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# Received Signal Strength Intensity-Based Determination Of Cell Phone Location Using Trilateration Method

**Kufre M. Udofia**
Department of Electrical/Electronic and Computer Engineering,
University of Uyo, Nigeria
kmudofia@uniuyo.edu.ng

***Abstract***— **In this paper, received signal strength intensity-based determination of cell phone location using trilateration method is presented. The determination of the two dimensional (2D) location (x,y ) of a cell phone is done using the path lengths , $d_1$, $d_2$and $d_3$ of the phone from three base stations with their respective location coordinates as, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ respectively. The path lengths between the cell phone and each of the base station is determined from the measured received signal strength intensity (RSSI) using the Hata propagation loss model. Then the coordinates of the three base stations and the corresponding path lengths to the cell phone are used in the trilateration method to determine the cell phone location. Also presented is the algorithm for a program that can be used to perform the computation. Some sample RSSI and base stations' coordinate dataset are used to evaluate the applicability of algorithm. In the first test case, the location (x,y ) of the cell phone is such that (x =-0.256 and y =1.338), in the second test case, (x =1.469 and y =2.149), in the third test case, (x =-1.233 and y =-1.37) and in the third test case, (x =-1.599 and y =0.451.**

***Keywords***— ***Hata propagation model, Received Signal Strength Intensity, Cell Phone Location, Trilateration Method, Pathloss***

## 1. Introduction

Today, the use of cell phone has grown exponentially [1,2,3,4,5,6,7]. Also, even in the remote locations in the developing countries, the used of cell phone has been widely reported. In any case, while cell phones are very useful, they have become the target of many hoodlums who steal phones for many reasons [8,9,10,11,12,13,14,15,16]. In that case, it is very important to be able to track cell phones in real-time based on the received signal strength intensity (RSSI) reported from the phone [17,18,19,20,21,22,23]. Also, cell phone tracking has been widely used to locate missing persons, kidnappers' den, co-location of people during the COVID-19 contact tracing and isolation procedures [24,25,26,27,28,29,30]. All these can be achieved by the use of algorithm which can be used to access the coordinates of at least three bases stations that report the received signal strength from the cell phone at any point in time.

Today, there are several methods that can be used to determine such cell phone locations. However, in this paper, the trilateration method is used. The trilateration method requires the location coordinates of three base stations along with the distance of the cell phone from each of the three base stations [31,32,33,34,35,36,37]. In this wise, the distance of the cell phone from each of the three base stations is determined using the RSSI of the received signal of the cell phone for each of the three base stations. In this paper, the Hata propagation loss model [38,39,40,41] is used to determine the path length based on the given RSSI value. Subsequently an algorithm for a program that can be used to read in the base stations' coordinates, the RSSI values and the other requisite input dataset and then estimate the location coordinates of the cell phone is developed. The algorithm is tested with some sample dataset.

## 2. Methodology

### 2.1 Determination of the 2 dimensional (2D) location (x,y ) of a cell phone

Determination of the 2 dimensional (2D) location (x,y ) of a cell phone can be done using the path lengths , $d_1$, $d_2$and $d_3$ of the phone from three base stations with their respective location coordinates as, $(x_1, y_1)$ , $(x_2, y_2)$ and $(x_3, y_3)$ respectively. The values of $d_1$, $d_2$ and $d_3$ are determined from the Received Signal Strength Intensity (RSSI) value of the signal received from the base station i by the cell phone. Now, with the path lengths and location coordinates of the base station, the location (x,y ) of a cell phone can be estimated. The following three equations of a circle with radius d and x and y coordinates are formed;

$$(x - x_1)^2 + (y - y_1)^2 = d_1^2 \quad (1)$$
$$(x - x_2)^2 + (y - y_2)^2 = d_2^2 \quad (2)$$
$$(x - x_3)^2 + (y - y_3)^2 = d_3^2 \quad (3)$$

The three equations are expanded to give;

$$x^2 - 2x(x_1) + x_1^2 + y^2 - 2y(y_1) + y_1^2 = d_1^2 \quad (4)$$
$$x^2 - 2x(x_2) + x_2^2 + y^2 - 2y(y_2) + y_2^2 = d_2^2 \quad (5)$$
$$x^2 - 2x(x_3) + x_3^2 + y^2 - 2y(y_3) + y_3^2 = d_3^2 \quad (6)$$

Equation 5 is subtracted from Equation 4 to give;

$$(-2x_1 + 2x_2)x + (-2y_1 + 2y_2)y = d_1^2 - d_2^2 - x_1^2 + x_2^2 - y_1^2 + y_2^2 \quad (7)$$

Also, Equation 6 is subtracted from Equation 5 to give;

$$(-2x_2 + 2x_3)x + (-2y_2 + 2y_3)y = d_2^2 - d_3^2 - x_2^2 + x_3^2 - y_2^2 + y_3^2 \quad (8)$$

