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A Dissertation Report on

Vaccination Monitoring System

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Abstract

Vaccination is an essential component of modern public health programs and is among our most cost-effective medical interventions. Yet despite vaccines' clear effectiveness in reducing risks of diseases that previously attacked large proportions of the population, caused many deaths, and left many people with permanent disabilities, current vaccination policies are not without controversy. Vaccines, like all other pharmaceutical products, are not entirely risk-free and door to door vaccination program such as the famous pulse polio vaccination program may not be very effective if the vaccination is not maintained in proper environment. An efficient tracking system is also required for such vaccination program to ensure that all the people are able to avail the benefits of such vaccination program.

The idea of vaccine monitoring is applicable in under developed (Africa) and developing nations (like India) where the vaccines storage environment (temperature) tracking is a big problem. When the environment is not optimal(temperature is not within the expected range or there is too much of light exposure or any other factors which may deteriorate the quality of the vaccine), the efficacy of these vaccines is lost. All the health worker carries is a portable box with some cold pads (door to door polio vaccine campaign). Our connected maraca has to help ensure the safety and efficacy of the vaccines. While the traveling health workers go around, based on the vaccine type and recommended environment setting, sensor data will be sent to the cloud. Over the cloud using the received data, we can monitor the vaccine storage environment to ensure that it is stored properly under prescribed condition. Also, the data will help us determine if a health worker has not followed the best practices, and take actions accordingly. Also, using smartphones and cloud, health workers can be prevented to administer spoiled vaccine. This idea can be extended to efficient storage and handling of other environment-sensitive medicines as well.

I.INTRODUCTION

General Introduction

Vaccination is among the most significant public health success stories of all time. However, like any pharmaceutical product, no vaccine is completely safe or completely effective. While almost all known vaccine adverse events are minor and self-limited, some vaccines have been associated with very rare but serious health effects.

Public concerns about the safety of whole-cell pertussis vaccine in the 1980s resulted in decreased vaccine coverage and the return of epidemic disease in Japan, Sweden, United Kingdom, and several other countries. Around the same time in the United States, similar concerns led to increases both in the number of lawsuits against manufacturers and the price of vaccines, and to a decrease in the number of manufacturers willing to produce vaccines.

Through our toolkit monitoring system an location tracking functionality, We can ensure that the quality of the vaccine is the best and we can also see all the areas covered by the immunization worker to ensure that all the area on ground has been covered and everyone has been immunized.

Statement of the Problem

The idea is to develop a “VACCINATION MONITORING” kit which helps to ensure the safety and efficiency of the vaccines. The kit makes use of sensors to measure various parameters that may spoil the vaccine. These parameters include temperature and exposure to light. These Sensor data will be sent to the cloud for data analytics and use in smartphone. Kit also keeps track of health workers’ location to ensure that they have covered all the assigned areas. Smartphones and cloud are used to prevent the health workers from delivering spoiled vaccine.

Objectives of the project

Our product will help to ensure the safety and efficiency of the vaccines. While the traveling health workers go around, based on the vaccine type and recommended environment setting, sensor data will be sent to the cloud. This data will help us to determine if a health worker has not followed the best practices, and has covered all the assigned area .Also, using smart phones and cloud, health workers can be prevented from delivering spoiled vaccine. This idea can also be used for other sensitive medicines. Various components used to build the vaccine monitoring system include

- Raspberry Pi 2
- Temperature sensor (DS18B20)
- Light intensity sensor(BH1750FVI)
- Accelerometer (MPU6050)

Project deliverables

1. Installation of Raspberry Pi and running first program.(Done)

2. Connecting temperature sensor to the pi and retrieving temperature values.

3. Calibrating and interfacing accelerometer and developing a 3D animation of the orientation of the accelerometer.

4. Connecting light sensor to the Pi and obtaining the intensity of the light.

5. Combining the three sensor data and troubleshooting.

6. Sending the sensor data along with the coordinates of the location of the vaccination box to the cloud.

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7. Analysis of data obtained in the cloud.

8. Troubleshooting and delivery of first prototype.

We will provide a holistic, complete and simplified view of the original data so as to arrive at a meaningful conclusion.

