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Smart Collectible-Connectible Things, The Interconnected and The Smarter World

[1]Ademeno W. O, [2]Oyefusi Adebayo Samson & [2]Amusa Samuel Adewale,
[1]Department of Science Laboratory Technology
[2]Department of Statistics
D S Adegbenro ICT Polytechnic
Itori-Ewekoro, Ogun State, Nigeria
[1]Email: ademenowemimo@gmail.com

ABSTRACT

The growing population of the world with increasing human activities and the need to satisfy daily necessities plunge men to searching for a lasting satisfaction in all spheres. This in turn, triggers increasing knowledge leading to advancement in technological breakthrough. The biggest of such events is the evolution of the internet of things (IoT). Many homes across the globe now employ one or more services of the IoT to meet with their daily needs and processes. This growing demand and knowledge provision through artificial intelligence (AI) of technology meet up of the demands resulted in the interconnection of the products and services required by the people. Today, the whole world is basking in the euphoria of this knowledge-based economy and systems imparting our world. This paper addresses the context and concept of smart collectible and connectible things which have been domesticated for local production and adoption. With the internet ravaging our homes, People, Process, data and things are interconnected across the globe making products and service provision a seamless activity thereby reducing time, cost, protocols, distance while increasing efficiency, opportunities and making available many alternatives. A review of these phenomena and presentation of few products will open our minds to appreciating and adapting to these changes as a welcome development by bracing up for the consequent monumental transformation through the ongoing smart city project around our world.

Keywords— Smart Collectible-Connectible Things, Interconnection, IoTs, The Smarter World

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1. INTRODUCTION

The Internet is a network of networks that brings people, process, data, and things together (www.netacad.com). Networks provide the foundation for the Internet and, ultimately, the IoT. The components of a network fall into one of the three categories: devices, media, and services. The two most common types of networks are LAN and WAN. Consolidating different types of networks into one platform creates a "converged network." Protocols define the details of how messages are transmitted and received. A group of inter-related protocols that are necessary to perform a communication function is called a protocol suite. Protocol suites help ensure interoperability between network devices.

One of the most common networking protocol suites is known as Transmission Control Protocol/Internet Protocol (TCP/IP). The bottom layer of the TCP/IP protocol suite, network access covers the protocols that devices must use when transferring data across the network. The devices can be connected to the network in one of these two ways: wired or wireless (www.netacad.com). There are four elements of IoT. They are: People, Process, Data, and Things. The interconnection among these entities could be machine-to-machine (M2M), machine-to-people (M2P) or people-to-people (P2P).

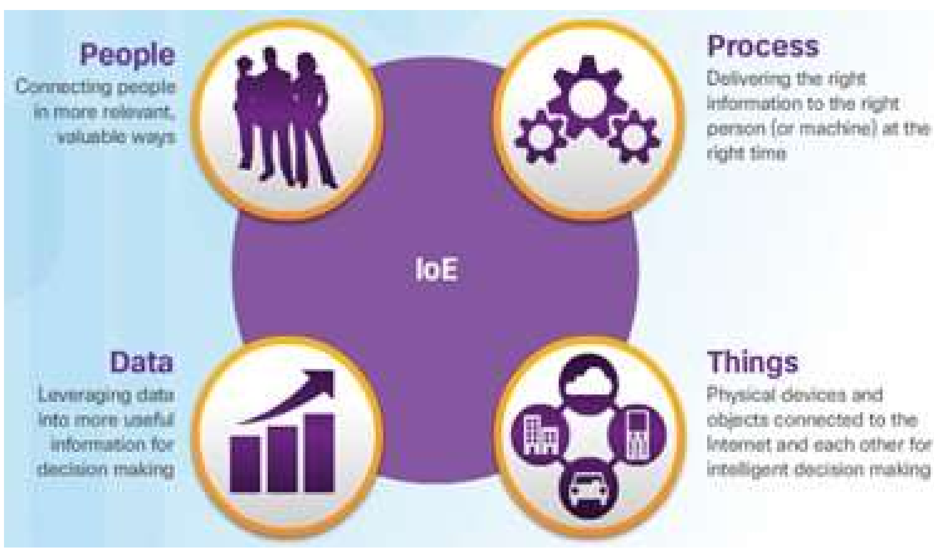


Fig 1: Elements of the Internet of Things (www.netacad.com).

1.1 What are Things?

Things in this context refer to objects and products which contain embedded technology to interact with internal servers over the internet and the external environment. They have features enabling them as network-capable, can communicate across a secure, reliable and available network platform and can create vast amounts of data. When made ready, the object or product connectible is now referred to as Smart thing or Smart Device. Smart things or devices make a smart home, smart cities, smart farms and culminating into a smart world. Smart things are geographic in nature and therefore are traceable (geographic location), linkable (networked), programmable (synchronized with the world-wide-web) and executable (controlled and manipulated for specific task) thereby making the world "a global village".

2. A REVIEW OF THE WORLD OF IoT

2.1 The Technology behind a Smart World

A ***smart device*** *is simply an electronic device connected to other devices or networks over different wireless protocols that can operate to some extent interactively and autonomously. such protocols as Bluetooth, NFC, Wi-Fi, 3G, etc., Several notable types of smart devices are smartphones, phablets and tablets, smartwatches, smart bands and smart key chains. The term can also refer to a device that exhibits some properties of ubiquitous computing, including—although not necessarily—artificial intelligence* ***(www.wikipedia.org).***

Smart devices feature among others, the following:

1. A statically fixed set of system hardware & software resources at the point of design.
2. Dynamically-oriented Plug and play resource component
3. Remote access and execution for external service provision
4. Localised internally autonomous service execution
5. Access to specific external environments: human, physical and distributed ICT / virtual computing interaction.
6. Ubiquitous computing features.

