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Smart Portable IOT Vaccine Monitor

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***Abstract*— This project is applicable to under developed and developing nations where the vaccines storage environment (temperature) tracking is a big problem. When the environment is not optimal (temperature is not within the expected range), the efficacy of these vaccines is lost. The health workers carry vaccine in a portable box with some cold pads eg) during door to door polio vaccine campaign. Our moto is to ensure the safety and efficacy of these 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. Using data analytics, we can predict if a vaccine vial is about to get spoiled (predictive analysis), so that it can be moved to a safety spot on time. 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.**

***Index Terms*— IOT, cloud, vaccine, temperature, edison, intel, android, AWS, java, HTML5.**

I. INTRODUCTION

At present the commercially popular solution is to only monitor the cold chains (statically installed freezers) to ensure proper storage of the vaccines. But the health workers need to go around on the field most of the time to administer the vaccines. Our application offers a solution to monitor the storage and safe keeping of the vaccines on the move. The recorded data also serves as a very important input for the scientists and engineers working on creating more environment-robust insulation box and vials. Our solution is economic as well. In case, the health workers need to go to remote areas, where Internet connectivity is absent, all the recorded data can be stored in the IoT device, to be pushed to the cloud in a batch, once the worker is back to connected area. Also, in the absence of Internet, anomaly detection algorithm running in the kit, can give a forewarning to the health worker immediately by turning on the buzzer.

II. PROBLEM STATEMENT

The Centers for Disease Control (CDC) estimates that hundreds of thousands of doses of vaccines, our front-line defense against diseases and flu viruses, are thrown out every year due to poor storage. This presents an enormous threat to cost controls, but there's a human cost too. When vaccines spoil, children and adults are unwittingly unprotected, or need to be re-vaccinated. It is more than a source of distress and It's a public health threat, because youngsters given understrength vaccines are unprotected against dangerous diseases. And it accounts for a big part of waste.

III. OVERVIEW OF SYSTEM

To overcome those problems, we have made a prototype named Smart Portable IOT vaccine Monitor which is made using Intel Galileo board with multiple sensors attached to, which is running in a portable box with vaccines, which a health worker is carrying. Sensor data recorded is processed in an anomaly detection algorithm inside the IoT board and if it detects environment anomaly, the buzzer starts sounding. The processed data is also periodically pushed to the cloud for further analysis. Analysed data will send a live Push Notification to the mobile phone of the health worker, and his coordinator (a meaningful and informative message is displayed) to handle the crisis situation effectively.

IV. CONSTRUCTION

1. **Hardware components:**

a) Intel Galileo board

b) sensors (temperature, light, air quality, gyro)

2. **Software components:**

a) Intel XDK for IoT to write JavaScript programs to run on Galileo

b) Putty to run setup commands and install npm modules on Galileo

c) Android SDK to write Android App to receive Push Notifications from the Cloud

d) Java to write Restful web services to receive data from Galileo

e) Linux programming on Amazon EC2 to setup Amazon cloud for data analysis

f) Apache Tomcat to run Restful web services to receive data from Galileo

g) Elastic search algorithm in Java setup to do data analysis for huge amount of data

h) NoSQL database setup to store the received data

i) HTML5 CSS programming to setup Kibana dashboard displaying real-time processed data with intuitive details

j) Java program to enable real time Push Notification to Android Phones using Amazon SNS and Google Cloud Messaging Service (GCM)

k) OS used: Windows 10.

V. COMPONENT DESCRIPTION

a) Intel Galileo board

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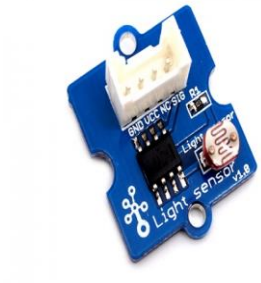
The Intel® Galileo Gen 2 board is based on the Intel® Quark SoC X1000, a 32-bit Intel Pentium®-class system on a chip (SoC). the Galileo board has several PC industry standard I/O ports and features to expand native usage and capabilities beyond the Arduino shield ecosystem.

A full sized mini-PCI Express slot, 100Mb Ethernet port, Micro-SD slot, USB TTL UART header, USB Host port, USB Client Port, and 8 MByte NOR flash come standard on the board. The genuine Intel processor and surrounding native I/O capabilities of the SoC provides for a fully featured offering for both the maker community and students.

b) **Light Sensor**



This module incorporates a Light Dependent Resistor (LDR). Typically, the resistance of the LDR or Photoresistor will decrease when the ambient light intensity increases. This means that the output signal from this module will be HIGH in bright light, and LOW in the dark.

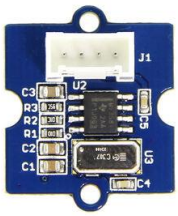
c) Air Quality sensor

This sensor is designed for comprehensive monitor over air condition. It's responsive to a wide scope of harmful gases, as carbon monoxide, alcohol, acetone, thinner, formaldehyde and so on. Due to the measuring mechanism, this sensor cannot output specific data to describe target gases' concentrations quantitatively. But it's still competent enough to be used in applications that require only qualitative results, like auto refresher sprayers and auto air cycling systems.

d) Temperature Sensor

uses a Thermistor to detect the ambient temperature. The resistance of a thermistor will increase when the ambient temperature decreases. It's this characteristic that we use to calculate the ambient temperature. The detectable range of this sensor is -40 - 125ºC, and the accuracy is ±1.5ºC

e) Signal Axis Analog Gyro



It's based on an angular velocity sensor (Murata-ENC-03R) that uses the phenomenon of Coriolis force. It can only measure the X-axis angular velocity, which is different from other 3-Axis gyro, but with a higher speed. It can be used for the position control and attitude control like the self-balanced 2WD.