Equation 7 and Equation 8 can be expressed as follows;

$$a(x) + b(y) = c \quad (9)$$

$$d(x) + e(y) = f \quad (10)$$

Where

$$a = (-2x_1 + 2x_2) \quad (11)$$

$$b = (-2y_1 + 2y_2) \quad (12)$$

$$c = d_1^2 - d_2^2 - x_1^2 + x_2^2 - y_1^2 + y_2^2 \quad (13)$$

$$d = (-2x_2 + 2x_3) \quad (14)$$

$$e = (-2y_2 + 2y_3) \quad (15)$$

$$f = d_2^2 - d_3^2 - x_2^2 + x_3^2 - y_2^2 + y_3^2 \quad (16)$$

Then, the solution for x and y are as follows;

$$x = \frac{c(e) - f(b)}{e(a) - b(d)} \quad (17)$$

$$y = \frac{c(d) - a(f)}{b(d) - a(e)} \quad (18)$$

## 2.2 Determination of the path length using the RSSI and Hata propagation model

The pathloss ($LP_H$) is computed from the measured RSSI (received signal strength intensity) and the Effective Isotropic Radiated Power (EIRPt(dBm ) as follows;

$$LP_H = EIRP_t(dBm) - RSSI(dBm) \quad (19)$$

When the propagation loss ($LP_H$) is known, the path length, given as $d_H$ is determined by [42] as follows;

$$d_H = 10^{\left(\frac{LP_H - A + k}{B}\right)} \quad (20)$$

Where

$$A = 69.55 + 26.16 * \log_{10}(f) - 13.82 * \log_{10}(h_b) - a(h_m) \quad (21)$$

$$B = 44.9 - 6.55 * \log_{10}(h_b) \quad (22)$$

$$K = \begin{cases} 0 & \text{Urban region} \\ 5.4 + 2 * \left[\log_{10}\left(\frac{f}{28}\right)\right]^2 & \text{Suburban region} \\ 40.94 + 4.78 * [\log_{10}(f)]^2 - 18.33 * \log_{10}(f) & \text{Rural region} \end{cases} \quad (23)$$

$$a(h_m) = \begin{cases} [1.1 * \log_{10} f - 0.7] * h_m - [1.56 * \log_{10} f - 0.8] & \text{for small city, medium city, open / rural area} \\ 8.28 * [\log_{10}(1.54 * h_m)]^2 - 1.1 & \text{for large city } f \leq 200\text{MHz} \\ 3.2 * [\log_{10}(11.75 * h_m)]^2 - 4.97 & \text{for large city } f \geq 400\text{MHz} \end{cases} \quad (24)$$

- ✓ f is expressed in MHz ; d is expresd in km
- ✓ 150 MHz≤ f≤ 1000MHz; 30m ≤$h_b$ ≤ 200m ;1m≤ $h_m$≤ 10 m and 1 km ≤ d ≤ 20km

In this paper, (EIRPt(dBm) is taken as 55.5 dBm, hence;

$$d_H = 10^{\left(\frac{EIRPt(dBm) - RSSI(dBm) - A + k}{B}\right)} \quad (25)$$

$$d_H = 10^{\left(\frac{55.5 - RSSI(dBm) - A + k}{B}\right)} \quad (26)$$

Therefore, if $RSSI_i$ is the RSSI measured by the cell phone for base station i, and $d_i$ is the path length of the cell phone from base station i, as estimated using the measured $RSSI_i$ by the cell phone, then;

$$d_i = 10^{\left(\frac{55.5 - RSSI_i - A + k}{B}\right)} \quad \text{for i= 1,2 and 3} \quad (27)$$

The values of $d_1$, $d_2$ and $d_3$ and $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ are then used to determine the location (x,y ) of a cell phone by using Equation 17 and Equation 18. The algorithm for a computer program that can be used to do the automated computation is given as follows:

**The algorithm for computation of cell phone location using measured RSSI and trilateration method**

**Step 1:** For i = 1, i<= 3, Step 1

**Step 2:** Input $f_i$ (in MHz), $h_{b(i)}$ (in m), $h_{m(i)}$ (in m), $RSSI_i$ (in dBm), $x_i$(in km), $y_i$(in km)

**Step 3:** $A = 69.55 + 26.16 * \log_{10}(f) - 13.82 * \log_{10}(h_b) - a(h_m)$

**Step 4**: $B = 44.9 - 6.55 * \log_{10}(h_b)$

**Step 5:** $K = 0$

**Step 6:** $a(h_m) = 3.2 * [\log_{10}(11.75 * h_m)]^2 - 4.97$

**Step 7**: $d_i = 10^{\left(\frac{55.5 - RSSI_i - A + k}{B}\right)}$

**Step 8:** Next i

**Step 9:** $a = (-2x_1 + 2x_2)$

**Step 10:** $b = (-2y_1 + 2y_2)$

**Step 11:** $c = d_1^2 - d_2^2 - x_1^2 + x_2^2 - y_1^2 + y_2^2$

**Step 12:** $d = (-2x_2 + 2x_3)$

**Step 14:** $e = (-2y_2 + 2y_3)$

**Step 15:** $f = d_2^2 - d_3^2 - x_2^2 + x_3^2 - y_2^2 + y_3^2$

**Step 16:** $x = \frac{c(e) - f(b)}{e(a) - b(d)}$

**Step 17:** $y = \frac{c(d) - a(f)}{b(d) - a(e)}$

### 3. Results and discussion

Based on the algorithm, numerical computation of cell phone locations was done using sample dataset. Specifically, the sample dataset of three base stations' coordinates were randomly generated along with the RSSI values and hence, the pathloss (based on Hata model). The Hata propagation loss model was then used to determine the path length based on the given pathloss. The results of the first test case is shown in Table 1 and Figure 1. In this case, the table shows the values of $RSSI_1, RSSI_2, RSSI_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ that are used to determine $d_1$, $d_2$and $d_3$ and the location (x,y ) of the cell phone, when x is negative and y is positive. In the first test case, the location (x,y ) of the cell phone is such that (x =-0.256 and y =1.338), that is , x is negative and y is positive, as shown in Table 1 and Figure 1.

The results of the second test case is shown in Table 2 and Figure 2. In the second test case, the location (x,y ) of the cell phone is such that (x =1.469 and y =2.149), that is , x is positive and y is positive, as shown in Table 2 and Figure 2.

Again, the results of the third test case is shown in Table 3 and Figure 3. In the third test case, the location (x,y ) of the cell phone is such that (x =-1.233 and y =-1.37), that is , x is negative and y is negative, as shown in Table 3 and Figure 3.

Furthermore, the results of the fourth test case is shown in Table 4 and Figure 4. In the third test case, the location (x,y ) of the cell phone is such that (x =-1.599 and y =0.451), that is , x is positive and y is negative, as shown in Table 4 and Figure 4.

Table 1 The results of the first test case: the values of $RSSI_1, RSSI_2, RSSI_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ that are used to determine $d_1$, $d_2$and $d_3$ and the location (x,y ) of a cell phone, when x is negative and y is positive.

| | X (km) | Y (km) | RSSI (dBm) | d in km (Distance in km from the tracked Cell Phone based on RSSI |
|---|---|---|---|---|
| Base Station 1 | 0.122 | 0.864 | -76.551 | 0.508 |
| Base Station 2 | 2.011 | 1.957 | -102.33 | 2.327 |
| Base Station 3 | 0.942 | 0.392 | -80.316 | 0.634 |

| | | | | |
|---|---|---|---|---|
| Tracked Cell Phone | -0.256 | 1.338 | | |

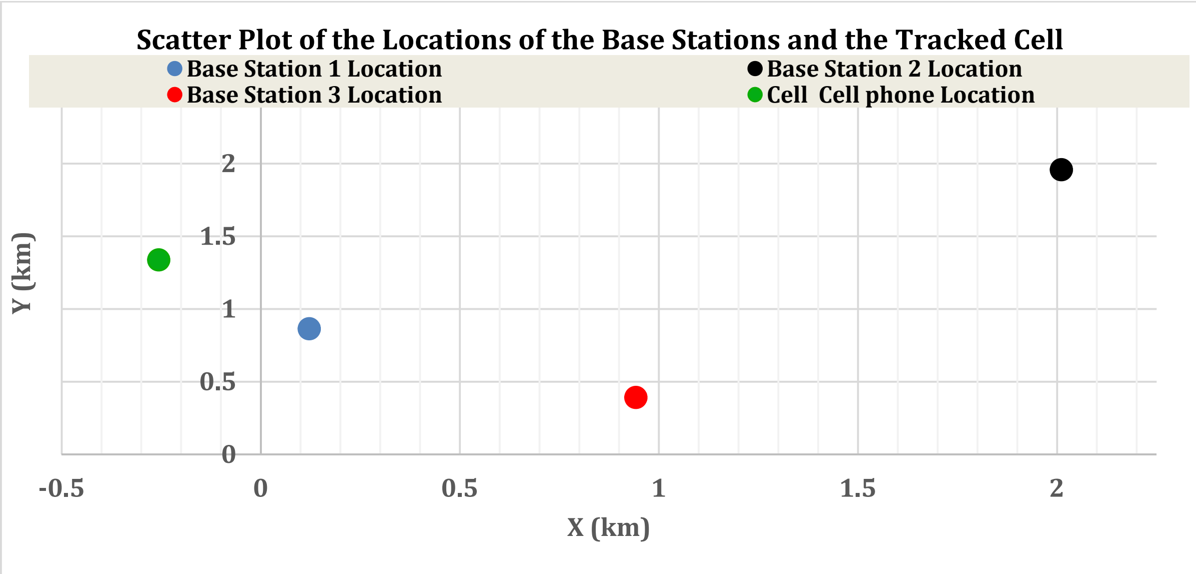


**Figure 1 The scatter plot of the locations of the base stations and the tracked cell phone when x is negative and y is positive.**

