Development of a Mobile Application for Mapping of Mobile Broadband Network Signal

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Abstract:
The increasing popularity of smartphones, laptops and other mobile devices in addition to the availability of high speed 3G/4G networks and yet to be launched 5G network, makes the future of mobile broadband predictably sure. However, there exist a digital divide with respect to the availability of internet access across different localities of the world. In order to have firsthand information of available broadband networks within any geographical location, it is necessary to have a network map hosted on a website for public access and information. This paper develops a software-based system capable of identifying a mobile broadband network connection mode (2G, 3G, 4G) offered within a geographical location and map same to the respective location on a web page. To achieve this, a mobile application to map mobile broadband network signal and a website with accompanying database to store and display the broadband network information as detected was developed. The mobile application was installed in android smartphones and moved around strategic locations within the Abuja Campus of the University of Port Harcourt for data acquisition. The collected data which include geographic location (longitude and latitude) and effective network type (2G, 3G and 4G), using three known networks; MTN, Glo and Airtel, was published on a web page (map), thus representing the network coverage within the campus. The outcome of the research showed that the designed system was capable of recognizing the available broadband networks and also capable of mapping generated information on a web page as specified. It was found that the broadband networks, MTN, Glo and Airtel offer 3G and 4G services within Abuja campus of University of PortHarcourt.

Keywords: Mobile Broadband, User Interface, Web Server, Wired, Wireless, Application Server, Network Coverage Area, Antenna, Base Station, User Equipment.

1.0 INTRODUCTION

Broadband networks represent data communication networks that employ a wide range of frequency channels as opposed to the narrow range of frequency channels obtainable with narrow band communication networks. According to Serbia government official gazette (2016, p.13), broadband access generally refers to high-speed internet access. The International Telecommunication Union (ITU) describes a broadband network as a technology offering access to networks with data rates faster than primary ISDN rate (1.5Mbps - 2 Mbps), while the OECD opines that broadband access is a technology that provides downstream speed higher than 256 kbps, and upstream access speed higher than 128 kbps. In essence, broadband simply refers to a communication system that offer access to high-speed internet services. Broadband access technologies include: wired (DSL, cable, fibre) or wireless (satellite or terrestrial). In other words, we have fixed line broadband networks and wireless/mobie broadband networks. Mobile Broadband networks are data networks that offer fast internet access through mobile devices such as smart phones, tablets, laptops and most often in the form of high capacity 3G and 4G/LTE. As important as broadband access is to national growth, there still exist a noticeable digital divide in broadband internet access or penetration in most countries of the world. As observed by Marshini et al (2013) “while the developed world is reaping the benefits of being connected to a fast and reliable broadband infrastructure, studies have shown that broadband can also be an enabling infrastructure to improve the lives of citizens in developing countries”. The disparity in internet access availability in different localities could result from remoteness and terrain of location, population density, lack of infrastructure, deployment costs and socio-economic hindrances. It gets wider as it progresses from developed to developing countries of the world. Broadband penetration in Nigeria, according to a recent report by Nigeria Communication Commission (NCC), is currently 33%. Representing the broadband digital divide generally relates to the study of three major parameters, namely: coverage (map), choice (cost) and quality. Coverage involves identifying areas serviced and areas not serviced by even one broadband access technology. In order to determine the amount of choice that a consumer has, one needs to find out the number of access technologies and internet service providers (ISPs) available at the subscriber’s location. More choices usually also mean lower cost for the subscriber. Broadband access quality is measured using a set of parameters such as download/upload speeds, latency, jitter and packet loss rate. Broadband network mapping is a term typically used to describe the geographical coverage of broadband network services. It is adjudged important by all stake holders, namely: subscribers, broadband service providers, regulators and policy makers. This paper intends to develop a mobile broadband signal mapping system which will enable automated mobile broadband signal mapping for any region. It will basically detect the availability of a mobile
broadband network in any location with respect to the effective network connection type (2G, 3G or 4G) and maps same to individual locations on a web page. It is important to have a knowledge of and continue to understand where broadband is available. The system after development will be used around the Abuja Campus of the University of Port Harcourt, Rivers State, Nigeria.

