Mobile location of UMTS network based on existing network planning software and measurement report from RNC

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Abstract— **In radio mobile system, mobile location is an important service for the operator itself and for the end user. It is necessary then to increase accuracy of location result with respect of quality price ratio. In this paper we propose to use the output of planning network software and measurement report of RNC in UMTS network to get the geographical coordinates of mobile, by RSSI method. We will use application case of part of Antananarivo city, and we will see the impact of propagation model on the positioning of UMTS mobile in this area**

Index Terms— Positioning, RSSI, propagation.

I. INTRODUCTION

The radio channel is subject to numerous phenomena affecting the transmission of the signal between the transmitter and the receiver. The RSSI mobile location method uses these signal parameters to obtain the position of the target.

It is important to determine the impacts of these parameters on the accuracy of location. For this purpose, additional measure tool or equipment may be required as well as many drive test. However, this entail supplementary high costs.

In this paper, we propose to study the impact of the channel model using existing network planning software on the RSSI location. In first place, we will introduce the fundamentals of RSSI location. Secondly, we will show the RSSI location method by radio frequency fingerprint, and description of essentials parameters to be used in.

Before illustrating by simulation in a part of Antananarivo city, we will presents the flow of the location process used, in view to clarify all steps needed.

Finally, we will summarize the main conclusions of this study and propose some points of improvement in perspective

II. FUNDAMENTALS OF RSSI LOCATION

Let's consider a system with m anchors which the estimated distance to the target point is d_i. The mobile presents signal strength of P_r. The received signal strength RSS (dBm) from the ith anchor where the distance d_i is given by:

$$P_r(d_i) = P_t - \left(\overline{PL}(d_i) + \mathcal{M}_{F_i} + X_{\sigma_i}\right) \quad (1)$$

where $P_t\,(\mathrm{dBm})$ is the transmission power of the mobile and $\overline{PL}(d_i)\,(\mathrm{dB})$ is the mean propagation loss or propagation loss in terms of distance d_i.

Generally, the fast fading $\mathcal{M}_F\,(\mathrm{dB})$ varies abruptly (30 to 40dB) along the distance only for a fraction of wavelength. In the other hand X_{σ_i} represents, the slow fading and shadowing, We can deduct distance d_i by the relation between received power $P_r(d_i)$ and the propagation loss model for $\overline{PL}(d_i)$ [3]

III. RADIO FREQUENCY FINGERPRINT RSSI LOCATION METHOD

The Radio frequency (RF) fingerprint RSSI location method is classified as mobile positioning, and can be applied to the wireless network. [4]

All the location technique based on the RF fingerprint can be divided into two steps: the training step where database CDB containing all anchors RSSI and coordinates is created, and the test phase or operational phase where the estimation of the mobile positioning is done.

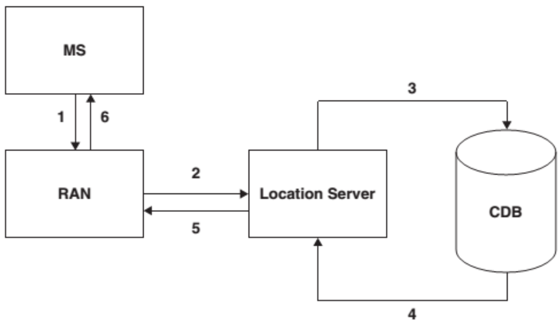

Fig. 1 RF fingerprint RSSI diagramm

A. *Matrix model of target*

For the target,to be localized we will use matrix of $N_a \times 3$ dimension.

$$\mathbf{F} = \begin{bmatrix} ID_1 & RSS_1 & RTD_1 \\ \vdots & \vdots & \vdots \\ ID_{N_a} & RSS_{N_a} & RTD_{N_a} \end{bmatrix} \quad (2)$$

Where N_a is the number of anchor to be used; ID_i and RSS_i are the cell identity and the received signal strength of the ith anchor; and RTD_i is the round trip delay between the MS and the ith anchor

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B. Matrix model of the anchor

The RF fingerprint in pixel (i, j) is represented by

$$S_{i,j} = \begin{bmatrix} ID_{i,j,1} & RSS_{i,j,1} & RTD_{i,j,1} \\ \vdots & \vdots & \vdots \\ ID_{i,j,N_{ij}} & RSS_{i,j,N_{ij}} & RTD_{i,j,N_{ij}} \end{bmatrix} \quad (3)$$

Where $ID_{i,j,k}$ is the cell identity of the kth cell

For the anchor and the target matrix, the line are in decreasing order according to the RSS value, it means that $RSS_{i,j,k'} \geq RSS_{i,j,k''}$ if , $k' \leq k''$

C. Search space reduction

Initially, the search space contain all anchors of the CDB elements. However it is difficult to compare the target RF fingerprint to all references RF fingerprints in the database. It will implies a high load of calculation and thus very long time to output the location result. It is then needed to reduce the search space. It will contain three steps.