Current Scope

With global vaccine coverage at 85 percent, it is easy to take for granted the supply systems that move temperature-sensitive vaccine products from manufacturing facilities to some of the world's most remote populations do not ensure the proper quality of vaccine due to storage problem in remote areas. For more than 30 years, ministries of health have maintained logistics systems that receive, store, transport, and refrigerate vaccines so that they are available where they are needed. These vaccine supply chains have not been perfect. In many countries, half of all vaccine doses are never administered and many more are wasted due to accidental freezing, heat exposure, expiry, and other mishaps.

Future Scope

The technology used in our product will help us ensure that optimal quality vaccine is delivered, transported, refrigerated, and tracked. The total volume of vaccines to be managed in many developing countries is expanding as much as five times as newer vaccines are introduced, with further increases expected when additional vaccines, such as those for malaria are introduced later in the decade. Our system may also be used in future to store some important medicines and the data obtained can be used by the researchers to design better vaccine storage systems.

II. PROJECT ORGANIZATION

Software Process Models

A software process model is an abstract representation of a process. It presents a description of a process. When we describe and discuss processes, we usually talk about the activities in these processes such as specifying a data model, designing a user interface, etc. and the ordering of these activities.

The spiral model combines the idea of iterative development with the systematic, controlled aspects of the waterfall model.

Spiral model is a combination of iterative development process model and sequential linear development model i.e. waterfall model with very high emphasis on risk analysis.

The spiral model has four phases. A software project repeatedly passes through these phases in iterations called Spirals.

Identification: This phase starts with gathering the business requirements in the baseline spiral. In the subsequent spirals as the product matures, identification of system requirements, subsystem requirements and unit requirements are all done in this phase.

This also includes understanding the system requirements by continuous communication between the customer and the system analyst. At the end of the spiral the product is deployed in the identified market.

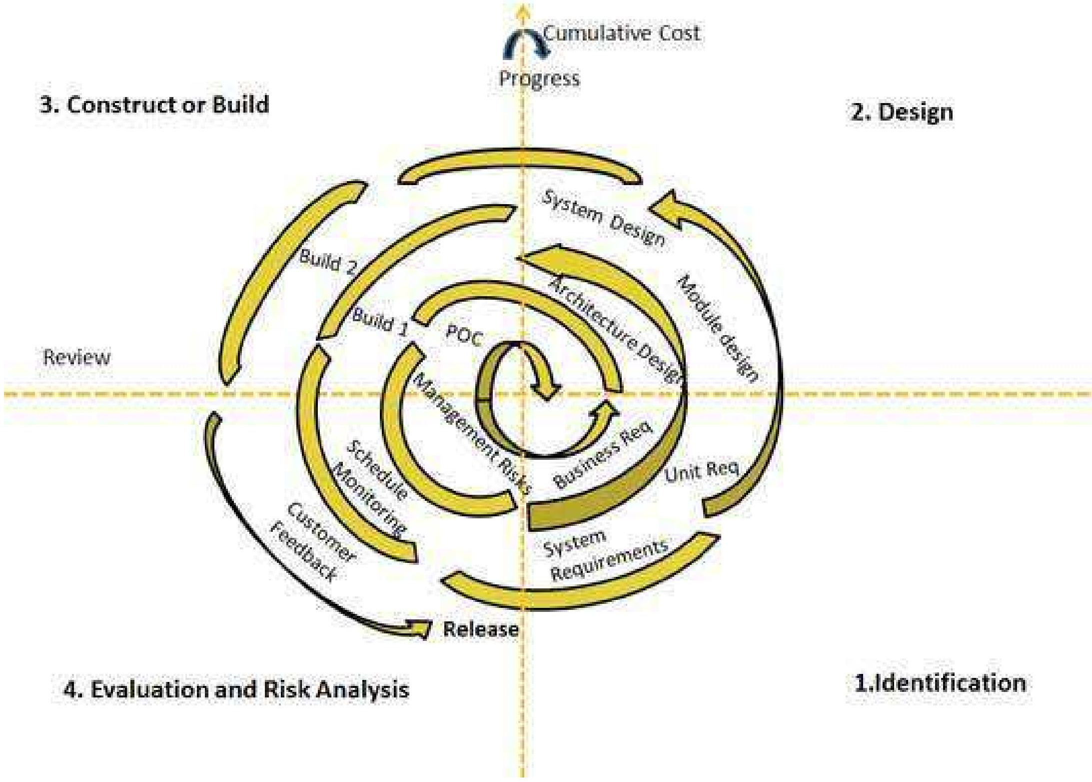
Design: Design phase starts with the conceptual design in the baseline spiral and involves architectural design, logical design of modules, physical product design and final design in the subsequent spirals