2.0. MOBILE BROADBAND AND APPLICATIONS TECHNOLOGIES

Mobile broadband is aimed at broadcast of signals to mobile phones, tablets, laptops and other digital devices in mostly larger geographic coverage area using wireless technologies. Mobile broadband serves an inherent human and business need: to do more without being restricted to a physical location (Rysavy 2017). In this section, an overview of the basic make up and evolution of mobile broadband network and mobile applications is presented. 2.1 The Evolution of Mobile Broadband Mobile broadband technologies can be classified in terms of the generation, namely; 2G, 3G, 4G and expected 5G which is still in design stage and hoped to be launched in the near future. Mobile broadband includes systems such as GSM, UMTS/HSPA, CDMA2000 and LTE. Though mobile broadband is a high speed internet system, the speed also depends on several factors such as; the number of simultaneous users, distance of user to the transmitter (base station or communication mast), weather conditions, mobility of user, multipath interference due to signal obstruction by landscape, buildings and vehicle etc. Subscribers on the UMTS/HSPA and CDMA2000 will mostly experience download speed in the range (5–15) Mbps while those on LTE will normally have download speed in the region of (5–30) Mbps. First generation (1G) network came to life in the 1980s and was basically implemented with analogue technology. It was only meant to provide voice calls services and lacks the digital trait to undertake data services. 1G technology had some security issues like airtime theft. It does not offer broadband service. Second generation (2G) network was the beginning of digital systems and was introduced in the 1990s. It offered services such as short messaging and low speed data. 2G technology replaced the initial analogue technology of 1G with digital technology, providing increased capacity to serve more voice calls in any given band of frequency spectrum. It also offered low speed data services using 2G improvements such as Global System for Mobile (GSM), General Packet Radio Service (GPRS) and Enhanced Data Rate for GSM Evolution (EDGE). GSM is a Time Division Multiple Access (TDMA) technology that operated with 25MHz frequency spectrum in 900MHz band, but now also works in the 1800MHz and 1900Mhz bands. GPRS and EDGE emerged from GSM with features to enhance data services and quality of service (QoS). Other 2G mobile broadband technologies are IS – 95 (Interim Standard – 95) and IS- 136 (Interim Standard -136). IS-95 uses Code Division Multiple Access (CDMA) while IS – 136 uses Time Division Multiple Access (TDMA). Third generation (3G) technology focused at significant voice capacity improvement and digital networks had to provide 144Kbps of throughput at mobile speeds, 384Kbps at pedestrian speeds and 2Mbps in indoor environments (Rysavy 2017). Key technologies of 3G are UMTS/HSPA and CDMA2000. 3G services used new digital technologies to provide dedicated data services with significant increases over 2G in data speeds. It also provided increased capacity for both voice and data, with later enhancements such as HSPA, providing more improved data services. UMTS (Universal Mobile Telecommunication Services) and CDMA are the broad categories of 3G broadband network. UMTS technology air interface evolution include WCDMA (Wideband Code Division Multiple Access), HSPA (High Speed Packet Access), HSPA+ etc. The CDMA2000 1XEV-DO (Evolution - Data Optimized) is an enhanced version of the CDMA family of standards (Yuba 2014). The fourth generation (4G) focuses on boosting mobile broadband performance and has been designed primarily to deliver significant increase in mobile data capacity and performance. 4G technology not only provides voice and other 3G services, but also offer ultra – broadband network access to mobile devices with applications which cover IP telephony, HD Mobile Television, video conferencing, gaming services, cloud computing (Vivek, Sanchit, Lakshmi, Aruna 2014). The high performance mobile broadband data service offering of 4G technology is centered around an internet protocol (IP) packet core which gives much faster broadband than 3G. Thus, 4G services support data-intensive applications such as video streaming, mapping and social networking, enhanced and improved data coverage, capacity and quality. Advanced LTE (Long Term Evolution) and Mobile WiMAX are typical 4G technologies. These broadband technology evolutions are shown in figure 2.1.

![Figure 2.1: Mobile Broadband Evolution](http://ijesc.org/)

2.2 Mobile Country Code (MCC) and Mobile Network Code (MNC)

Mobile Country Code (MCC) is the identification code for a country where a mobile subscriber belongs to. The combination of MCC with Mobile Network Code (MNC) uniquely identify a mobile subscriber network. This mix of MCC/MNC is also called Home Network Identity (HNI). The combination of MCC/MNC and Mobile Subscriber Identification number (MSIN) makes up the International Mobile Subscriber Identity (IMSI). The IMSI is a unique number and usually 15 digits for GSM and UMTS network mobile system. This IMSI identifies a subscriber and is stored in Subscriber Identity Module (SIM).
MCC of Nigeria is 621 and the list of MCC/MNC (HNI) for mobile networks in Nigeria is as shown in Table 2.1. These codes are required for the mobile application development as regards the identification of mobile networks and country of operation.

