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POSITIONING TECHNIQUE USING ONE HEARABLE UMTS CELL TO PREDICT ROAD USERS

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ABSTRACT

Timing trilateration requires timing information from three herbal UMTS base stations to accurately predict the position of mobile users. But, when only the serving UMTS cell is hearable, the Round Trip Time (RTT) of the cell is used, along with Telco's beamwidth information, and a new technique called One Cell Road Angle Algorithm (OCRAA) to determine the proximity of the mobile users' location. OCRAA ensures that the stored road point falls within the serving cell's coverage based on a pre-calculated variable called Average Beamwidth (Abwt) for the antenna configuration of all cells covering the map's road points. For an urban road in Kuala Lumpur (Malaysia), the simulation results produced location accuracy error of 65 meters for 95% of the experiment's data, which is considered very desirable for navigational services

Keywords: *Location Technique, Positioning For Umts, Navigation, Round Trip Time, Trilateration,*

1. INTRODUCTION

For navigation and emergency search, it is very important to accurately predict the position or location of the mobile users. FCC in the USA has provided a benchmark to Telecommunication operators (Telco) that for E-911 location search accuracy to be within 100 m for 67% of the searches and within 300m for 95% of the searches. Timing techniques that use trilateration from three or more Base Stations (BS) provides more accurate results to predict the user's location [1]. But in UMTS, it is not always achievable to obtain three hearable unique BS for this purpose due to limitations such as multipath and geographical profile of the cellular area. Therefore, in this study, using UMTS's RTT of the existing serving cell, the serving cell's antenna information, road networks being covered by the serving cell (through the knowledge of the Location Area Code), and with a proposed matching algorithm for road points called OCRAA, the prediction of mobile users travelling on roads during emergency searches and navigation purposes becomes more accurate. For this experiment, all the road points within an urban area (from Menara Celcom to Wangsa Melawati) were stored in a database, along with the coordinates of the BS covering this area, antenna cell information (such as three sector cells of BS), each cells beamwidth, and the Telco's Node B's directional antenna beam [2]. Since the exact beamwidth of Telco's cells towards the coverage area is not always accurate, therefore, a parameter called Abwt would be utilized where an average beam width for each cell would be determined through running a program script after drive tests for radio coverage has been conducted. This parameter would then be used during location search (through simulation) by the OCRAA algorithm, along with the knowledge of the Cell ID (Cell Identification) of the serving cell, antenna information, and its RTT information which will be extracted by Universal Intelligent Positioning System (UIPS) from the Telco's network [3].

In this paper, the OCRAA algorithm and the simulation parameters are emphasized, and followed by the results and discussion that promotes the usage of location search for navigational and emergency search services when only one herbal cell is available for location determination through the Telco's network.

2. ALGORITHM AND SIMULATION ENVIRONMENT

When hearbility (network does not detect more neighboring BS) of the User Equipment (UE) is limited to only the serving cell, initially the Cell ID's coordinate could be used to estimate the possible coverage of the user. A cell ID's coverage area in urban surrounding's could be from 50m to

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up to 1Km, but the usage timing trilateration technique such as the Observe Time Difference of Arrival (OTDOA) from at least three BS provide a better location accuracy than just using one BS or cell's information. Therefore, there is a need to develop a new technique, OCRAA where only road points within the one cell's coverage are evaluated for determining the user's position [4]

3. ALGORITHM TO GENERATE AND STORE ABWT

In general, drive test is conducted regularly by the Telco for coverage optimization purposes. For this research, the following information would be required and evaluated within an urban area such as, all Cell ID's coordinate, all road points or discrete point coordinates that passes through the area being studied, all cell antenna's beam directions, Telco's planned beam width of each cell, and BS antenna configuration (such as 3 or 6 sectored cells, directional or omni). From our tests, actual beamwidth can never be similar to the Telco's planned beam, therefore a parameter called *Abw*t (Average Beamwidth) for cells (such as for 3 sector cell configuration) covering roads (within the urban map area) would be used here to be initially determined by the following program that was written in Matlab.