In the first step, the search space is restricted to the CDB elements within the best server area of the sector with the highest RSS in the target RF.

In the second step, the result search space of first step is restricted to the elements whose best server RTD values are equal to the best server RTD value in the target RF fingerprint.

In the third step, the result search space of second step is restricted to the elements whose reference RF fingerprints contain the first N cells listed in the target RF fingerprint.

If we represents by $\mathcal{A}$ the original search space containing all the CDB elements. We have:

$$\gamma = 1 - \frac{\neq \mathcal{D}}{\neq \mathcal{A}} \quad (4)$$

Where γ is search space reduction factor, $\neq \mathcal{D}$ is the number of element of the reduced search space. $\mathcal{D} \subset \mathcal{A}$.

D. Distance calculation between the target and the anchor selected

The Euclidian distance between the RF fingerprint target $\mathbf{F}$ and the RF fingerprint anchors $\mathbf{S}'_{i,j}$in the RSS dimension is given by:

$$d_{i,j} = \sqrt{\sum_{k=1}^{N} \left(\left| \frac{\mathbf{S}'_{i,j}(n_k, 2) - \mathbf{F}(k, 2)}{\delta} \right| \right)^2} \quad (05)$$

Where n_k is the index of the line of $\mathbf{S}'_{i,j}$ where the CID is the same as the CID of kth line of $\mathbf{F}$: $\mathbf{S}'_{i,j}(n_k, 1) = \mathbf{F}(k, 1)$ with $n_k \in [1, N_{i,j}]$.

The parameter $N_{i,j}$ is the number of line in $\mathbf{S}'_{i,j}$. The parameter δ represents the mobile inherent RSS measurement inaccuracy in decibel units.

IV. Description of Parameters Measures in UMTS

Measures related to the anchor come from the existing network planning software, while the measures related to the target come from measurement report of RNC of given user through his IMSI and the RRC protocol

A. CID, PSC and RTD

During the research phase of cell, the mobile determine the exact PSC used by the cell. The PSC is typically identified by the correlation symbol by symbol through CPICH. The PSC value is in $[0{,}512]$ [5]

In monitored set, only the PSC is known. To determine which cells are in fact communicating with the mobile, it is necessary to use Cell IDs. When CID is available it means that they are in active set.

In our case, the RTD take the value 0 when the corresponding cell is in the active set and -1 when the cell is in the monitored set.

B. RSSI, RSCP, Ec/No

The P-CPICH RSCP is the received power on one code measured on the P-CPICH RSCP

The UTRA carrier RSSI is the received wide band power, including thermal noise and noise generated in the receiver.

The CPICH Ec/N0 is the received energy per chip divided by the power density in the band.

These measures are liaised by following equation: [6]

$$Ec/No = \frac{P - CPICH\ RSCP}{UTRA\ carrier\ RSSI} \quad (6)$$

The RSSI measures of anchor are directly available from the network planning software. For the target, the data from the RNC are the RSCP and the Ec/No, and we use the formula (6) to get the related RSSI

V. Description of Location Process Used

We presents below the diagram of the location process used. The data of base station are stored in text file to be read and inserted to the software, as well as the data of fictional mobile.

The data of the base stations of this file are composed, inter alia, of their geographical coordinates, the heights and the azimuths of their antennas.

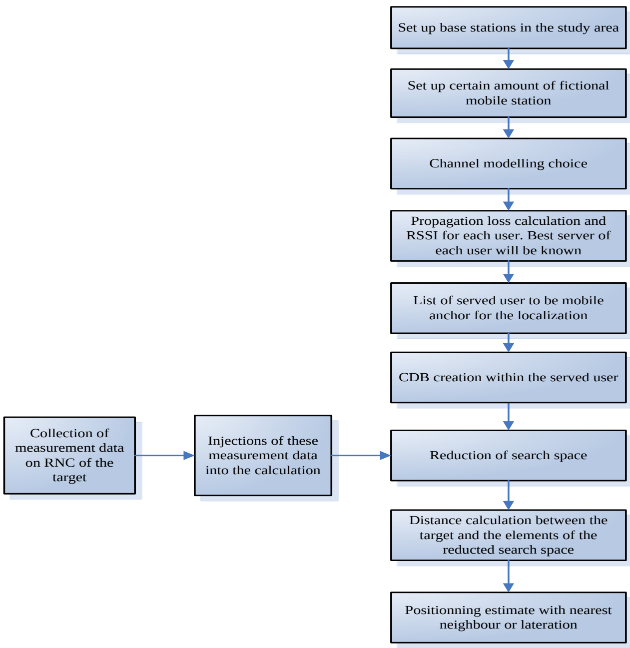

Fig. 2 Diagram of location process

The GPS coordinates of the base stations will be transformed into Cartesian coordinates, a base station is chosen to be the reference (0,0).