### Table 2.1. MCC-MNC of Nigeria

<table>
<thead>
<tr>
<th>MCC</th>
<th>MNC</th>
<th>Network / Mobile Providers</th>
</tr>
</thead>
<tbody>
<tr>
<td>621</td>
<td>20</td>
<td>Airtel</td>
</tr>
<tr>
<td>621</td>
<td>60</td>
<td>9mobile</td>
</tr>
<tr>
<td>621</td>
<td>50</td>
<td>Glo Mobile</td>
</tr>
<tr>
<td>621</td>
<td>40</td>
<td>M-Tel</td>
</tr>
<tr>
<td>621</td>
<td>30</td>
<td>MTN</td>
</tr>
<tr>
<td>621</td>
<td>99</td>
<td>Starcomms</td>
</tr>
<tr>
<td>621</td>
<td>25</td>
<td>Visafone</td>
</tr>
</tbody>
</table>

### 2.3 Mobile Applications Development

Mobile websites and applications are designed for mobile devices. Mobile websites are built on browser-based pages that are supported by HTML and CSS standards. They are designed for small-sized screens using media queries and also incorporating, in some cases, specific features such as location-based or click to call functionalities. A mobile application is a self-contained program that pulls content from powerful internet like websites, downloads data, depending on whether the application is online or offline (Rakesh 2016). Users generally prefer to use a mobile application which they can download once and use whenever they want instead of opening a browser, type in a URL and wait for data to be rendered in the browser. There are three methods for building mobile applications. These are native, web and hybrid. The development of native applications confines developers to write their code in a scripting language that is native to the platform. Android and iOS are the two largest mobile platforms and have been competing against one another since the late 2000s subjecting developers to continuous struggle of ensuring that their applications receive visibility on both platforms (Oliver 2018). To develop an app for iOS platform, the scripting language should be objective C or swift. Java or Kotlin is used for Android platform native script while C# is for Windows. These different programming languages used for specific platforms is inefficient for developers because so much amount of time is spent to rewrite their application in an entirely different coding language which may even behave significantly differently too. “Native applications are built on a platform dependent strategy, meaning different platforms have their own tools and technology required” (Oliver 2018). Native apps provide best performance and enable access to all of the underlying functionalities of the mobile phone they run on A mobile web app uses an instance of a mobile web browser to run. They are suited for mobile websites which run especially on small screen mobile devices. Web application is scripted using HTML5, CSS and JavaScript. The final deliverable consists of files that can be hosted on a web server and the application can be accessed using an instance of a web browser (Anirudh, Carlos 2012). Application developers resorted to web applications because they could be created without the restriction to a particular platform. A hybrid mobile app permits writing and maintenance of a single code base for a universal platform. It is a multi-platform mobile app resembling a web application but runs inside a browser window called WebView. A hybrid application enables developers to use web development skills such as HTML5, CSS and JavaScript to develop a mobile application. After the code is written, it can be adapted for different platforms by editing only a little part of it that targets a specific platform. Hybrid applications are developed using frameworks such as Ionic, Apache Cordova, Angular. They are open source tools designed to fast track the development of a hybrid mobile applications. Much as the hybrid application possess native and web applications attributes, it has a few drawbacks. The performance of both native and hybrid apps is different. Native apps perform better because it allows access to the core functionalities of the mobile device. In the case of hybrid apps, the mobile device browser introduces a layer between the mobile platform and source code. This layer prevents access to the mobile device basic functionalities. Native app is faster when compared to hybrid equivalent. However native app is restricted to single platform whereas hybrid app single codebase serves multi-platform. Both native and hybrid apps are downloadable from their respective application store. Mobile web app is different and is not downloadable because it is browser based.

### 3.0 DESIGN SPECIFICATIONS

The broadband mapping system is required to obtain broadband signal information and map same to a web page. The mobile application unit is to be made to observe the broadband network and obtain signal information while the web application is meant to visualize the signal information on a webpage. The users of the application are people who want to contribute to a comprehensive broadband network map.