Construct or Build: Construct phase refers to production of the actual software product at every spiral. In the baseline spiral when the product is just thought of and the design is being developed a POC (Proof of Concept) is developed in this phase to get customer feedback.

Then in the subsequent spirals with higher clarity on requirements and design details a working model of the software called build is produced with a version number. These builds are sent to customer for feedback.

Evaluation and Risk Analysis: Risk Analysis includes identifying, estimating, and monitoring technical feasibility and management risks, such as schedule slippage and cost overrun. After testing the build, at the end of first iteration, the customer evaluates the software and provides feedback.

Following is a diagrammatic representation of spiral model listing the activities in each phase:



Based on the customer evaluation, software development process enters into the next iteration and subsequently follows the linear approach to implement the feedback suggested by the customer. The process of iterations along the spiral continues throughout the life of the software.

Roles and Responsibilities

Since the project requires multiple skill sets, each and every individual was assigned equal responsibility.

The project can be divided into the following five major responsibilities:

1. Data streaming and retrieving : To justice this area of the project the person must have clear understanding of cloud storage management.
2. Sensor usage: The person with intelligence decision would known about proper usage of sensor data in different scenarios.
3. Android Development: The person familiar with android platform had made an front end app development as interconnection between sensors and cloud storage.
4. Knowledge about Soc and Google APIs: The person must be comfortable in using System of computer i.e Raspberry pi and Google APIs to use them effectively in our tracking system .

5. Documentation: The person should be a proficient typist and must have extraordinary vocabulary and grammar skills.

All the members of the team should be co-operative, organized and well aware of the project goals, aspirations, deadlines and outcomes. Each and every individual has a key role in making the project a success.

III. LITERATURE SURVEY

Introduction

During a literature survey we collect some of information about the vaccination storage management system for city and rural areas across various countries, we found the following

Study 1: Hepatitis B (HB) vaccine delivery outside the cold chain: the Long-An county, China example. Global Perspectives on Hepatitis. International Task Force on Hepatitis B Immunization.

This study was performed in China and sponsored by China's Expanded Programme for Immunization (EPI). The study included a research component designed to explore mechanisms for integrating HB vaccine into the immunization schedule. In Long-An County, the majority of births (80.5%) occur at home and are attended by village midwives or 2 village doctors. In the program, vaccine administered by village midwives was delivered to the home of each midwife on a quarterly basis for storage at room temperature. The plasma-derived HB vaccine administered by the village doctors was maintained in cold storage until given to the infant within 72 hours after birth. The village doctors were notified of the births by the village midwives within 12 hours of delivery. The second and third doses of HB were given with other EPI vaccines as part of mobile outreach services.4 A sero-survey was performed to examine the seroconversion rate of HB antibody in babies who received a birth-dose vaccine stored at room temperature versus under refrigeration. The survey was performed after the infants had received the three doses of HB vaccine. The study group included 590 infants aged 10 to 20 months. Of the study group, 358 infants received their birth dose from vaccine stored at ambient temperatures and administered by a village midwife, and 232 infants received vaccine stored in refrigerators and administered by a village doctor. The seroconversion rate was 81.6% in the OCC group and 81.9% in the refrigeration group. Maternal HB surface antigen (HBsAg) rates were 15.4% and 20.7% respectively. There was no difference between HBsAg rates amongst vaccinated infants in the OCC and refrigeration groups (1.1% vs. 2.2%). All HBsAg positive infants were born to HBsAg positive mothers. The estimated protective efficacy of vaccination (the percent reduction in HBsAg attributable to vaccination amongst infants exposed to HB virus) was similar at 84.5% and 77.8%, respectively in the two groups.4,5 Preliminary findings in this study demonstrated that HB vaccine stored OCC for up to three months can remain effective and be delivered to infants at birth.