Table 2 The results of the second test case showing the values of $RSSI_1, RSSI_2, RSSI_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ that are used to determine $d_1$, $d_2$ and $d_3$ and the location (x,y ) of a cell phone, when x is positive and y is positive.

| | X (km) | Y (km) | RSSI (dBm) | d in km (Distance in km from the tracked Cell Phone based on RSSI |
|---|---|---|---|---|
| Base Station 1 | 0.306 | 0.653 | -71.628 | 1.427 |
| Base Station 2 | 0.108 | 1.365 | -87.267 | 0.956 |
| Base Station 3 | 0.247 | 1.178 | -84.274 | 0.801 |
| Tracked Cell Phone | 1.469 | 2.149 | | |

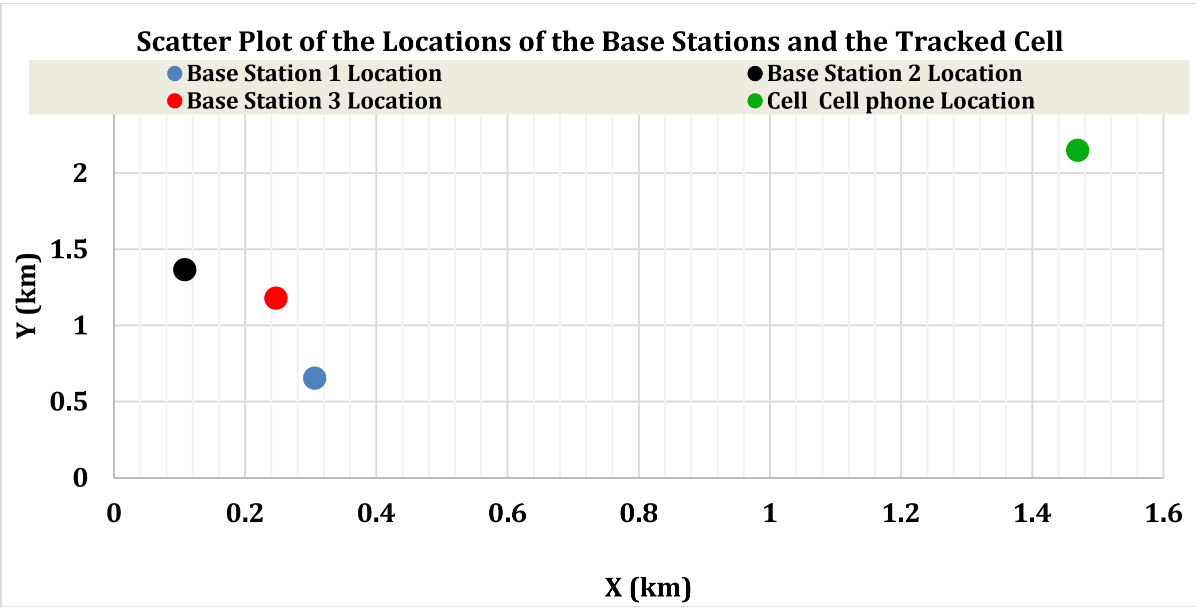


**Figure 2 The scatter plot of the locations of the base stations and the tracked cell phone when x is positive and y is positive.**

Table 3 The results of the third test case showing the values of $RSSI_1, RSSI_2, RSSI_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ that are used to determine $d_1$, $d_2$ and $d_3$ and the location (x,y ) of a cell phone, when x is negative and y is negative.

| | X (km) | Y (km) | RSSI (dBm) | d in km (Distance in km from the tracked Cell Phone based on RSSI |
|---|---|---|---|---|
| Base Station 1 | 1.342 | 0.935 | -91.225 | 0.464 |
| Base Station 2 | 1.147 | 1.475 | -94.024 | 1.425 |
| Base Station 3 | 1.215 | 1.353 | -93.445 | 1.377 |
| Tracked Cell Phone | -1.233 | -1.37 | | |