OCRAA finds the closest BS (cell) to road networks and then ensures the UE estimated is within cell coverage's beamwidth or otherwise it may provide the closest distance to serving cell but not the closest to actual UE [5].

```
srroad=size(rroad);% load sample road
for k=1:srroad(1,1)
disr(k)=sqrt((BS1(i,1)-rroad(k,1))^2+(BS1(i,2)-
rroad(k,2))^2); end
d1=d(1);%time of arrival from Node B to UE
[adr,bdr]=sort(abs(disr-d1));% d1 is the time of
arrival (with multipath delays)
Run this at dag=60 degrees
[a,b]=max(Dcheck1);%check maximum error point
az1=azimuth(BS1(b,2),BS1(b,1),UE_estimated(b,2)
,UE_estimated(b,1));
```

BS1(b,4), compare the azimuth of UE estimated to BS1 and also check the directional angle of BS1(Node B). Then run at dag=360° and insert the position *b* into azimuth and find the worst *Abwt* for this urban of 3 cells sector with planned 60° beamwidth. Dag is the new value for this simulation, for example we use, 71°.

4. ALGORITHM TO RUN OCRAA AND SIMULATE LOCATION ESTIMATION

When the Cell ID's Abwt has been stored as above, and location estimation is required for the serving cell, the RTT command is invoked by UIPS. For this simulation, RTT divided by 2 is the time of arrival, where multipath delays between 0 to 25 µs will be added to the time of arrival to represent between the first to the third ray of the 12 ray model for UMTS [6]. In general, time delays will also cause the distance findings (based on time-distance relationship) to be slightly erroneous. The following pseudo code is the proposed algorithm to determine the estimated position of the mobile user.

```
for j=1:length(bdr)
UE=[rroad(bdr(j),1) rroad(bdr(j),2)];
azm1=azimuth(BS1(i,2),BS1(i,1),UE(2),UE(1));
bangle=BS1(i,4); %(directional angle information
is stored in column 4 for each BS in our database)
dag=71; % dag value will be the Abwt value
if abs(bangle-azm1)<dag&azm1<(360-
dag)&bangle<(360-dag)
   app(j)=1;
elseif bangle>=(360-dag)&azm1<(360-dag)
   if azm1<=dag&abs(azm1+360-bangle)<dag
      app(j)=1;
   elseif azm1>dag&abs(bangle-azm1)<dag
      app(j)=1;
   else
app(j)=0;
   end
elseif bangle>=(360-dag)&azm1>=(360-
dag)&abs(bangle-azm1)<dag
   app(j)=1;
elseif bangle<(360-dag)&azm1>=(360-dag)
   if bangle<=dag&abs(bangle+360-azm1)<dag
      App (j) =1;
   elseif bangle>dag&abs(azm1-bangle)<dag
      app(j)=1;
   else
      app(j)=0;
   end
else
   app(j)=0;
end; end
[abbr,bbdr]=find(app==1); %find the nearest road
point that is only covered by          serving cell
UE=[rroad(bdr(bbdr(1)),1)
rroad(bdr(bbdr(1)),2)];%substitute the road points
```

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to get the estimated UE
UE_estimated(i,:)=[UE]; %The position of the user is estimated

In this section, a program was executed to determine the Abwt for a cell, assuming that most of the 3 sector cells of BS along the urban route of Menara Celcom to Taman Melawati had been planned by Telco for 60° bandwidth for each cell. The first step was to run the algorithm in order to determine the maximum error difference of UE estimated from the actual UE simulated [7]. This is determined when initial Abwt used is 360°. This maximum coordinate is noted with the difference of angle from the actual UE. This difference of angle would then be recorded as the Abwt value for the cell and would be stored as part of UIPS's database. When tested using the algorithm in section 2.1, most of the 3 sector cells along the urban route had Abwt value between 71° to 100°.

During the simulation for location search, OCRAA would use this Abwt for the corresponding cell, where it will ensure that the nearest matching road point is also the points within the serving cell's average antenna beam coverage. As mentioned earlier, the beam coverage is evaluated using the knowledge of RTT (estimated distance from the cell's coordinate), knowledge of the serving's cell directional antenna beam and its average beamwidth, Abwt. If for any reason, the estimated nearest road point falls outside the beam's coverage, a next new point would be searched in order to estimate UE's location,