**The requirements of the system:**

- A backend interface for administrator to modify location parameters (application center and zoom functionality of map sector), view database etc.
- An interface for users to switch on/off application (home page) and view the signal information generated (about page).
- A web interface for viewing of the network map.
- The mobile application is hybrid and should work on multiple platforms, and in this case, Android and iOS platforms.
- The mobile application should be in ionic JavaScript framework.
- The application server is gunicorn and web server is nginx.
- The system should use postgres as database.
- The mobile application should use Apache Cordova to access device’s functionalities like location.
- The webpage user interface should be built using Vue while the business logic backend is scripted with Django.

### 3.1 Development of Mobile Application

This application is a two page mobile application, namely home page and the about page. While the home page contains the switching interface for users, the about page displays the signal data being fetched by the application at regular intervals as it is switched on. To get started with Ionic, Android SDK was chosen as the IDE, downloaded and installed. Npm, Nodejs package management software, that enables the download of additional
software development tools and libraries was downloaded and installed. At completion of Node installation, the following
install Cordova and ionic command line code was used to install the ionic library with npm:

```
$ npm install --g cordova ionic
```

For update of Ionic or Cordova, the following commands can be run.

```
$ npm update --g ionic
$ npm update --g cordova
```

To create the ionic project folder called Sigmap in this work, the underlisted command line code was invoked.

```
$ cd Sigmap
$ ionic start Sigmap
```

To start the development server the following command line code was used

```
$ cd Sigmap
$ ionic serve
```

The running application can now be visualized with the aid of Android Virtual Device (AVD) on the installed Android SDK. Now that the app can run successfully, it can be modified to incorporate other required components and features. This is achieved by opening the created application folder, sigmap. Sigmap folder contains folders such as app, assets, pages, providers, theme, etc. The sublime text editor or any other suitable editor can be used to edit relevant sections to reflect the app’s features and components. The ionic script targets the GPS of the phone to obtain location information. With the plugins for sim, network, geolocation etc., imported into the app module and appropriate code lines modified, the mobile application is able to fetch the network and location information of the device. The network type (network name) is identified with their mobile country code (MCC) and mobile network code (MNC). The network information generated by the mobile application is sent through the specified URL to the Django web application which does the business logic and saves the data on the postgres database through the server. The code listing in figures 3.1, 3.2 are used to realize the home page and about page respectively.

Figure 3.3 depicts the image of the designed mobile app as installed on the mobile phone. While figure 3.4 shows the designed app user interfaces, home page and about page put side by side. At this stage, the switch button is red at switch off and would turn green at switch on.

```
SIGNMAP.app/src/pages/about/about.html
```

```
<ion-header>
  <ion-navbar color="primary">
    <ion-title>Sign MAP</ion-title>
  </ion-navbar>
</ion-header>

<ion-content padding>
  <ion-item>
    <h1 text-center>This is a project by </h1>
    <h1 text-center><strong>Innocent Dibie</strong></h1>
    <p text-center>It maps signal strength to location</p>
  </ion-item>
  <ion-item>
    <h3>Last Sync: {{lastSync}}</h3>
  </ion-item>
  <ion-item>
    <h3>Network: {{carrierName}}</h3>
  </ion-item>
  <ion-list>
    <ion-item *ngFor="let item of logs" text-wrap>
      <p>{{item}}</p>
    </ion-item>
  </ion-list>
</ion-content>
```

```
SIGNMAP.app/src/pages/home/home.html
```

```
<ion-header>
  <ion-navbar color="primary">
    <ion-title>Home</ion-title>
  </ion-navbar>
</ion-header>

<ion-content padding>
  <p>
    Use the Toggle button below to turn the Sign MAPper on or off.
  </p>
  <h3 *ngIf="isOn" text-center>Signal MAPper is online and looking for Signal</h3>
  <h3 *ngIf="!isOn" text-center>Click the button below to start mapping</h3>
  <div class="container" *ngIf="isOn" text-center>
    <a href="#" class="green-btn btn" (click)="toggle()" text-center></a>
  </div>
  <div class="container" *ngIf="!isOn" text-center>
    <a href="#" class="red-btn btn" (click)="toggle()" text-center></a>
  </div>
</ion-content>
```

Figure 3.2. Code Listing for Mobile App about Page

```
SIGNMAP.app/src/pages/about/about.html
```

Figure 3.3. Mobile Application Installed on a Smart Phone

```
SIGNMAP.app/src/pages/home/home.html
```