VI. TECHNICAL WORKING

Intel Galileo board with multiple sensors (temperature, light, air quality, gyro) attached to it, is running in a portable box with vaccines, which a health worker is carrying. The board can be connected directly to Wi-Fi, or we can enable to Bluetooth to connect to the mobile phone of the worker. Sensor data recorded is processed in an anomaly detection algorithm inside the IoT board and if it detects environment anomaly, the buzzer starts sounding. The processed data is also periodically pushed to the cloud for further analysis. Analysed data will send a live Push Notification to the mobile phone of the health worker, and hi0s coordinator (a meaningful and informative message is displayed) to handle the crisis situation effectively.

1) **Cloud connectivity:**

Crucial sensor data recorded inside the portable box is periodically pushed to the cloud. Cloud has enough resource to efficiently process the huge amount of data received. The data analysis done on cloud, is not possible to do in the IoT board. The insights received from the data analysis not only helps a health worker take corrective measures on time, but also promises the building of a better solution in the future.

2) **Sensor utilization:**

Multiple sensors are used to monitor the environment of the portable box carrying the vaccines. In the future GPS sensors can also be added to track the movement of the health worker,

generating more insights. The amount of information gathered from the sensors in an absolutely non-intrusive way is very effective in such ground level scenarios.

Usage of each sensor data

i. Temperature: strict temperature range should be maintained, otherwise raise alert

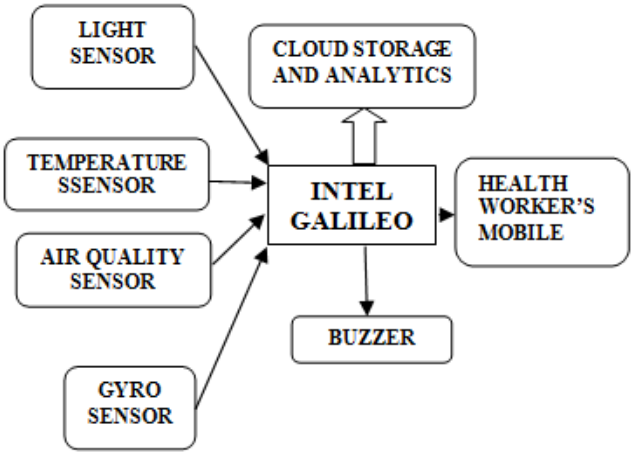
ii. Light: Over exposure to light can spoil the vials, raise alert

iii. Air Quality: degradation in air quality means, insulation is not working properly, raise alert

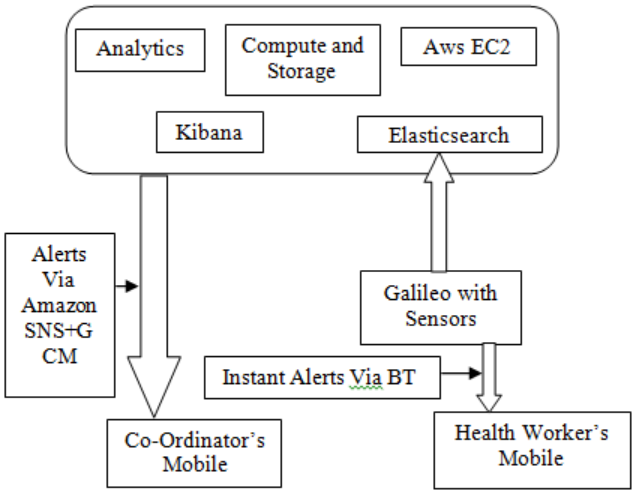
iv. Gyro: if the vial is not kept in a proper position and if it is moving too much, it can go bad, raise alert

v. Buzzer: raise alert

BLOCK DIAGRAM OF SYSTEM



OVERALL BLOCK DIAGRAM



VII. SUMMARY

At present the commercial solution is to only monitor the cold chains (statically installed freezers) to ensure proper storage of the vaccines. But the health workers need to go around on the field most of the time to administer the vaccines. Our prototype is made using Intel Galileo board with multiple sensors attached to it, is running in a portable box with vaccines, which a health worker is carrying offers a solution to monitor the storage and safe keeping of the vaccines on the move.

VIII. CONCLUSION

We do everything to make health workers aware that they are dealing with expensive vaccines and we really want to handle and store it properly while taking those vaccines in a portable box during campaign so that those vaccines do not lose their potency, our prototype will help efficient storage and handling of the vaccines and other environment-sensitive medicines as well.

IX. FUTURE WORK

a) Connect the Galileo board directly to the phone using Bluetooth. In remote areas, where Internet connectivity is absent, the data from the sensors will be stored inside the phone's SD card over Bluetooth. Also, the data can be stored inside the IoT board itself. Later when the health worker is in Internet zone, the data will be pushed to the cloud.

b) An Android app for the health worker: Each health worker gets money for administering a vaccine. This is one of his biggest incentive. After administering the vaccine, he will be using the app to register the administration. These registrations will be used to calculate his incentive. As soon as the IoT board detects a vaccine going bad, it will disable the registration of administering of that vaccine. This way, the health worker won't administer a spoiled vaccine, just for incentive.

c) One box can be made to carry different kinds of vaccine vials to reduce luggage. Each type of vaccine has a different set of optimal environmental thresholds. The IoT kit should be able to monitor each of the different vaccine vials, based on their different set of optimal thresholds, and not using one common set of thresholds for all the vials in the box.

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