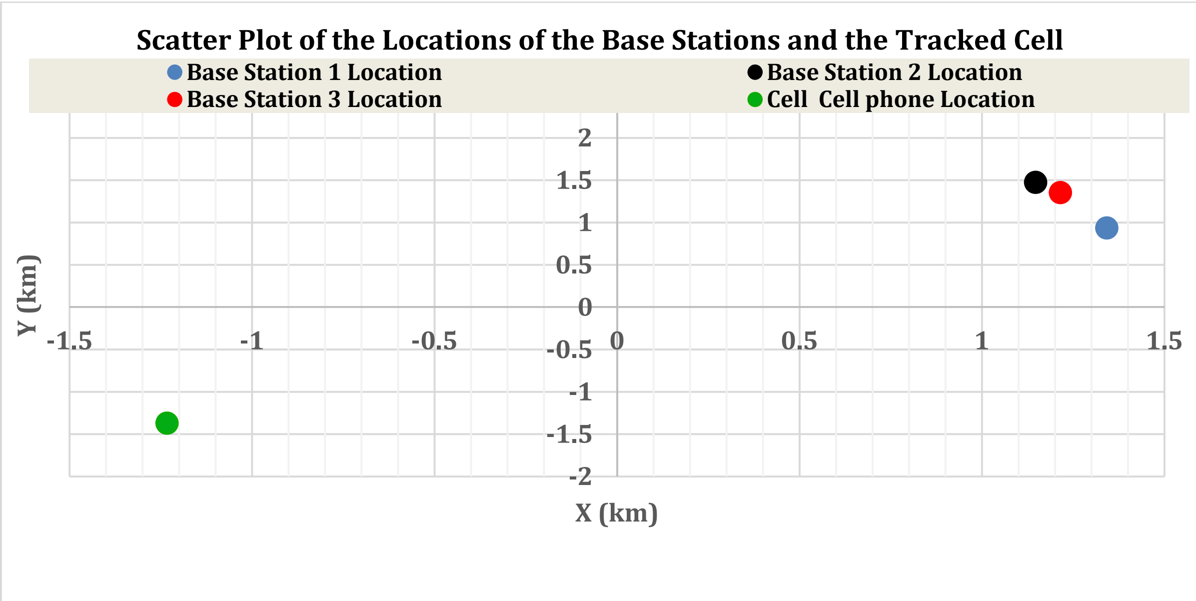


**Figure 3 The scatter plot of the locations of the base stations and the tracked cell phone when x is negative and y is negative.**

Table 4 The results of the fourth test case showing the values of $RSSI_1, RSSI_2, RSSI_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ that are used to determine $d_1$, $d_2$ and $d_3$ and the location (x,y ) of a cell phone, when x is positive and y is negative.

| | X (km) | Y (km) | RSSI (dBm) | d in km (Distance in km from the tracked Cell Phone based on RSSI |
|---|---|---|---|---|
| Base Station 1 | 1.077 | 0.899 | -87.749 | 0.523 |
| Base Station 2 | 0.35 | 0.073 | -51.356 | 0.115 |
| Base Station 3 | 1.671 | 1.574 | -98.368 | 1.841 |
| Tracked Cell Phone | 1.599 | -0.451 | | |

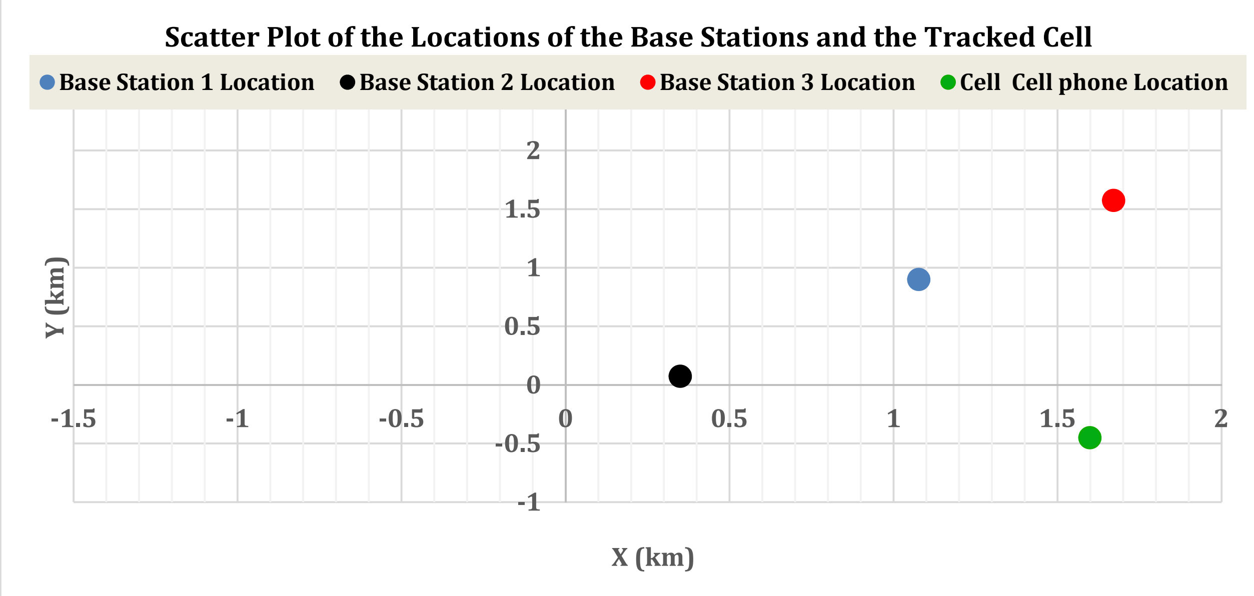


**Figure 4 The scatter plot of the locations of the base stations and the tracked cell phone when x is positive and y is negative.**