Figure 3.1. Code Listing for Mobile App HomePage

3.3 Web Application Development

The frontend or web application is written in Vue, a progressive JavaScript framework used to create modern web applications. Modern JavaScript applications are mostly used on the Web, but also power a lot of desktop and mobile applications. The Vue web application functions by requesting for the network information stored on the database from the server through Django, the server side web application, so it could publish same on the web page.
To start with frontend development, is the installation of the Vue CLI on the computer by using the command line utility, to install it globally using npm as below:

```bash
npm install -g @vue/cli
```

The CLI is essential for rapid Vue.js development. It ensures all needed tools are working as required. In order to create the Vue app with the CLI code is invoked as follows:

```javascript
vue create sigmap-frontend-master
```

This code creates the sigmap frontend application folder. By default, babel and ESLint are created in the app folder. The application will after creation and configuration run as built on Webpack. Dedicated configuration files for domiciliation of application configurations are selected when prompted by Vue CLI. The created application folder contains different starter files among which is package.json. The sigmap frontend folder contains all the functionalities required for the publishing of broadband signal map. The various files are modified to achieve relevant display functionalities as desired. With the circle function, the appropriate positions will be defined for publication of received signal information on the frontend web user interface. In order to use google map on the Vue app, the developed mobile application need to be registered with google API. The code listing in figure 3.5 depictss sample code for the web application index page. More so, for the backend business logic functionalities, python 3.7 was downloaded and installed and Django installed afterwards. This backend or server side web application is the administrative or business logic backbone. It relates with both the Vue frontend application and the mobile application as regards interactions (information interchange) with the server. Codes written here serve to in one circumstance, obtain data from the mobile app and save on the database and in another situation retrieve data from the database as requested by the Vue frontend web app for publication on the webpage. The broadband network signal parameter to be mapped is the effective network type/mode (4G, 3G, 2G) change against location. For proper identification, colour code was used to differentiate the different effective network connection types as shown in table 3.1. These colour codes are used to achieve the network map. Each of the data points to be published on the webpage will be characterized as such and the colour code used to describe the relevant portion on the webpage. This was easily achieved using the circle function and fetch operation.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Effective Network Connection type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>4G</td>
</tr>
<tr>
<td>Yellow</td>
<td>3G</td>
</tr>
<tr>
<td>Red</td>
<td>2G</td>
</tr>
<tr>
<td>Black</td>
<td>None</td>
</tr>
</tbody>
</table>

Figure 3.6 shows the designed web app user interface for display of network map. At this instant, network is selected and the described point thus show dark spots.

### 4.0 RESULTS AND DISCUSSION

In this section, the developed and installed mobile application on the smart phone was switched on by tapping on the circular toggle switch button.
Immediately the app goes online and so long the location/GPS service of the phone is activated, broadband network signal information relating to the network name, effective connection type (2G, 3G, 4G), position (longitude and latitude) and time, will be generated automatically. Figures 4.1 shows the user interface of the active mobile application at switch on. The broadband network information generated for all the locations visited by the user is transmitted to the database on the web application via the URL for storage. In order to view the data as map, the test webpage address, http://sigmap.everyday.com.ng was opened on the browser. Location points are described with latitude and longitude lines and events such as effective connection type/mode change, can be displayed on the map. In the case of this work, the event that will trigger the visualization of network map is the selection of particular network from the select button on the test webpage. With the map, it can be ascertained which networks are available, and if network operators really offer 4G, 3G or 2G services in the various test locations.

The map coverage gives an indication of which operator is strongest and in which area as visualized with the map with respect to the effective network connection type (4G, 3G or 2G). Upon selecting the active networks of MTN, Airtel and Glo in turn, the maps showing the highlighted network data points will be displayed on the webpage. Figure 4.2 shows a map of MTN network as at the time of data collection. Similar results were obtained for Glo and Airtel networks. The mobile broadband network mapping system developed was able to capture location and network information as specified through regular observation of the network at intervals. Data mapped on webpage were the most currently generated values from each of the positions covered. For the three chosen mobile broadband networks, MTN, Glo and Airtel, it was discovered that 4G and 3G services are available. However, there was no incidence of 2G detection as at the time of data collection.

5.0 CONCLUSION

The importance of having a measure of broadband network coverage cannot be overemphasized. Some developed countries of the world and regulators are making concerted effort to have a comprehensive broadband network map which will guide infrastructure investment and also inform subscribers on the available services.

6.0. REFERENCES

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