Smart devices may include: *Tab* and *pad* type, personalised smart mobile devices, Smart environment devices. The term *Smart Device Environments* can be classified into two. Firstly, various kind of device environments. Three different kinds of environments for devices could be identified, they are:[2]

- *The Virtual computing environments* which enable smart devices to access pertinent services anywhere and anytime.
- *The Physical environments* that may be embedded with a variety of smart devices of different types including tags, sensors and controllers with different form factors ranging from nano to micro to macro sized.
- *The Human environments*: humans, either individually or collectively, inherently form a smart environment for devices. However, humans themselves are accosted by smart devices such as mobile phones, surface-mounted devices (wearable computing) and contain embedded devices (e.g., pacemakers to maintain a healthy heart operation).

Secondly, the term *Smart Device Environments* can also refer to the concept of a smart environment which focuses more specifically on the physical environment of the device. The physical environment is smart because it is embedded or scattered with smart devices that can sense and control part of it ***(www.wikipedia.org)***.

2.2 Web of Things (WoT) and Internet of Things (IoT)

The **Web of Things** (**WoT**) is a term used to describe approaches, software architectural styles and programming patterns that allow real-world objects to be part of the World Wide Web. Similarly to what the Web (Application Layer) is to the Internet (Network Layer), the Web of Things provides an Application Layer that simplifies the creation of Internet of Things applications. (*Guinard, Dominique; Vlad, Trifa (2015))*

2.2.1 The Web of Things is largely based on the idea of things pushing data to the Web where more intelligence and big-data patterns can be applied as an example to help us manage our health (Wearables), optimise our energy consumption (Smart Grid), etc. This, however, can only happen in a large-scale way if some of the data can be efficiently shared across services.

The sharing layer ensures that data generated by things can be shared in an efficient and secure manner.

2.2.2 The Internet of Things (IoT)

Everyday activities are characterized by adoption, production, application and utilization of things either physical or virtual.

Fig 2: A Prototype of the IoT Enabled Smart City

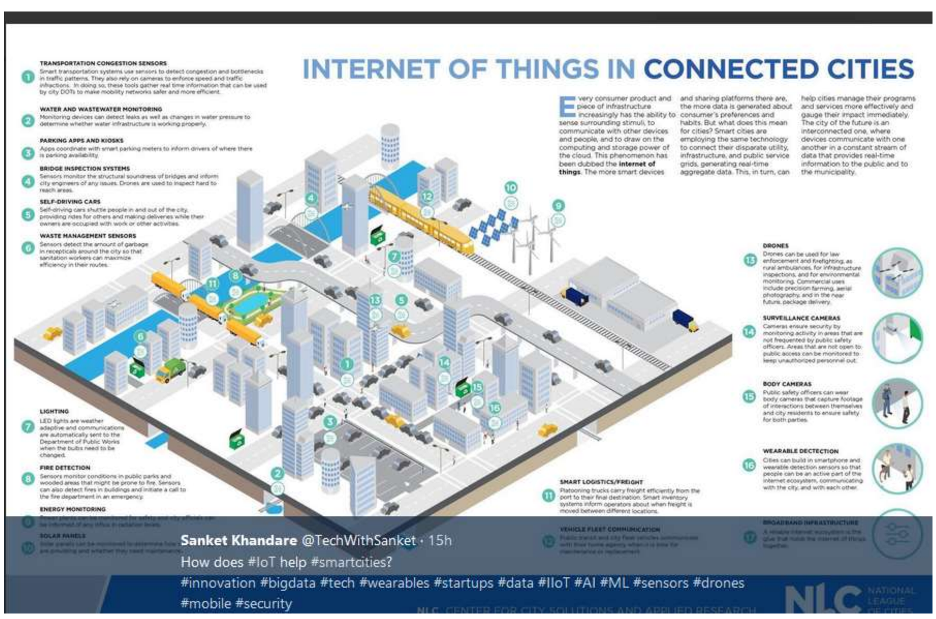


Fig 3: The Composition of IoT in a smart City

2.3 Smart City Projects

2.3.1 The Building of Smart Cities

Products and infrastructure in communities today, have ability to sense surrounding stimuli to communicate other devices and people, to draw on the computing and storage power of the cloud. The more the smart devices and sharing platforms, the more data (big data) is generated about uses, taste and preferences. This means that smart cities are employing same technology to connect their utility infrastructure and public service grids, generating real-time data. This in turn, helps cities manage their programmes and services more effectively and measure impacts immediately. The city of the future is our interconnected one where devices communicate with one another in a constant stream of data that provide real-time information to the public and to the municipality.

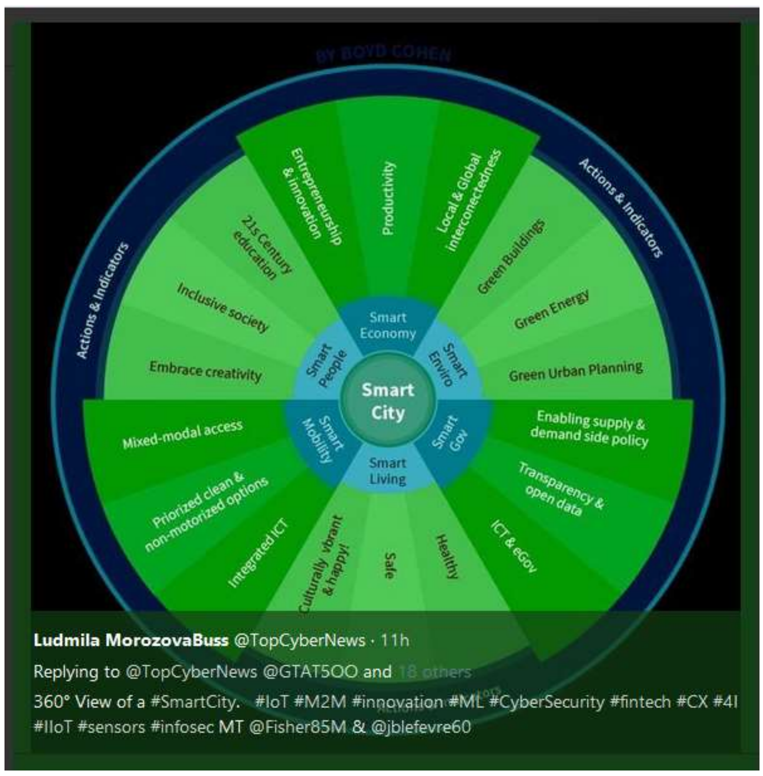


Fig 4: 360^0 View of an Ideal Smart city

2.3.2 The Components of Smart Technologies

Featuring Smart, Tiny but "Powerful" Things, this paper reviews various smart components of a smart city. Twenty (20) of such are presented among millions. However, we shall only showcase three (3) namely: Smart Bin, Smart Watch and Smart Doctor such as pulse oxy-ratiometer popularly known as oximeter.