The complete input dataset used to evaluate the calgorithm is presented in Table 5. The table shows the coordinates of the three base stations used at each point along with the RSSI values of the signal received by the cell phone from each of the base stations. The corresponding path loss is also shown for each of the RSSI values. The results of the computations using the input dataset in Table 5 are given in Table 6. The results show the path length and the corresponding cell phone location coordinates for each data record in Table 5.

Table 5 The values of $\mathrm{RSSI}_1, \mathrm{RSSI}_2, \mathrm{RSSI}_3$, $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ and the corresponding pathloss that are used to determine the location (x,y ) of a cell phone

| S/N | X1 | Y1 | RSSI 1 (dB) | Pathloss 1 (dB) | X2 | Y2 | RSSI 2 (dB) | Pathloss 2 (dB) | X3 | Y3 | RSSI 3 (dB) | Pathloss 3 (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.122 | 0.864 | -76.6 | 132.1 | 2.011 | 1.957 | -102.3 | 157.8 | 0.942 | 0.392 | -80.3 | 135.8 |
| 2 | 1.394 | 0.193 | -87.8 | 143.3 | 0.342 | 0.492 | -66.6 | 122.1 | 2.006 | 1.509 | -100.1 | 155.6 |
| 5 | 1.066 | 1.422 | -93.0 | 148.5 | 0.405 | 1.373 | -88.2 | 143.7 | 1.318 | 0.550 | -88.2 | 143.7 |
| 7 | 1.672 | 1.305 | -96.7 | 152.2 | 0.694 | 0.139 | -71.1 | 126.6 | 0.390 | 0.386 | -64.2 | 119.7 |
| 8 | 1.671 | 0.069 | -91.7 | 147.2 | 1.945 | 0.521 | -95.7 | 151.2 | 0.875 | 0.588 | -81.2 | 136.7 |
| 10 | 0.306 | 0.653 | -71.6 | 127.1 | 0.108 | 1.365 | -87.3 | 142.8 | 0.247 | 1.178 | -84.3 | 139.8 |
| 11 | 1.348 | 1.085 | -92.4 | 147.9 | 1.508 | 1.726 | -98.3 | 153.8 | 1.205 | 1.397 | -93.7 | 149.2 |
| 14 | 1.326 | 1.676 | -96.8 | 152.3 | 1.120 | 1.380 | -93.0 | 148.5 | 1.191 | 1.317 | -93.0 | 148.5 |
| 17 | 0.884 | 1.086 | -87.7 | 143.2 | 2.009 | 0.790 | -97.1 | 152.6 | 1.261 | 1.299 | -93.3 | 148.8 |
| 18 | 1.687 | 0.665 | -93.4 | 148.9 | 0.616 | 1.872 | -95.2 | 150.7 | 0.542 | 1.932 | -95.6 | 151.1 |
| 19 | 0.171 | 0.216 | -42.7 | 98.2 | 1.433 | 0.002 | -88.2 | 143.7 | 1.685 | 0.427 | -92.5 | 148.0 |
| 21 | 0.354 | 1.592 | -91.1 | 146.6 | 1.102 | 0.867 | -87.7 | 143.2 | 1.492 | 0.483 | -90.3 | 145.8 |
| 22 | 0.799 | 0.865 | -83.8 | 139.3 | 1.427 | 0.942 | -92.2 | 147.7 | 0.703 | 0.244 | -72.4 | 127.9 |
| 23 | 1.699 | 0.186 | -92.2 | 147.7 | 1.362 | 1.574 | -96.3 | 151.8 | 1.194 | 1.241 | -92.3 | 147.8 |
| 26 | 0.816 | 0.574 | -79.8 | 135.3 | 2.042 | 0.963 | -98.0 | 153.5 | 1.798 | 1.353 | -97.9 | 153.4 |