Study 2: Home delivery of heat–stable vaccines in Indonesia: outreach immunization with a prefilled, single-use injection device. Sutanto A, Suarnawa IM, Nelson CM, Stewart T, Soewarso I. Bulletin of the World Health Organization. 1999.

A study conducted from July 1995 to April 1996 in the Indonesian Islands of Lombok and Bali involved 110 midwives in the delivery of HB vaccine to infants and tetanus toxoid to their mothers.6 During the study, instead of standard disposable syringes with multidose vials, village midwives used the Uniject® device a prefilled, single-dose, autodisable injection device. Provincial and district supervisors trained the midwives prior to the study. All Uniject injections were given at the homes of newborn infants. Questionnaires and interviews were used to gather data from mothers and midwives. The plasma-derived HB was distributed from the Indonesian vaccine manufacturer Perum Bio Farma, and was kept under normal cold-chain conditions during transport and storage at the health centers. After the midwives had picked up supplies of vaccine-filled Uniject devices at the health centers, they were allowed to keep them under ambient conditions for up to one month. A potency test and a serological analysis were conducted during the study to ensure safety and efficiency of the storage strategy. Training and a threshold heat indicator were also used to prevent heat exposure. The threshold heat indicator was attached to each box to determine if the vaccines were exposed to damaging temperatures. The heat indicator changed color when exposed to temperatures 49°C. Infants received the birth dose of HB vaccine delivered either with a standard syringe and vaccine stored in the cold chain, or with the Uniject device prefilled with vaccine stored for one month OCC. Seroconversion rates were identical for the two groups.

Conclusion of Survey

Internet of things and computer technology is very famous in vaccine monitoring for its potentials and efficiency as well as quality of service. The device and the application is provided to all governmental and nongovernmental organizations. It plays a vital role better management of vaccines. The main objective behind this concept is to provide better facilities and ensure availability of superior quality vaccine at places where local bodies and health organizations do not have good facilities for storing vaccine for long time period. With the help of this new concept we can ensure that vaccine is stored properly and the distribution of the vaccine is properly monitored .Apart from this the fact that the administrator will also be able to keep track of the location and the condition of the storage facility supplements to our endeavor of ensuring availability of good quality vaccine.

IV.SOFTWARE REQUIREMENT SPECIFICATION

1. External Interface Requirements

a. User Interfaces:

First page would be login page. This page will allow the user to login as manager or volunteer. The volunteer side mobile application will consist of three buttons start, end and delivered. On pressing the start button, the information about the location of the volunteer is continuously uploaded to the cloud and this uploading will stop on pressing the stop button. Deliver button is used to increment count of vaccinated children. The manager side mobile application will have track and buttons. Track button is used to monitor the location of volunteer.

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b. Hardware Interfaces:

The mobile application takes the data that is stored in cloud by raspberry pi. Raspberry pi makes use of Raspian OS. A python code is written to collect various data from the sensors and upload it to the cloud. The various sensors used include

(a) Light sensor (BH1750FVI)

(b) Temperature (DS18B20)

(c) Accelerometer (MPU6050)

The digital output generated by these sensors are uploaded into the cloud using a python code. The cloud platform used here is ‘CARRIOTS’. The physical GPS is managed by the GPS application in the mobile phone and the hardware connection to the database server is managed by the underlying operating system on the mobile phone and the web server.

c. Software Interfaces:

Yousup API is installed in the Raspian OS which is used to send whatsapp message to the volunteers when abnormal conditions are found in vaccination box.The physical location of volunteers is tracked continuously by using maps to ensure that they cover all the assigned areas. The communication between the database and the web portal consists of operation concerning both reading and modifying the data, while the communication between the database and the mobile application consists of only reading operations.

d. Communication Interfaces:

The communication between the different parts of the system is important since they depend on each other. Internet connection and a web browser are required in order to access the data from the cloud and analyze it.