1. Transportation congestion Sensors: smart transportation system use sensors to detect congestion and bottlenecks in traffic pattern.
2. Water and waste water monitoring: detection of leakages in pipes as well as changes in the water pressures to determine whether infrastructure is working properly.
3. Parking Apps and Kiosks: Apps coordinate with smart parking meters to inform drivers of where parking space is available.

4. Bridge Inspection System: sensors monitor structural soundness of bridges and inform city engineers of any issues. Drones are used to inspect hard areas.
5. Self-driving cars or driverless Cars: Myriads of IoT sensors and wireless technologies such as M2M communication will develop driverless vehicles.
6. Waste Management Sensors: Amount of garbage are detected by sensors in recepticles around the city so that sanitation workers can maximize efficiency in the routes.
7. Lighting: LED light are weather adaptive and communications are automatically sent to the public works department when the bulbs need to be changed.
8. Fire Detection: Sensors monitor conditions in parks and wooded areas prone to fire, in buildings and offices, and initiate a call to the fire department in an emergency.
9. Energy monitoring: power planet can be monitored for safety and city officials can be informed of any influx in radiation levels.
10. Solar Panels: can be monitored to determine how they are providing and whether they need maintenance.
11. Smart logistics/freight: Sector trucks carry freight efficiently from the port to their final destination. Smart inventory system informs operators about when freight is moved between different locations.
12. Vehicle Fleet communication: Public transit and city fleet communicate with their home agency when it is time for maintenance and replacement.
13. Drones as fire fighters, rural ambulance, infrastructure inspection, environmental monitoring, precision farming, aerial photographs, package delivery, video recording and events coverage, missile droppings/gun shots, security surveillance etc.
14. Surveillance Cameras: areas not opened to the public access and not frequently visited by public safety officers can be monitored by security surveillance cameras to keep off unauthorized visitors.
15. Body cameras: Public safety Officers can wear body cameras that captures footages of interactions between themselves and city residents to ensure safety for both parties.
16. Wearable Detection: cities can build in smart phone and wearable detection sensors so that people can be an active part of the internet ecosystem communicating with the city and each other.
17. Broadband infrastructure: a reliable internet ecosystem is the glue that holds the IoT together.
18. Smart Bin: uses sensors to detect users coming to drop waste at home and office, and thereby opens lid for the users to drop wastes. It also senses when the bin is filled up and inform the manager by sending email. This effects prompt response to waste disposal and promotes a healthy environment.
19. Smart Watch: is a personal digital assistant to our mobile phones and tabs: one can be notified of calls, messages and other vital information via smart watch without necessarily holding phones and tabs. It is also a smart doctor in self-diagnostics as it can read and record our body temperature, blood pressure to determine our health status. It could also be connected to our family doctor or hospital to provide prompt health care delivery.
20. Pulse Oximeter: is a smart diagnostic device employ to measure a patient's pulse rate and oxygen in the blood level. A sick fellow or anyone who is interested in wellness could adopt one.

2.4 The Future of a Smart Universe

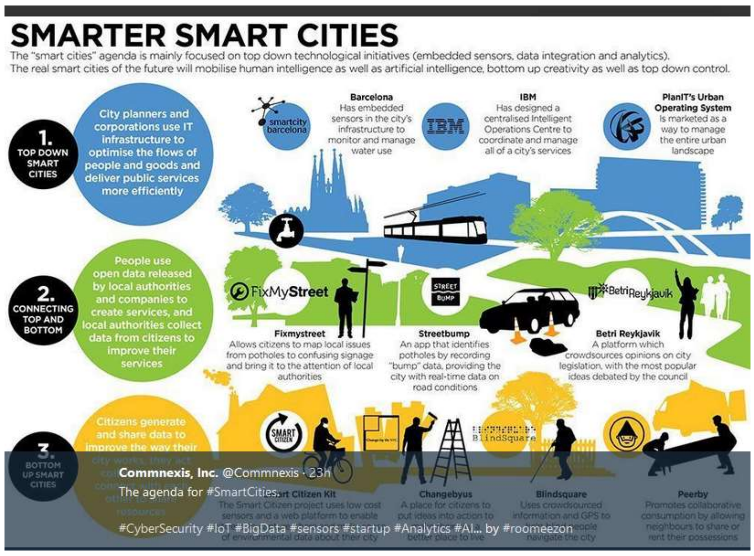


Fig 5: The Agenda for Smart Cities.

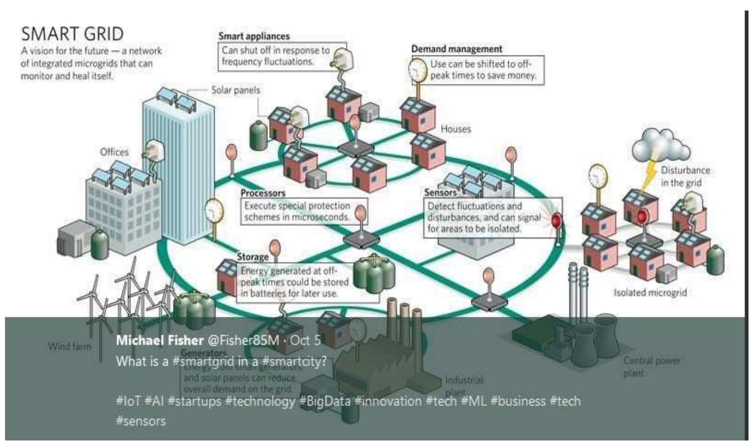


Fig 6: The Smartgrid of a Smart City

Fig 7: The Future of a Smart City.