5. RESULTS AND DISCUSSION

A total of 194 samples was simulated along the urban route, which is approximately 9.7 km long. The algorithm in section 2.2 was used with the mentioned simulation parameters in order to determine the estimated location of UE of the 194 known samples of actual UE's location. The tables 1 show the result of Cumulative Distribution Function (CDF) for location error difference in meters. The processing time (PT) was also around 0.38 Sec per sample. From the result, the value between 71° to 100° of Abwt provide location accuracy (distance error) to be within 66 m for 95% of the experiments. Since all the BSs' cells with hearability on the urban-suburban road tested had an antenna configuration of BS with 3 sector cells, so it is safe to say that the average suitable beamwidth Abwt value for most of these cells were from 71 to 100. The highest error difference was about 224 m and located at sample number 192 (near Wangsa Melawati area). Finally, OCRAA has shown to provide an angle search within the tolerance of the average beam coverage width until it finds the closest road point with reference to the Node B or with respect to the time of arrival from BS. This road point is assumed to be the user's travelled point during location search. Fig.1 illustrates the azimuth direction from UE estimated to Node B for all 194 samples on the urban road when hearability = 71°), where the azimuth of UE estimated from samples 73 through 83 was 311°, and the Node Bs directional angle (for samples 73 through 83) was at 240°. The actual UE's azimuth at sample 83 was at 324.6°, which means the actual beamwidth is at 84.6° (324.6°-240°=84.6°). But if we were to use 60° (as Telco's planned beamwidth) or Abwt as 60, as in Table I, location errors would be very high because OCRAA's angle search is also limited to be within 60° causing it to accept more bad estimations that are also closer to the road points. Therefore Abwt between 71 through 100 provides good location estimation for this route when planned Telco's beamwidth was around 60°.

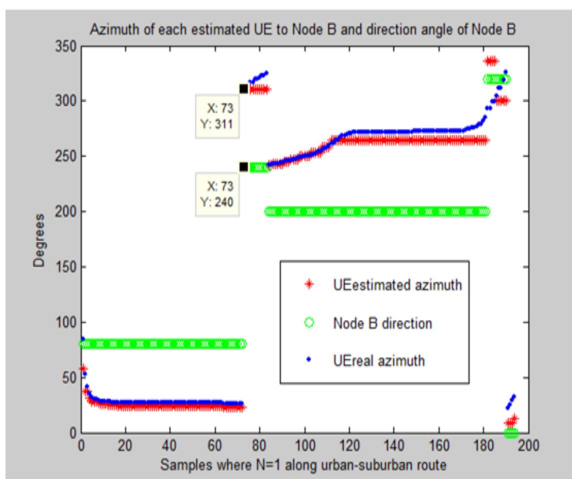

Fig. 1.Azimuth Direction To UE Estimated (Abwt=71) From Node B, Telco's Node B Antenna Direction, And Azimuth Direction To UE Real From Node B [3]

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Table I. CDF For UE Location Estimation Using OCRAA And One UMTS Cell

CDF	67% (m)	95% (m)	Max Error (m) and sample
OCRAA (*Abwt*=60) PT=0.38 sec/estimate	38.21	561	656 (UE 83th, 7.1 degrees diff)
OCRAA (*Abwt*=71) PT=0.38 sec/estimate	17.77	65.43	124.3 (UE 83th, 71 degrees diff)
OCRAA (*Abwt*=85) PT=0.38 sec/estimate	10.78	65.43	224.2 (UE 192nd, 74.2 deg diff)
OCRAA (*Abwt*=90) PT=0.38 sec/estimate	10.96	65.43	224.2 (UE 192nd, 74.2 deg diff)
OCRAA (*Abwt*=100) PT=0.38 sec/estimate	10.76	65.43	224.2 (UE 192nd, 74.2 deg diff)
OCRAA (*Abwt*=105) PT=0.38 sec/estimate	11.08	124.3	259.9 (UE 12th, 104.9 deg diff)
OCRAA (*Abwt*=120) PT=0.38 sec/estimate	11.29	349	515.1 (UE 70th, 106 deg diff)

6. CONCLUSION

In this study, when a user is travelling on a road with hearability of UMTS cells limited to the serving cell, OCRAA algorithm is utilized with the RTT of the serving cell to predict the proximity of the mobile user. The location accuracy of this technique does meet the FCC's E-911 standards for 95% of location searches. Telco's database on antenna direction, beamwidth, antenna configuration, cell coordinates and drive test results should be the latest in order to ensure the accuracy of this technique is maintained when implemented by Telco through the usage of UIPS. Before running the simulation, the map road points should also be calibrated with the actual distance of UE from the BS (time of arrival with no delays). For further studies, this technique will be integrated as part of the UIPS location determining technique, and to be utilized when quality of positioning is meant for emergency or navigational search

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