2.Functional Requirements

a.Functional Requirement 1.1:

TITLE: Download mobile application

DESC: A user should be able to download the mobile application through either an application store or similar service on the mobile phone. The application should be free to download.

Functional Requirement 1.2:

TITLE: User log-in - Mobile application

DESC: The user should be able to log in to the mobile application. The log-in information will be stored on the phone and in the future the user should be logged in automatically. If the user logs in as administrator, he gets full access to volunteer’s location and activities

DEP: FR1

a. Functional Requirement 1.3:

TITLE: Get the sensor reading

DESC: The various data readings such as temperature (in Kelvin), light intensity (in luminous) and equilibrium (angle of rotation) inside the vaccine box are obtained using python code.

b. Functional Requirement 1.4:

TITLE: Upload the sensor reading to cloud

DESC: Sensor data reading are uploaded to cloud using python code. The cloud platform used is ‘CARRIOTS’.

DEP: FR3

c. Functional Requirement 1.5:

TITLE: Check for abnormal conditions

DESC: If temperature is not within range specified by WHO or if there is light exposure or if there is too much of shaking, the manager as well as volunteer are notified so that they can take appropriate actions to preserve the vaccines.

DEP: FR4

d. Functional Requirement 1.6

TITLE: Send GPS coordinates to cloud

DESC: The volunteer’s mobile continuously sends GPS coordinates like longitude and latitude to cloud.

DEP: FR2

e. Functional Requirement 1.7:

TITLE: Track the volunteer

DESC: The manager side application receives the GPS coordinates from cloud and traces it to ensure that volunteers covers all the assigned areas.

DEP: FR1, FR6

3. Software System Attributes

a. Reliability:

The reliability that the system gives precise sensor reading. The cloud platform used should be reliable, secure and fast. There should be proper internet connectivity to cloud.

b. Availability:

. The system should be available all the time during vaccination program.

c. Security:

The system should be secure enough to prevent the external attacker from entering malicious data which may affect the normal functioning of the software and generate unnecessary exception conditions

d. Portability:

The system is portable across different operating system

e. Maintainability:

The code written is modular, simple and easy to read. Hence the maintenance required is less. The application need not be updated frequently.

4.Performance Requirements:

The performance of the system depends upon the reliability and efficiency of sensors ie how fast the sensors produce readings.

It also depends upon cloud platform we choose ie higher the capacity of the cloud, higher the performance. Also we require high speed internet for instant uploading of data values

5. Design Constraints:

The sensor may produce incorrect result or burn when the voltage supplied is varied, so we must ensure that voltage supplied should not exceed specific values. The database may crash when there is large number of querying to it,so the database should be created so that it is capable to store large number of data. The cloud platform may become slow when there is large number processing in it, so the cloud platform should be selected carefully.

6. Other Requirements:

Knowledge of android programming, python programming and connection of sensors to raspberry pi.

V. DESIGN

1. Introduction

a. Number of Modules

1. the SoC (System of Chip)

2. Python

3. Sensors to be used in the Project

4. Cloud platform

b. Modules description

the SoC (System of Chip)**:**

Raspberry Pi has become the most popular single-board computer on the market and spawned many imitators, but none with the rich community that has grown organically around the Raspberry Pi**.**

Python:

Python is a widely used general-purpose, high-level programming language which enabled us to work with android and raspberry pi in our project.