4. RESEARCH ANALYSIS

The research work reviewed and analysed three of the IoT projects embarked upon recently among other completed and ongoing. These are Smart bin, Smart Watch and Smart Pulse-Rate Oximeter ("Smart Doctor"). The required components, construction, operation and results are thus presented.

4.1 The Making of Smart Collectible-Connectible Things

4.1.1 Web-Controlled Smart Bin

COMPONENTS: The components used in this project consist of Trash-can, Arduino microcontroller, Ultrasonic sensor (HC-SR04), Arduino GSM shield, Micro SD card Module, GPS module, Solder-less Bread-Board, solar power bank and Jumper Wire.

Fig8: GPS Module

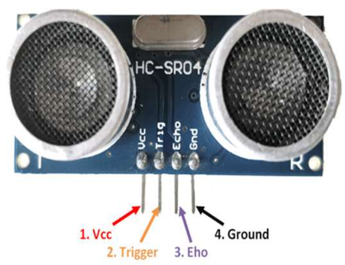


Fig 9: Ultrasonic Sensor

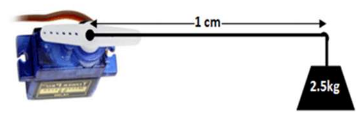


Fig 10: SG-90G SERVO

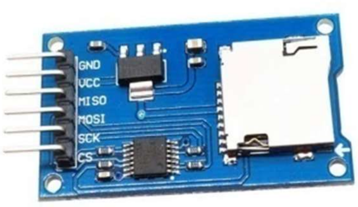


Fig 11: SD Card Module

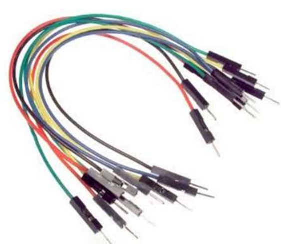


Fig 12: Jumper Wire

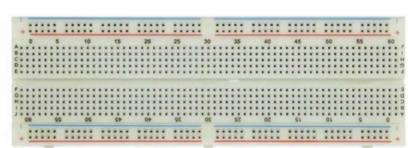


Fig 13: Solder-less Bread Board

Fig 14: Solar Power Bank

Fig 15: LED Light

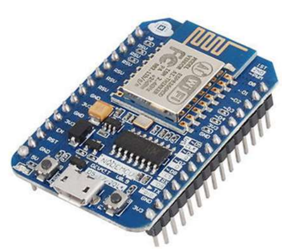


Fig 16: NodeMCU Development Board/kit

Fig 17: Trash Bin

4.2 Design and Construction

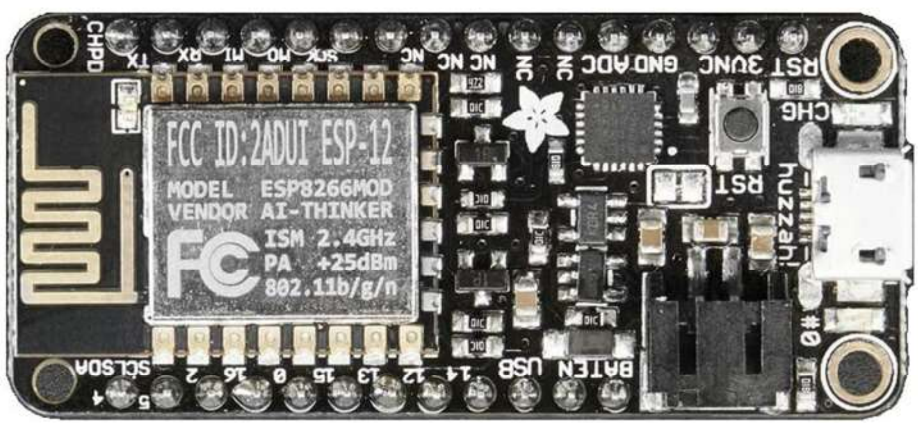


Fig 18: Typical Development Board – NodeMCU ESP8266 (Adafruit Feather HUZZAH)

Adafruit Feather HUZZAH has 80 MHz microcontroller with 3.3V logic, a full Wi-Fi stack and a battery connector for added portability. Most importantly, it's simple to set up, reliable and predictable performance. It can be programmed via the Arduino IDE.

Software (IDE)
An Arduino integrated development environment (IDE) is a software for building applications that combines common developer tools into a single graphical user interface (GUI). An IDE typically consists of:

Source code editor: A text editor that can assist in writing software code with features such as syntax highlighting with visual cues, providing language specific auto-completion, and checking for bugs as code is being written.

Local build automation: Utilities that automate simple, repeatable tasks as part of creating a local build of the software for use by the developer, like compiling computer source code into binary code, packaging binary code, and running automated tests.

Debugger: A program for testing other programs that can graphically display the location of a bug in the original code.

Web Design
A website was built so we that the bin can send the notification to the service station website. Why is a website built? The website was so we can have a work email that can be used along with the SMPT server, the website built goes by the name www.intelligenttrasbin.online which was hosted by Dreamhost company www.dreamhost.org and the custom/work email used was dsa@intelligenttrashbin.online, without a custom/work email we won't be able to open SMTP server and without a owning a website we can't have a work email.

SMTP Server
The Simple Mail Transfer Protocol (SMTP) is a communication protocol for electronic mail transmission. As an Internet standard, SMTP was first defined in 1982 by RFC 821, and updated in 2008 by RFC 5321 to Extended SMTP additions, which is the protocol variety in widespread use today. Mail servers and other message transfer agents use SMTP to send and receive mail messages. SMTP servers commonly use the Transmission Control Protocol on port number 25. User-level email clients typically use SMTP only for sending messages to a mail server for relaying, and typically submit outgoing email to the mail server on port 587 or 465 per RFC 8314. For retrieving messages, IMAP and POP3 are standard, but proprietary servers also often implement proprietary protocols, e.g., Exchange ActiveSync.

HC-SR04 Ultrasonic Sensors
The HC-SR04 Ultrasonic (US) sensor is a 4 pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The sensor works with the simple high school formula: Distance = Speed × Time

The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module as shown in the picture below.