| 27 | 1.077 | 0.899 | -87.7 | 143.2 | 0.350 | 0.073 | -51.4 | 106.9 | 1.671 | 1.574 | -98.4 | 153.9 |
| 28 | 0.852 | 1.077 | -87.3 | 142.8 | 0.067 | 0.359 | -52.0 | 107.5 | 0.533 | 0.716 | -77.0 | 132.5 |
| 29 | 1.342 | 0.935 | -91.2 | 146.7 | 1.147 | 1.475 | -94.0 | 149.5 | 1.215 | 1.353 | -93.4 | 148.9 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **30** | **1.283** | **1.789** | **-97.5** | **153.0** | **1.802** | **0.968** | **-96.0** | **151.5** | **0.046** | **0.851** | **-75.9** | **131.4** |
| **31** | **0.597** | **1.059** | **-84.5** | **140.0** | **1.368** | **0.312** | **-87.7** | **143.2** | **0.869** | **1.721** | **-94.7** | **150.2** |
| **33** | **0.032** | **1.303** | **-86.1** | **141.6** | **0.754** | **1.241** | **-88.5** | **144.0** | **0.330** | **0.524** | **-67.6** | **123.1** |
| **35** | **0.342** | **0.492** | **-66.6** | **122.1** | **1.636** | **1.468** | **-97.4** | **152.9** | **0.854** | **1.231** | **-89.3** | **144.8** |
| **36** | **0.217** | **1.382** | **-87.7** | **143.2** | **0.927** | **1.980** | **-97.3** | **152.8** | **2.009** | **0.790** | **-97.1** | **152.6** |
| **37** | **0.761** | **0.591** | **-79.0** | **134.5** | **0.884** | **1.086** | **-87.7** | **143.2** | **0.616** | **1.872** | **-95.2** | **150.7** |
| **38** | **0.405** | **1.373** | **-88.2** | **143.7** | **1.687** | **0.665** | **-93.4** | **148.9** | **1.433** | **0.002** | **-88.2** | **143.7** |
| **39** | **1.001** | **1.421** | **-92.5** | **148.0** | **0.171** | **0.216** | **-42.7** | **98.2** | **1.362** | **0.945** | **-91.5** | **147.0** |
| **40** | **0.694** | **0.139** | **-71.1** | **126.6** | **0.272** | **1.249** | **-85.6** | **141.1** | **1.102** | **0.867** | **-87.7** | **143.2** |
| **42** | **1.881** | **0.458** | **-94.8** | **150.3** | **0.799** | **0.865** | **-83.8** | **139.3** | **1.362** | **1.574** | **-96.3** | **151.8** |
| **43** | **0.108** | **1.365** | **-87.3** | **142.8** | **1.699** | **0.186** | **-92.2** | **147.7** | **0.364** | **0.659** | **-72.8** | **128.3** |
| **45** | **0.550** | **0.704** | **-77.1** | **132.6** | **0.124** | **0.314** | **-49.5** | **105.0** | **2.042** | **0.963** | **-98.0** | **153.5** |
| **48** | **1.927** | **0.014** | **-94.7** | **150.2** | **0.852** | **1.077** | **-87.3** | **142.8** | **1.147** | **1.475** | **-94.0** | **149.5** |
| **49** | **0.854** | **1.231** | **-89.3** | **144.8** | **1.342** | **0.935** | **-91.2** | **146.7** | **1.802** | **0.968** | **-96.0** | **151.5** |

