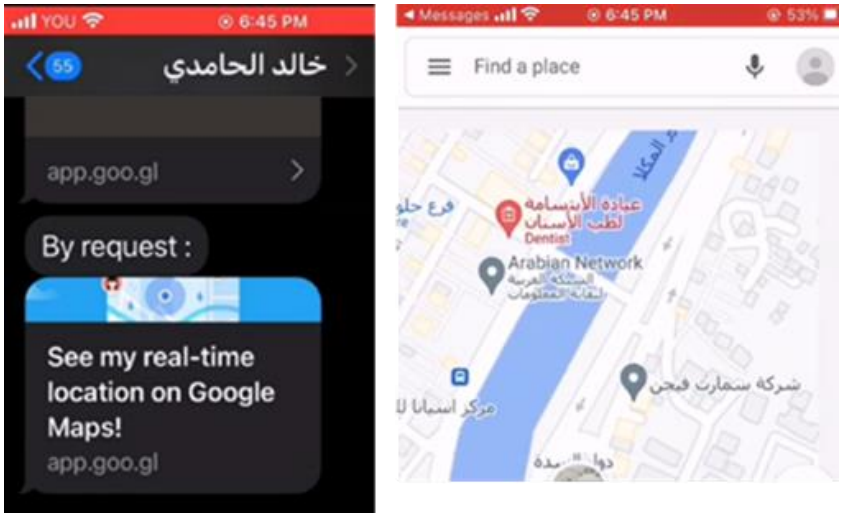

Figure 12 GSM-Sent Location is Automatically Opened by the Mobile Device's GPS Service

7.1. Request a Location

When a parent sends a request message for the child's current location, the system will check its database for the child's location and then send back a response with that information. Figures 11 and 12 show the system's reaction after receiving a request message for the child's location: the system will perform a "sim handshake". Figure 12 shows the message that will be displayed after the request location.

7.2. Air Pollution

If the level of pollution in an environment exceeds 110, a message SMS will be sent to alert parent that the pollution level has reached an unhealthy limit and they should take steps to protect their child. Figures 13 and 14 show the scenario.

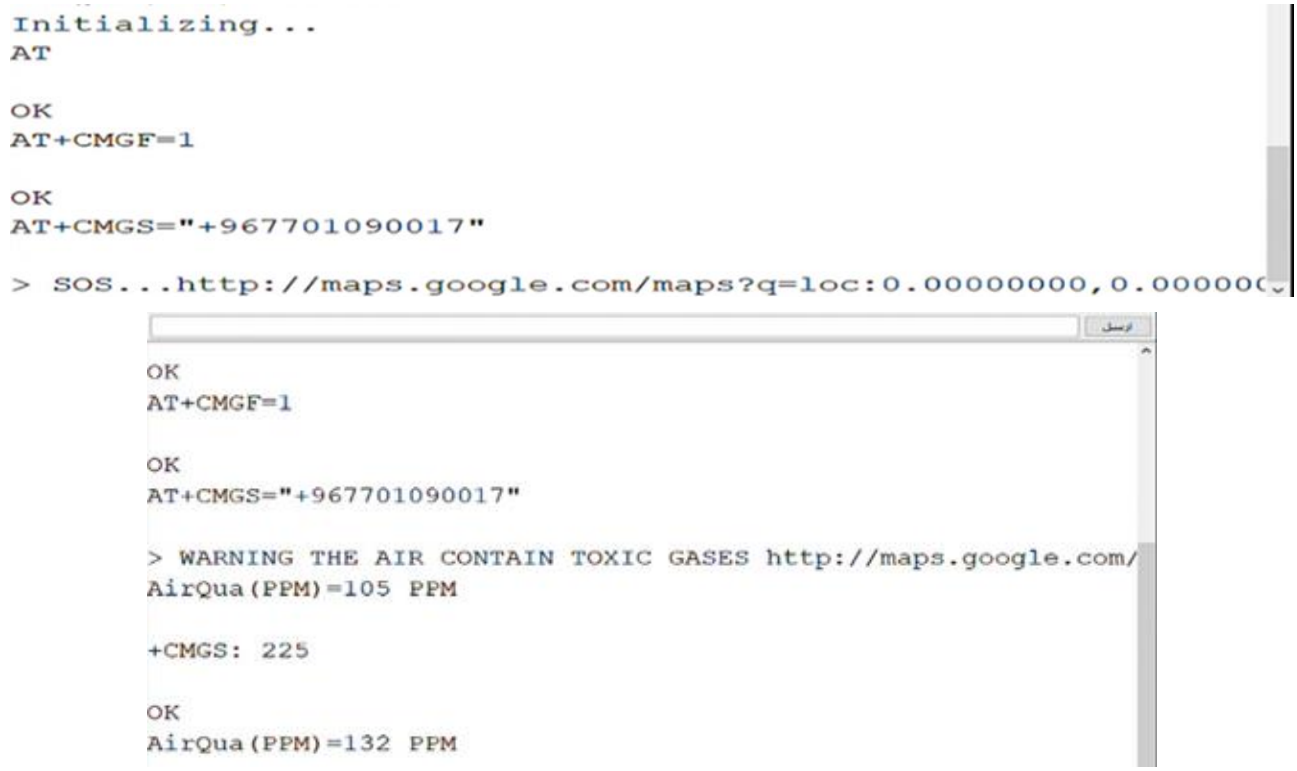

Figure 13 Air Pollution Exceeds the Threshold

Figure 14 Detection of Air Pollution and Location of the Child

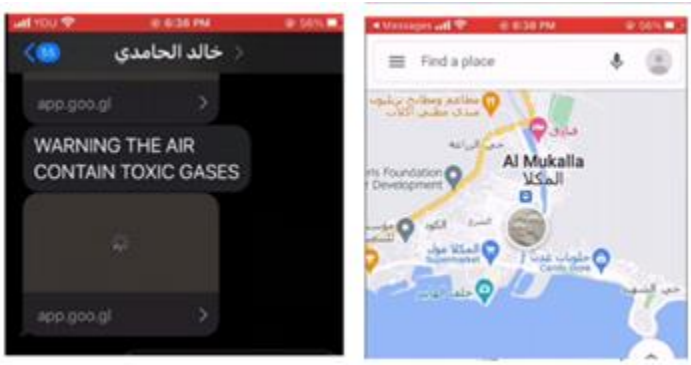

Figure 15 Result Message After the Child Sends an SOS Signal

7.3. Pushbutton

When a child pressed a button to ask their parent for help. Figure 15 shows the message results that send to the parent after the child requested assistance.

7.4. Discussion

The experiment results show that SPSOC (a system used to protect children) is capable of achieving its goals. This shows how important the system is, since both parents and children benefit from it. It allows parents to keep track of their children any time, any place, to quickly locate them if there is a threat, and to alert the parents if there is an issue like air pollution that could harm the child. This reduces the amount of crime that can affect children, and allows parents to have peace of mind knowing that their child is safe.

8. CONCLUSION

This paper describes the development of a Smart system for outdoor Child Protection with components including Arduino Uno, GSM shield, GPS module, MQ135, pushbutton, and buzzer - all working together to give real-time location and air pollution data in specific areas and times. This system was then tested in real-world conditions to find out how successful it was. The results of the evaluation were positive and showed that the system is both useful and easy to use.

In future work, we recommend to expand the system functionality by adding a mobile application and other sensors. This application would allow parent to see a map with a path that would show all of the places the child had visited. In addition, the system should be smaller and wearable. Sensors like a temperature sensor and BPM (beats per minute) can be added, to help detection any potential problems the child might be having.

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