Fig 19: Ultrasonic Sensor Pin Configuration

Ultrasonic Sensor Distance

Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of Ultrasonic wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turn-on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a microcontroller or microprocessor.

Operation

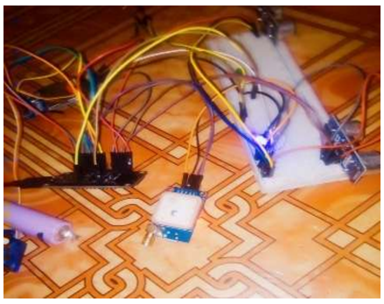
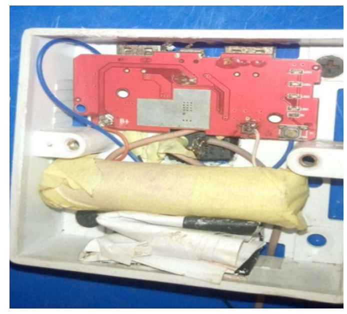
The smart bin is an IoT (internet of things) device, what makes this device/system an IoT is that it can make use of the internet. The microcontroller is programmed in these way. The design of an intelligent trash-can, also known as smart bin, is simply the transformation of our normal trash-can we use at home or in public places. It can be used by anyone either in the public or private. The smart bin has a water-resistant compartment where the controller is placed to protect it. The battery or power station is sited near the solar panel and the micro controller since it is a DC power supply, in a bid to conserve the battery life, since the length of the wires will affect the life of the battery.

The solar panel is placed on top of the lid of the bin, the battery can be recharged from a source different from the solar panel, it can be recharged with an AC to DC charger because of weather condition which may not be favorable for solar panel to produce enough power supply. The bin is designed in such a way that an external antenna may be attached to the GPS module for strong network to the GPS satellite. There are two ultrasonic sensors used, one is to sense human presence near it when it is to be used and the other to sense the level of dirts in the bin.

A 9-gram servo is attached to the cover of the bin to open and close the bin when it is triggered by the ultrasonic sensor that senses human presence, the servo angle is directly to the distance of the ultrasonic sensor. LED light is attached to the body of the bin to give visual expression of the level of dirts to the user. When the bin is full/filled up, a notification message is sent through the internet to the service station containing the status of the bin, the location and time coupled with a visual notification given by the LED light gives a signal by blinking when filled.

The level at which the bin is filled is collected from the ultrasonic sensor attached to the bin and the location and time at which the bin is filled is collected from the GPS module attached to the ESP8266 NodeMCU, the message which is sent to the service station through the internet was sent through the website created for the project (www.intelligenttrashbin.online). The domain through the SMTP server created for the website mailed when the service station for notifications, the location of the bin is now sent to the nearest waste truck driver and the driver navigates to the location for pick up. The whole process is initiated again by the system.

Showcasing The Design

 Fig 20 Experimenting with bread board	 Fig 21: Implementing the work done on breadboard	 Fig 22: The power compartment using power bank PCB and battery
 Fig 23: The devices are connected and placed in their compartments provided. The wires are well labeled.	 Fig 24: Constructed Intelligent Trash Can	 Fig: 25: Trash Can opened at a near distance of 40cm.
 Fig 26: Trash Can opened at the closest proximity of 20cm at 150^{o} inclination		

The Smart Watch

Components for Configuration:

THE PCB (PRINTED CIRCUIT BOARD), SMD SWITCH, MICRO USB, 10 UF CAPACITOR, 10K OHM RESISTOR, TP4056, ESP8266, SMD TACTILE SWITCHES, 3.3V REGULATOR, OLED DISPLAY, VOLT LI-PO BATTERY.

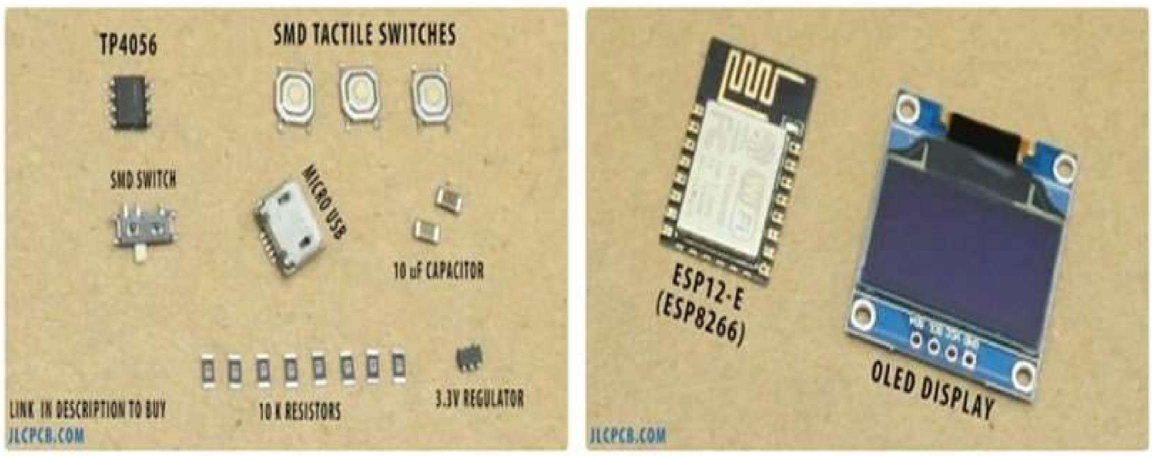


Fig 27: Components of a Smart Watch

The Design And Construction

The devices are commonly colorful and made of plastic. They normally have no display unless a button is pushed. These smartwatches have limited capability compared to other smartwatches; their main functions consist of being able to conduct calls, displaying of time, and sometimes have air temperature sensitivity. There is no generally intuitive nature for gesture controls on smartwatches, except for one: bringing the watch into eyesight.

Everything else is new. With such a small screen size, gestures like pinch-to-zoom, or double-tap will probably not work on most apps. The primary function of a smartwatch is to serve as a “satellite accessory” to a user’s smartphone. As such, an effective smartwatch implementation ought to display only the most relevant information, then direct the user to their smartphone for more information.