Sensors:

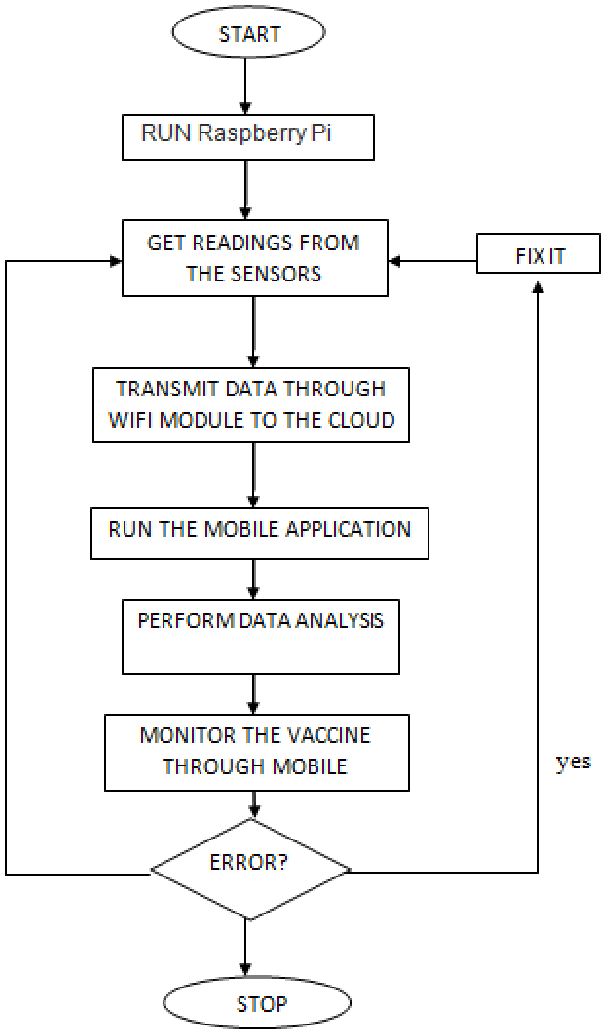
- Temperature Sensor uses a Thermistor to detect the ambient temperature

- Light Sensor module incorporates a Light Dependent
- Accelerometer is an instrument for measuring the acceleration of a moving or vibrating body.

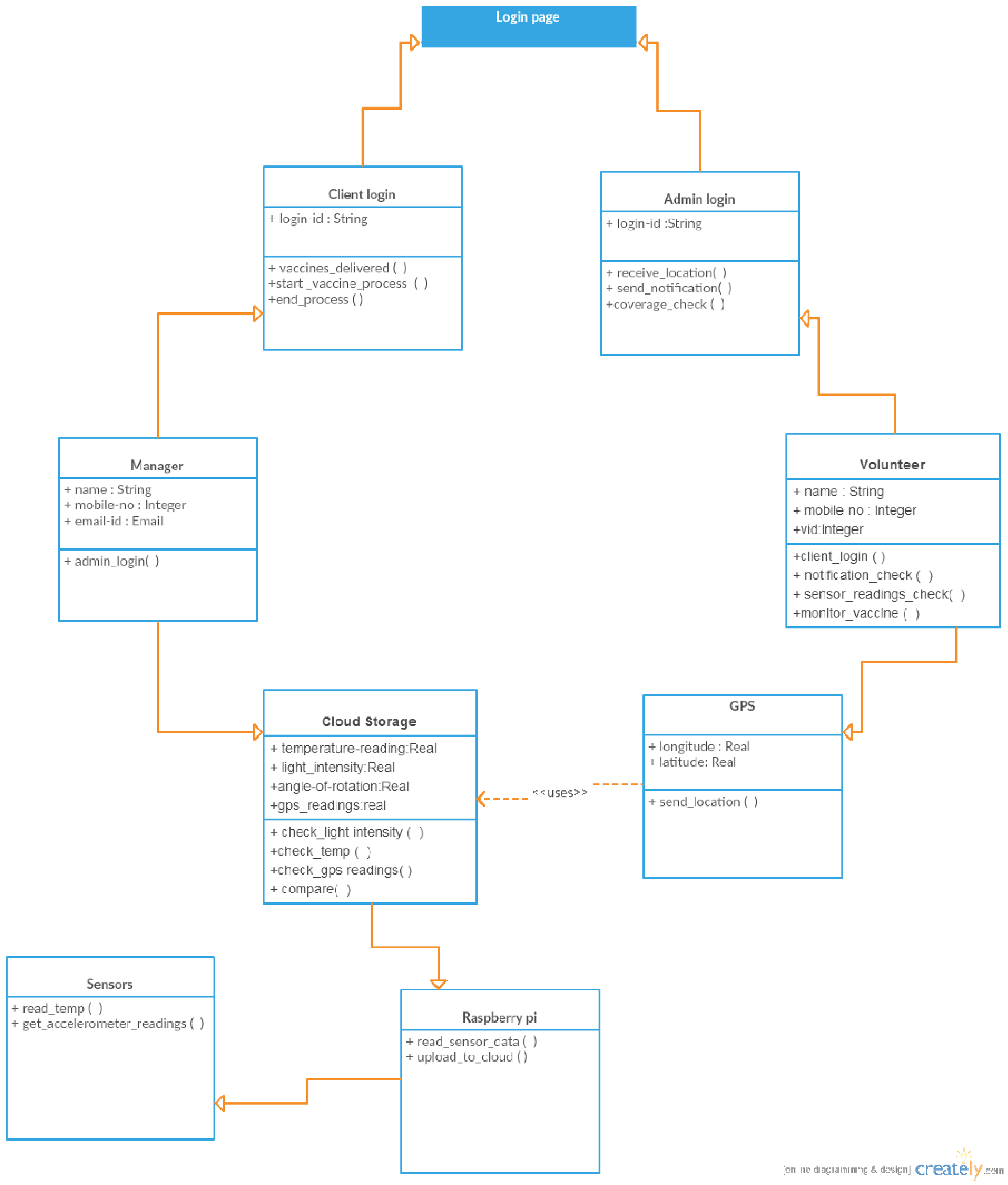
Cloud Platform:

Cloud platform which we are using for data storage and retrieval is Carriots.

1.Data FlowDiagram



2.Sequence diagram



VI. IMPLEMENTATION

Tools Introduction

The tools used for the implementation of this project are many, varying from data storage in cloud , analysis of sensor data and android for sending notifications. Below paragraphs will highlight the importance of each tool that is used in this project.

The following tools are:

- **Carriots**: is an application hosting and development platform (Platform as a Service) specially designed for projects related to the Internet of Things (IoT) and Machine to Machine (M2M). Enables data collection from connected objects (the things part), store it, build powerful applications with few lines of code and integration with external IT systems (the internet part).
- **System of Chip**:

  Raspberry Pi has become the most popular single-board computer on the market and spawned many imitators, but none with the rich community that has grown organically around the Raspberry Pi.The Raspberry Pi B+ and Pi 2 both come with the same Videocore GPU as before and in our tests there was a small improvement in FPS (Frames Per Second) for the Raspberry Pi 2 largely thanks to the increased RAM present on the board.

- **Sensors:**

  Temperature Sensor

  Temperature Sensor uses a Thermistor to detect the ambient temperature. The resistance of a thermistor will increase when the ambient temperature decreases.

Light Sensor

Light Sensor module incorporates a Light Dependent Resistor(LDR).Typically, the resistance of the LDR or Photo resistor will decrease when the ambient light intensity increases.

Accelerometer It is an instrument for measuring the acceleration of a moving or vibrating body.

- **Python**: Python is a widely used general-purpose, high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java. The language provides constructs intended to enable clear programs on both a small and large scale.

Technology Introduction

The data we collected from sensor and gps locations is mainly stored and retrieved in cloud storage . The following technology is mainly utilized:

Cloud Storage (carriots): **Cloud storage** is a model of data storage in which the digital data is stored in logical pools, the physical storage spans multiple servers (and often locations), and the physical environment is typically owned and managed by a hosting company. These cloud storage providers are responsible for keeping the data available and accessible, and the physical environment protected and running. People and organizations buy or lease storage capacity from the providers to store user, organization, or application data.

Cloud storage services may be accessed through a co-located cloud computer service, a web service application programming interface (API) or by applications that utilize the API, such as cloud desktop storage, a cloud storage gateway or Web-based content management systems.