Table 6 The values of $(x_1, y_1)$, $(x_2, y_2)$ and $(x_3, y_3)$ and the corresponding path lengths $d_1$, $d_2$ and $d_3$ that are used to determine the location (x,y ) of a cell phone

| S/N | X1 | Y1 | X2 | Y2 | X3 | Y3 | $d_1$ | $d_2$ | $d_3$ | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.122 | 0.864 | 2.011 | 1.957 | 0.942 | 0.392 | 0.508 | 2.327 | 0.634 | -0.256 | 1.338 |
| 2 | 1.394 | 0.193 | 0.342 | 0.492 | 2.006 | 1.509 | 2.288 | 0.282 | 2.041 | -1.172 | 1.789 |
| 3 | 1.066 | 1.422 | 0.405 | 1.373 | 1.318 | 0.55 | 1.917 | 1.012 | 1.012 | -1.099 | -0.878 |
| 4 | 1.672 | 1.305 | 0.694 | 0.139 | 0.39 | 0.386 | 1.703 | 0.369 | 0.245 | 0.089 | 0.454 |
| 5 | 1.671 | 0.069 | 1.945 | 0.521 | 0.875 | 0.588 | 1.606 | 1.57 | 0.667 | 0.699 | 1.094 |
| 6 | 0.306 | 0.653 | 0.108 | 1.365 | 0.247 | 1.178 | 1.427 | 0.956 | 0.801 | 1.469 | 2.149 |
| 7 | 1.348 | 1.085 | 1.508 | 1.726 | 1.205 | 1.397 | 1.345 | 1.831 | 1.4 | -0.802 | 0.758 |
| 8 | 1.326 | 1.676 | 1.12 | 1.38 | 1.191 | 1.317 | 1.126 | 1.338 | 1.338 | 0.796 | 2.708 |
| 9 | 0.884 | 1.086 | 2.009 | 0.79 | 1.261 | 1.299 | 0.944 | 1.71 | 1.369 | 0.4 | 0.393 |
| 10 | 1.687 | 0.665 | 0.616 | 1.872 | 0.542 | 1.932 | 0.889 | 1.525 | 1.561 | -0.19 | -0.557 |
| 11 | 0.171 | 0.216 | 1.433 | 0.002 | 1.685 | 0.427 | 0.838 | 1.012 | 1.3 | 0.716 | 0.356 |
| 12 | 0.354 | 1.592 | 1.102 | 0.867 | 1.492 | 0.483 | 0.745 | 0.983 | 1.14 | -0.122 | 0.637 |
| 13 | 0.799 | 0.865 | 1.427 | 0.942 | 0.703 | 0.244 | 0.702 | 1.278 | 0.397 | 0.277 | 0.306 |
| 14 | 1.699 | 0.186 | 1.362 | 1.574 | 1.194 | 1.241 | 0.662 | 1.633 | 1.286 | 0.993 | -0.054 |
| 15 | 0.816 | 0.574 | 2.042 | 0.963 | 1.798 | 1.353 | 0.555 | 1.8 | 1.789 | 0.237 | 0.758 |
| 16 | 1.077 | 0.899 | 0.35 | 0.073 | 1.671 | 1.574 | 0.523 | 0.115 | 1.841 | 1.599 | -0.451 |
| 17 | 0.852 | 1.077 | 0.067 | 0.359 | 0.533 | 0.716 | 0.493 | 0.119 | 0.522 | -0.096 | 1.166 |
| 18 | 1.342 | 0.935 | 1.147 | 1.475 | 1.215 | 1.353 | 0.464 | 1.425 | 1.377 | -1.233 | -1.37 |
| 19 | 1.283 | 1.789 | 1.802 | 0.968 | 0.046 | 0.851 | 0.438 | 1.597 | 0.488 | -0.077 | 1.79 |
| 20 | 0.597 | 1.059 | 1.368 | 0.312 | 0.869 | 1.721 | 0.413 | 0.983 | 1.483 | 0.163 | 0.373 |
| 21 | 0.032 | 1.303 | 0.754 | 1.241 | 0.33 | 0.524 | 0.367 | 1.029 | 0.299 | -0.257 | 1.157 |
| 22 | 0.342 | 0.492 | 1.636 | 1.468 | 0.854 | 1.231 | 0.326 | 1.739 | 1.077 | 0.418 | 0.241 |
| 23 | 0.217 | 1.382 | 0.927 | 1.98 | 2.009 | 0.79 | 0.307 | 1.729 | 1.71 | -0.08 | 0.034 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 0.761 | 0.591 | 0.884 | 1.086 | 0.616 | 1.872 | 0.29 | 0.983 | 1.525 | -0.035 | 0.159 |
| 25 | 0.405 | 1.373 | 1.687 | 0.665 | 1.433 | 0.002 | 0.273 | 1.377 | 1.012 | 0.259 | 0.88 |
| 26 | 1.001 | 1.421 | 0.171 | 0.216 | 1.362 | 0.945 | 0.257 | 0.069 | 1.228 | -1.42 | 2.175 |
| 27 | 0.694 | 0.139 | 0.272 | 1.249 | 1.102 | 0.867 | 0.243 | 0.867 | 0.983 | 0.381 | 0.343 |
| 28 | 1.881 | 0.458 | 0.799 | 0.865 | 1.362 | 1.574 | 0.216 | 0.778 | 1.633 | 1.143 | -0.548 |
| 29 | 0.108 | 1.365 | 1.699 | 0.186 | 0.364 | 0.659 | 0.203 | 1.278 | 0.406 | 0.669 | 1.135 |
| 30 | 0.55 | 0.704 | 0.124 | 0.314 | 2.042 | 0.963 | 0.181 | 0.103 | 1.8 | 1.256 | -0.525 |
| 31 | 1.927 | 0.014 | 0.852 | 1.077 | 1.147 | 1.475 | 0.151 | 0.956 | 1.425 | 0.947 | -0.32 |
| 32 | 0.854 | 1.231 | 1.342 | 0.935 | 1.802 | 0.968 | 0.143 | 1.207 | 1.597 | 0.639 | 2.754 |

## 4. Conclusion

The use of measured received signal strength intensity (RSSI) and trilateration method to determine the location of cell phone is presented. The RSSI value is used to first determine the path loss and then the Hata path loss model is used to compute the path length of each of the three base stations to the cell phone. Then the coordinates of the three base stations and the correspond path lengths to the cell phone are used in the trilateration method to determine the cell phone location.

Also presented is the algorithm for a program that can be used to perform the computation. Some sample RSSI and base stations' coordinate dataset are used to evaluate the applicability of algorithm. In all, the results which are presented in tables and scatter plots shows that the algorithm can effectively be used to estimate the location of a cell phone when the RSSI value and the corresponding coordinates of three base stations are given.

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