The PCB

A printed circuit board was employed so as to minimize wire connection and make compact device, portable enough to be mounted on a wrist. If we were to use a different circuit, a Wi-Fi module, display, a charging module, and battery would be required, where the components such as resistor, capacitor, voltage regulator, the micro USB Jack and battery charging compartment, are added or connected to the Circuit board. The best way to reduce the usage of wires is to make a PCB. An SMD/SMT switch was installed to sit flat, directly on top of a PCB (printed circuit board). It is a tactile component that needs to be touched/pressed down in order to operate the smart watch device, smaller than through-hole switches.

OLED Display

Like a smartphone, a smartwatch has a touchscreen display, which allows you to perform actions by tapping or swiping the screen. Most smartwatches can also be used to make phone calls and send and receive text messages. While these apps run directly on the smartwatch, they require a smartphone to function.

1. OLEDs do not require backlight due to their inherent emissive properties
2. Power consumption is reduced by the omission of the backlight requirement

OLEDs do not suffer from viewing at different angles because of their consistent contrast ratio

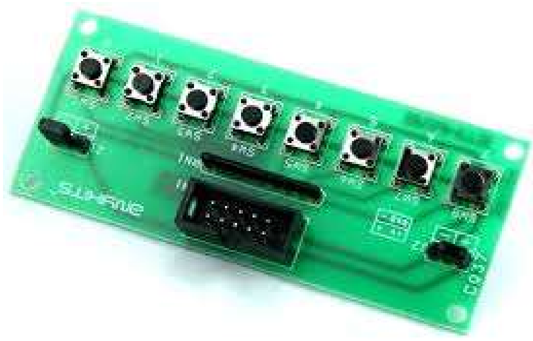


Fig 28: The PCB

Fig 29: The 3.3V voltage Regulator

Fig 30: Soldering the Components

Fig 31: The Li-Po Battery, OLED Display/Compartment

4.3 Operations

Smartwatch can be useful for Commercial purposes, for people working in the office and also for people who just can't afford holding their phone everywhere. Smartwatch makes the data processing faster, easier and accurate. Smartwatch displaying notifications are one of main reasons you would buy one. The ease of having messages sent to your wrist and being able to identify their importance without removing your phone from a pocket or bag is invaluable. It simplifies your life and it saves time. If your smartwatch is synchronised with your phone, you can easily take calls and answer messages immediately. FOMO (fear of missing out) is now a thing of the past thanks to this advanced timepiece.

For us, notifications are the main reason you'd buy a smartwatch. The ease of having them sent to your wrist and being able to identify their importance without removing your phone from a pocket or bag is invaluable. It simplifies your life and it saves time - and time is important. Aside from being a pedometer, most smartwatches can track activity, nutrition, and calories burned. Some can also monitor heart rate and blood pressure. These data can help you reach your fitness goals faster as well as give an overview of your overall health.

Smartwatches have more general functionality closer to smartphones, including mobile apps, a mobile operating system, internet connectivity and Wi-Fi/Bluetooth connectivity. Some smartwatches function as portable media players, with FM radio and playback of digital audio and video files via a Bluetooth headset. Some models, called watch phones (or vice versa), have mobile cellular functionality like making calls. The Smartwatch can also be used in multitasking environments.

The Smart Doctor (Pulse-Rate Oximeter)
The Smart Pulse Oxy-ratiometer (also known as Pulse-rate Oximeter) is a non-invasive and easy test that measures oxygen saturation level in the blood. The pulse rate oximeter is a small clip-like device that is attached to a body part, like toes, fingers or and earlobe. It uses max30100 heartbeat sensor model which is the most efficient model to work with in terms of coding and wiring, and Arduino Nano board (an Internet of Things (IoT) technology). It utilizes an electronic processor and a pair of small light emitting diodes(LEDs) facing a photodiode through a translucent part of the patient’s body, usually a fingertip or earlobe.

COMPONENTS: The circuit consists of Arduino Nano board (a microcontroller (PIC18F452), transistor network, photoplethysmogram (PPG) amplifier, digital-to-analog converter (DAC), pulse oximeter probe and an LCD screen to display results. Coding in C++ and supports only limited C syntax, max30100 heartbeat sensor.

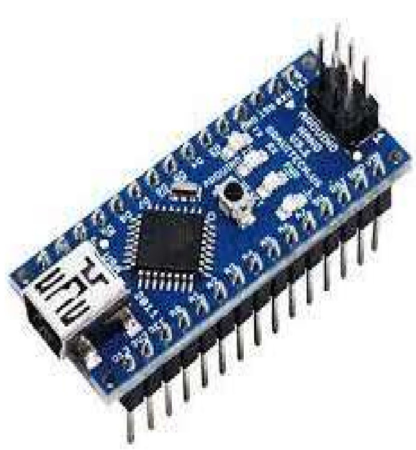


Fig: 32: Arduino UNO Board

Fig. 33: Commercially Produced Oximeter

4.4 Design and Construction

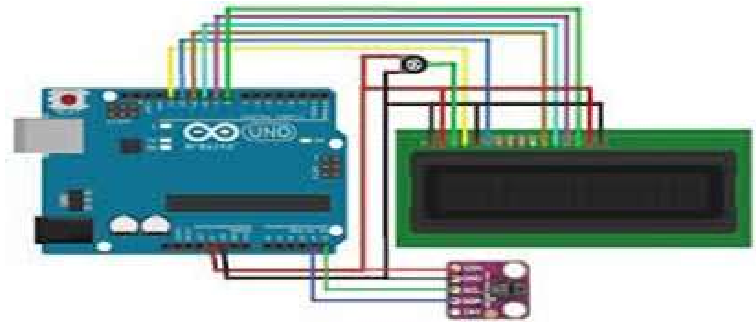


Fig 34: Circuit Diagram of the Smart Pulse-Rate Oximeter

In order to achieve the portability design goals, the open source Arduino software was used to design the circuit and miniaturize the board to make it as small as possible. A Vero board was used as it allows flexibility in terms of fabrication. The components were successfully integrated into the circuit and a fully functional eco-friendly healthcare device was designed and developed for in-house patients who lack mobility to update doctors on their condition. A sick person can make use of the device for self-diagnosis in the comfort of one's room. People with respiratory or cardiovascular conditions, very young infants, and individuals with some infections may benefit from the smart pulse oximeter.