Overall view of the project in terms of implementation

First page would be login page. This page will allow the user to login as manager or volunteer. The volunteer side mobile application will consist of three buttons start, end and delivered. On pressing the start button, the information about the location of the volunteer is continuously uploaded to the cloud and this uploading will stop on pressing the stop button. Deliver button is used to increment count of vaccinated children. The manager side mobile application will have track and buttons. Track button is used to monitor the location of volunteer. Raspberry pi makes use of Raspian OS. A python code is written to collect various data from the sensors and upload it to the cloud. The digital output generated by these sensors are uploaded into the cloud using a python code.

The volunteer's mobile continuously sends GPS coordinates like longitude and latitude to cloud. The physical location of volunteers is tracked continuously by using maps to ensure that they cover all the assigned areas. If temperature is not within range specified by WHO or if there is light exposure or if there is too much of shaking, the manager as well as volunteer are notified so that they can take appropriate actions to preserve the vaccines.

VII. TESTING

Results and Snapshots

The result of the above analysis is generation of a website where users can view data obtained with regard to the originally listed program objectives.

Fig 4:Raspian connection to receive sensor data

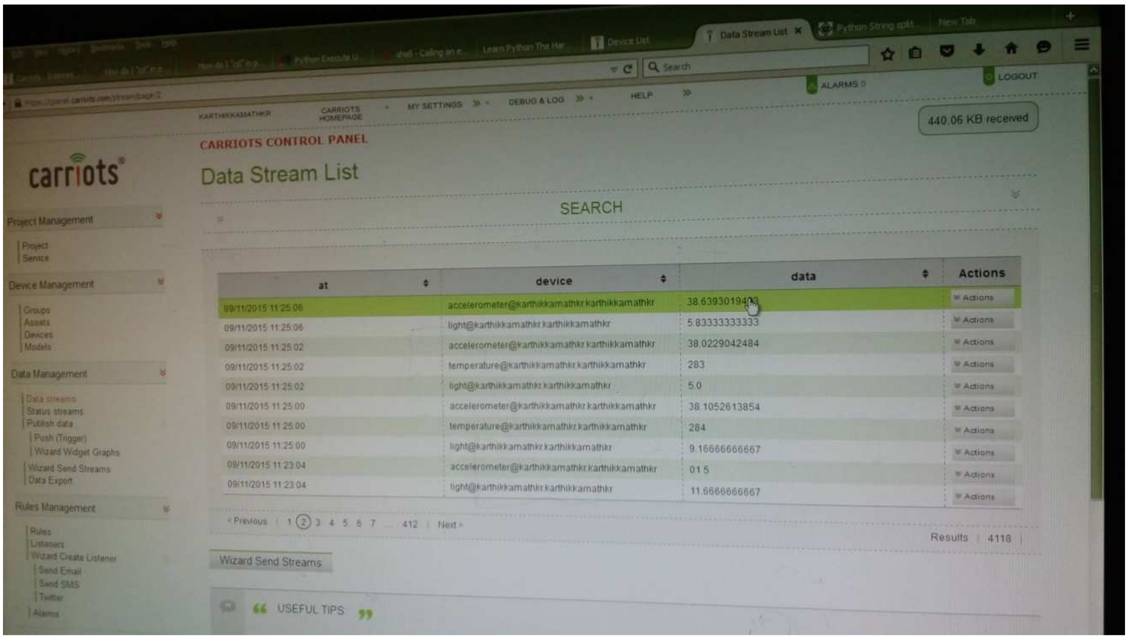


Fig 5:Sensor Data Streaming Using Cloud Platform Carriots

VIII. CONCLUSION & SCOPE FOR FUTURE WORK

This working product model elaborates the new working concept of vaccination storage monitoring system. Internet of things and computer technology is very famous in vaccine monitoring for its potentials and efficiency as well as quality of service. The device and the application is provided to all governmental and nongovernmental organizations. It plays a vital role better management of vaccines. The main objective behind this concept is to provide better facilities and ensure availability of superior quality vaccine at places where local bodies and health organizations do not have good facilities for storing vaccine for long time period. With the help of this new concept we can ensure that vaccine is stored properly and the distribution of the vaccine is properly monitored .Apart from this the fact that the administrator will also be able to keep track of the location and the condition of the storage facility supplements to our endeavor of ensuring availability of good quality vaccine.

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