Then the calculations of propagation losses follow, to arrive at the calculations of RSSI of each fictional mobile user.

Each user will have their best server according to the level of RSSI calculated. The served user will be mobile anchor for the location system. At this stage the CDB is created. All anchor will have in this way the form of equation (3) of section III.

The input data of the target will be collected from RNC by launching tracing within a specific IMSI of the mobile target.

The RNC will output then the CID, the RSCP and the Ec/No of mobile target in his active cell set and his monitored cell set. The target will have matrix form of equation (2) in the section III.

Getting the form of mobile target and mobile anchor, we follow up with the search space reduction, and then calculation of Euclidian distances between the element of the reduced search area and the target. After, we will get the coordinates of estimated location of the target by the method of nearest neighbors or by lateration.

VI. Simulation

Our application case was done on a part of urban area of Antananarivo City, on UMTS network, frequency of 2,1 GHz.

The area is 6x6 km² with 51 cells. The plan used has 50m of resolution

A. Set up base station and mobile station

We have put 2000 fictional users in the first place for the process of getting CDB of mobile reference. The cell of Akorondrano has been chosen to be the original point (0,0).

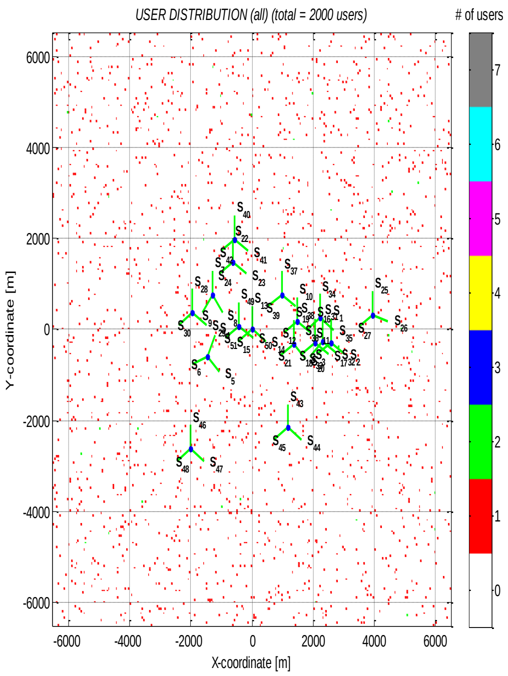

Fig. 3 Set up base station and mobile station

B. Numeric values examples for target matrix and anchors matrix

To illustrate the anchor matrix, let’s take examples from the Okumara Hata model and UMTS Pedestrian model used.

$$S177(OH) = \begin{bmatrix} 22 & -57{,}7977 & 0 \\ 1 & -61{,}2747 & -1 \\ \cdots & \cdots & \cdots \\ 9 & -105{,}2404 & -1 \\ 48 & -111{,}963 & -1 \end{bmatrix} \quad (7)$$

$$S581(UP) = \begin{bmatrix} 1 & -57{,}7845 & 0 \\ 27 & -62{,}0353 & -1 \\ \cdots & \cdots & \cdots \\ 48 & -124{,}3721 & -1 \\ 6 & -130{,}4506 & -1 \end{bmatrix} \quad (8)$$

For the target point, the data are extracted from the measurements provided by the RNC. The raw data is not usable, so we had to process the data for a more readable form.