Operation

People can access the device anywhere and keep the data updated in real time. The gadget can help to monitor for the changing conditions of patients anytime. It comprises of all web empowered gadget that gathers, sends and follows up on the information they gain from their general surroundings utilizing implanted sensor, processors and correspondence equipment. For this project, the IoT device implemented was constructed so that the project can be used and results seen on the LCD screen.

Fig 35: Constructed Smart Pulse-rate Oximeter

Table 1: Diagnosis and Results

TIME	PATIENTS NAMES	BPM	SPO2 (%)
	PATIENT 1	44.49	94
	PATIENT 2	59.42	94
Arriving at the lab	PATIENT 3	76.69	94
	PATIENT 4	56.58	96
	PATIENT 5	67.64	93
	PATIENT 6	33.38	202
	PATIENT 1	72.42	76
	PATIENT 2	90.51	96
After rest	PATIENT 3	51.63	94
	PATIENT 4	55.43	95
	PATIENT 5	87.75	94
	PATIENT 6	55.57	96
	PATIENT 1	66.56	96
	PATIENT 2	65.66	95
Before leaving the lab	PATIENT 3	72.34	97
	PATIENT 4	75.67	94
	PATIENT 5	72.70	89
	PATIENT 6	60.12	97

Any healthy individual ordinarily should accomplish typical SpO_2 of 94% to 99% (Amperor Direct 2022). For patients with mellow respiratory ailments, the SpO_2 ought to be 90% or above. Else, oxygen will be required for patients with SpO_2 level below 90% (Amperor Direct 2022). It is important to observe the dearth of pulse oximeter in many low income countries and the inaccessibility of patients to a dependable, tough, and reasonable estimation gadget for precise diagnosis in single gadgets. Thus, a dire need for mobile device powered with rechargeable battery to overcome the problem of sudden power cut.

"The SpO_2 reading should always be considered an estimate of oxygen saturation. For example, if an FDA-cleared pulse oximeter reads 90%, then the true oxygen saturation in the blood is generally between 86-94%. Pulse oximeter accuracy is highest at saturations of 90-100%, intermediate at 80-90%, and lowest below 80%. Due to accuracy limitations at the individual level, SpO_2 provides more utility for trends over time instead of absolute thresholds. Additionally, the FDA only reviews the accuracy of prescription use oximeters, not OTC oximeters meant for general wellness or sporting/aviation purposes" (FDA SAFETY COMMUNICATIONS 2022 www.fda_hhs.gov).

By this sample measurement, the effectiveness of the device has been established in diagnosis and conformity with the WHO recommended standard for SpO_2 (95 %) and BPM (120/80) for the device's production.

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

In a smart world of today, interconnection of almost everything is becoming possible day by day. People are having seamless and stress-free activities and transaction of business, education, commerce and all forms of social interactions are becoming easier. Services, people, things and places are getting connected at the speed of light, human skills and efforts are being upgraded by the emerging technologies making collectible-connectible entities smarter for a faster and smarter world.

5.2 Conclusion

There is a leveraging between developed, developing and under-developed world, between the educated and uneducated, the rich and the poor, the old and the young by this changing and transforming evolution of the Internet of Things (IoT).

5.3 Recommendation

This research work is to serve as an advocate for the embracement of the emerging change by the global community. It is therefore recommended that people, nations, organizations and industries should adopt and adapt to this transformational economy. Educational institutions should incorporate and integrate curricula that promote this changing and digital cultures and economy into the learning and teaching processes in all our secondary and post-secondary institutions. Industries and institutes for training and research should promote technological innovation and incubation reflecting the changing trends and widening nations developmental drives.

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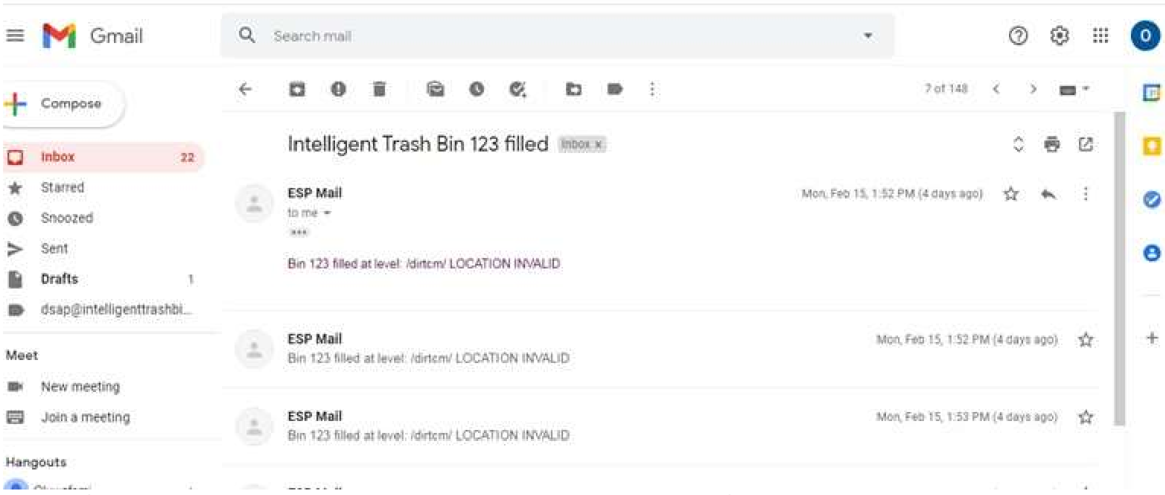
APPENDIX I: CODING

```
#include <ESP8266WiFi.h>
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <Servo.h>
#include <SPI.h>
#include <ESP_Mail_Client.h>
#define WIFI_SSID "dsap"
#define WIFI_PASSWORD "dsap1234"
#define AUTHOR_EMAIL "smtp login"
#define AUTHOR_PASSWORD "smtp password"
.
.
.
WiFiServer server(80);
 }
void smtpCallback(SMTP_Status status)
{
Serial.println(status.info());

if (status.success())
{
Serial.println("——————");
Serial.printf("Message sent success: %d\n", status.completedCount());
Serial.printf("Message sent failled: %d\n", status.failedCount());
Serial.println("——————\n");
struct tm dt;
for (size_t i = 0; i < smtp.sendingResult.size(); i++)
{
SMTP_Result result = smtp.sendingResult.getItem(i);
localtime_r(&result.timesstamp, &dt);
Serial.printf("Message No: %d\n", i + 1);
Serial.printf("Status: %s\n", result.completed ? "success" : "failed");
Serial.printf("Date/Time: %d/%d/%d %d:%d:%d\n", dt.tm_year + 1900, dt.tm_mon + 1,
dt.tm_mday, dt.tm_hour, dt.tm_min, dt.tm_sec);
Serial.printf("Recipient: %s\n", result.recipients);
```

APPENDIX II

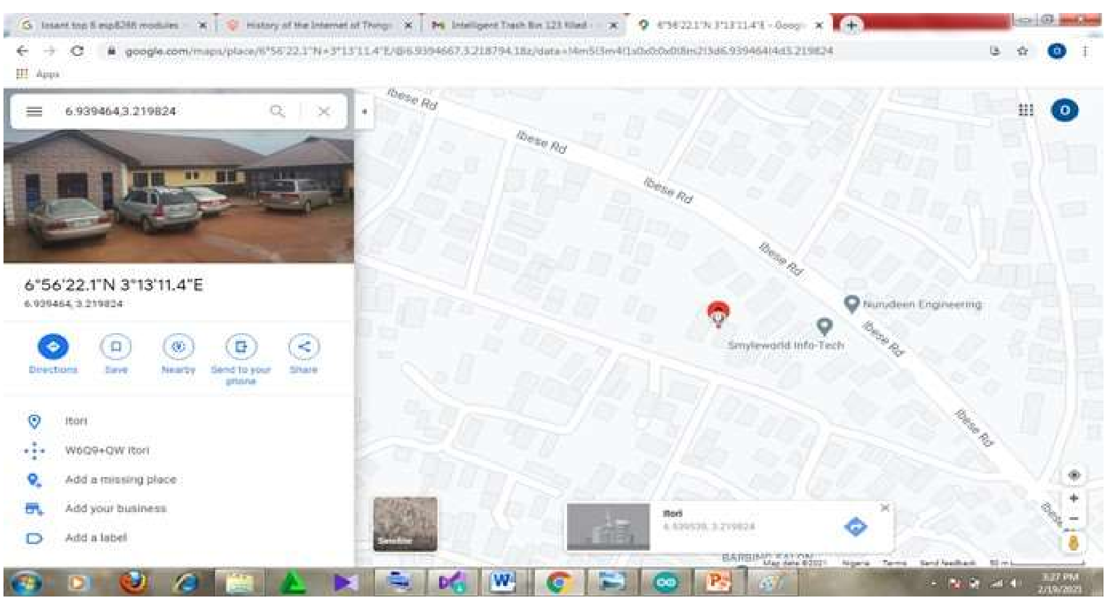
E-MAIL GENERATED BY THE BIN This is the email we got from the bin while testing.



Trash Can sent E-mail to announce its non-storage space, for waste evacuation and disposal.

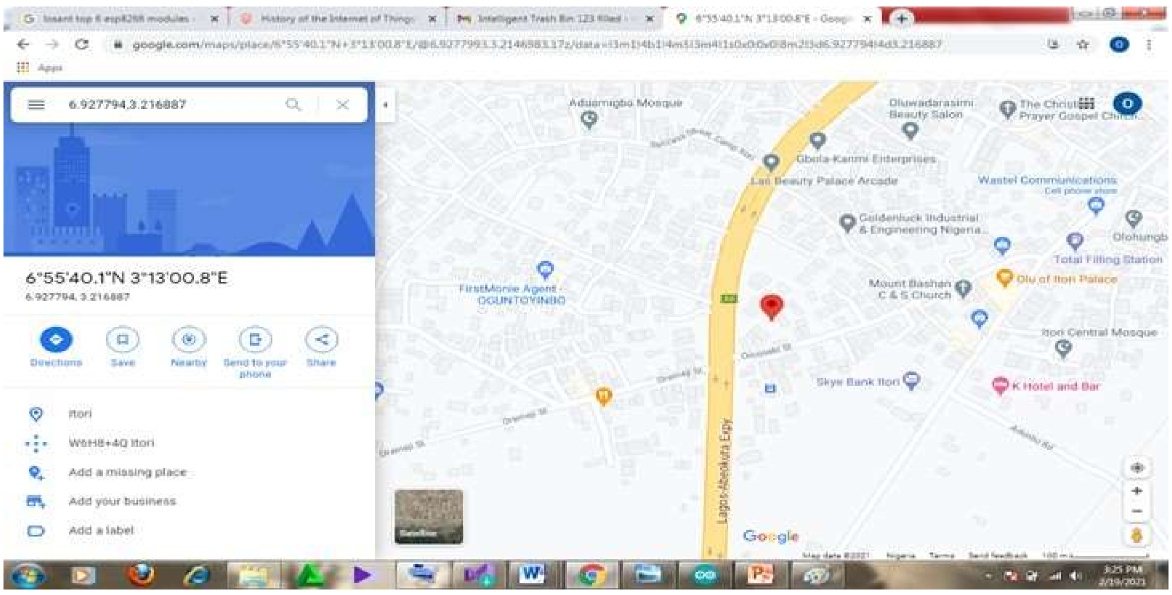
APPENDIX III
THE CITY AREA OF THE TESTING LOCATION

At the first testing location, geographic coordinates of 6.927794, 3.216887 were displayed



In another location, we got geographic coordinates of 6.939464,3.219824. Those number are the latitudes and longitudes of the Trash Can location, if those numbers are copied to Google map it displays the location of the bin.

APPENDIX IV
TESTING LOCATION GEOGRAPHIC FEATURES



The bin sends notification to cloud server, the service station gets the notification from cloud and send it to the nearest garbage truck driver near the area for pick up.