For example, for one test done in Akorondrano area, the raw data are like following:

```
Ligne; CID1; RNC1; CID2; RNC2; CID3; measID; OFF; TM; PSC; EcNO;;;
1;39029;2;;;;1;6;25088;267;-5;;;
1;39029;2;;;;1;6;25343;259;-8;;;
1;39029;2;;;;1;6;25600;259;-10,5;;;
2;39029;2;29029;2;;11;6;25088;267;-4;;;
2;39029;2;29029;2;;11;6;25344;259;-7;;;
2;39029;2;29029;2;;11;6;25599;251;-15;;;
3;39029;2;29029;2;;1;6;25088;267;-3,5;;;
3;39029;2;29029;2;;1;6;25344;259;-12;;;
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Fig. 3 Processed test data in Akorondrano area

We take the line where most number of cell are included

For Akorondrano case we have:

$$F_{Ak} = \begin{bmatrix} 50 & -49 & 0 \\ 51 & -51 & 0 \\ 15 & -51{,}5 & 0 \\ 14 & -51{,}5 & 0 \\ 13 & -52 & -1 \end{bmatrix} \quad (9)$$

For Alarobia case we have :

$$F_{Al} = \begin{bmatrix} 30 & -69{,}5 & 0 \\ 9 & -69{,}5 & 0 \\ 8 & -70 & -1 \end{bmatrix} \quad (10)$$

C. Search space reduction factor

The following table shows us the search space reduction factor via Okumara Hata (OH) model and UMTS Pedestrian Model (UP)

	Search Space Reduction Factor		Mobile Anchor	
	OH	UP	OH	UP
Akorondrano	0,9995	0,9995	S1356	S512
Alarobia	0,994	0,9975	S1566, S1398,S1039	S1132, S97

Table. 1 Search space reduction by type of channel modelling

D. Location result by nearest neighbor

The blue estimated position represents the channel modelling of Okumara Hata. The green is the UMTS Pedestrian model. In Akorondrano area, modelling of Okumara Hata gives a location closer to the actual position.

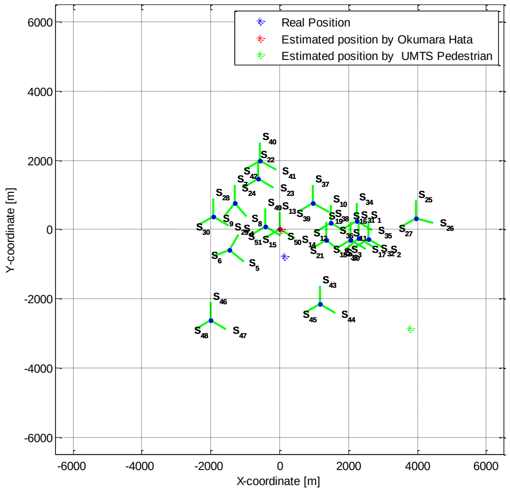

Fig 4 Estimated position by nearest neighbor

E. Location result by lateration method

In the Alarobia area, the two modelling of Okumura Hata and UMTS Pedestrian give roughly the same error distances.

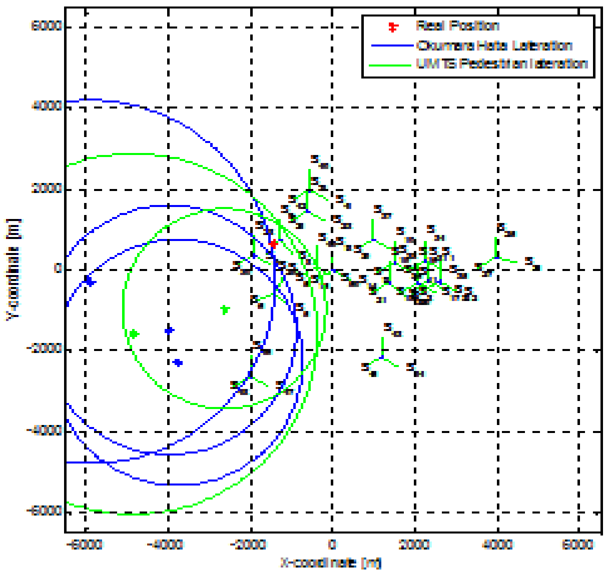

Fig 5 Estimated position by lateration

F. Cumulative distribution function of position errors

The error median obtained for Okumara Hata is 341.71 meters, while that of UMTS Pedestrian is 331.66 meters.

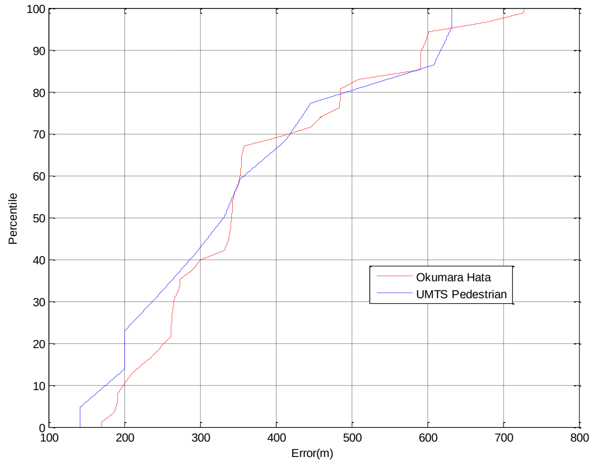

Fig 6 Cumulative distribution of error

VII. Conclusion and Prospects

In these examples, certain errors are still high when we are using RF fingerprint RSSI location method within network planning software and practical measures from RNC. The prospects envisaged will then to find means of minimizing these errors

We can in this way, add some practical values of drive test in the database for the area where modelling channel is more difficult.

With the mobile technology evolution, it is interesting to use combined location method like RSSI-TOA to optimize again the accuracy of the mobile positioning.

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