Location Estimation Algorithm Using Smart Antenna

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Abstract— This paper propose user location estimation method which uses smart antenna based reception direction. Existing AOA method is capable of producing error due to the change of azimuth. The range of error increases as the distance between a terminal and base station increases. In order to solve this problem, the method of measuring the reception direction of signal and TOA from several branches can be proposed. Our proposed method is verified by creating same error of azimuth environment by using variety of computer simulations. Our proposal of location estimation method shows increased performance of location estimation than AOA method.

Keywords—AOA, TOA, Smart Antenna, Location, Estimation.

I. INTRODUCTION

With the development of mobile communication, various location estimation schemes have been researched. Such methods consist of triangulation, using distance and orientation, computing points of intersection by mathematics and so on. In location estimation system based on general mobile communication, generally two methods have been used a lot: Ranged-based PL, which is to estimate the location, after calculating radio signal’s time of arrival using many reception base stations and DF (Direction Finding) which is to estimate the orientation of the reception of radio signal[1].

Recently, there are the TDOA (Time Difference of Arrival) estimation method using the TOA (Time of Arrival) difference of radio signal arriving at each base station and another estimation method using AOA (Angle of Arrival) of radio signal arriving at base station. The TDOA is not needed to synchronize between device and base station, because of using time difference receiving from multiple base stations but it is vulnerable to Time Delay because of Multipath and NLOS (Non Line of Sight)[2]-[4].

Accordingly, an enhanced estimation method has been researched, by which both TDOA and AOA overcome the environment of Multipath and NLOS. Comparing AOA with suggested method of location estimation, this thesis verified the efficiency of the suggested by simulation.

The composition of the thesis is like below. In Chapter II, pros and cons of existing location estimation are explained. In Chapter III, the location estimation using smart antenna is suggested. In Chapter IV, enhanced performance suggested by the result of simulation will be verified and Conclusion will be featured in Chapter V.

II. THE FEATURE OF LOCATION ESTIMATION METHOD

The TDOA method is shown as a hyperbola with points that are fixed in distance difference between a device and each station, after finding points that are fixed in time difference and calculating the difference of transport time of radio signal between a device and more than two stations[5].

![Fig. 1. TDOA Method](image)

Like Fig.1 this is a method to estimate device location with points of intersection of each hyperbola. The TDOA method has the weakness that errors occurred in transport time of radio signal and location estimation affected by Repeater.

The AOA method is to estimate device location, using azimuth after calculating the orientation of signal from device to base station. In Fig.2, the orientation of signal calculated from each station is expressed as direct line and intersection points are computed as location of device[5].
Because, AOA method assumes that received signal has LOS (Line of Sight) component in areas such as downtown affected by Multipath, the distortion of received signal causes accuracy of location estimation of AOA to decline.

III. PROPOSAL METHOD

We suggest the method based on smart antenna having antenna arrays. To estimate the location of device, the procedure like Fig.3 will be followed.

After reception orientation is decided, TOA of reception signal is measured to calculate the distance between device and station.

A device location will be estimated after intersected area like Fig. 5 is calculated with data of orientation and distance measured from each station.

IV. SIMULATION AND RESULTS

To verify performance of location estimation that we suggested, the result of simulation by Matlab is analyzed.

A. Experiment environment

The comparison of the existing AOA method and suggested method is executed in the general outline of this experiment. The detailed summary is like TABLE I.

![Pattern Structure](image)

**Fig. 4. Pattern Structure**

<table>
<thead>
<tr>
<th>Methods</th>
<th>AOA, Proposal Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of BaseStation</td>
<td>3</td>
</tr>
<tr>
<td>Number of BaseStation Antenna</td>
<td>3, 4</td>
</tr>
<tr>
<td>Distance between each BaseStation</td>
<td>1000m</td>
</tr>
<tr>
<td>Number of trials</td>
<td>1000</td>
</tr>
<tr>
<td>Received angle of BaseStation</td>
<td>120°</td>
</tr>
<tr>
<td>Received angle of each Antenna</td>
<td>40°, 30°</td>
</tr>
</tbody>
</table>

The reception orientation of station is 120 degrees and according to the number of antenna of station, the orientation that each antenna receives will be determined. The distance
from each station is 1km and the number of repeated test is 1000 times.

Multipath Channel is applied to situation of Bed Urban in model of IST-4 WINNER2 Channel[6].

**Fig. 6. Multipath Channel Model(Bed Urban)**

### B. Performance analysis of the orientation of received signal

To verify discriminant ability of signals received from base antenna, discriminant performance test of signal is executed according to repeated unique pattern. The result of accuracy of the device location is shown as TABLE 2, which comes with designation of initial device location and signals and reception orientation of each antenna.

<table>
<thead>
<tr>
<th>TABLE II.</th>
<th>COMPARE TO DETERMINE THE PERFORMANCE OF RECEIVED SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>None Pattern</td>
<td>Pattern</td>
</tr>
<tr>
<td>72%</td>
<td>89%</td>
</tr>
</tbody>
</table>

By inserting unique pattern, signal discriminant performance by unique pattern is improved in spite of affection of Multipath.

### C. Analysis of location estimation performance

To compare location estimation method that we suggested with AOA method, such experiment is executed. In each repeated experiment, device locations were set randomly.

Fig. 7 is the result of each method when the number of antenna of AOA method and suggested method is 3 or 4.

**Fig. 7. Performance of Location Estimation**

To compare location estimation performance, estimation errors are presented as cumulative distribution function. By this experiment, the distance error of existing AOA method is around 22m on average and that of suggested method is around 17.5m averagely.

We can assure that this suggested method to use reception signal affected by identical Multipath is better than the existing AOA method.

### V. Conclusions

In this thesis, we suggested location estimation method by using smart antenna and analyzed the performance of location estimation.

Because the existing AOA method is sensitive to errors of reception degree, it causes estimation performance to decline. We do suggest this method of determining location and orientation of device using characteristics of smart antenna.

Although there are influences of Multipath, this method we suggested makes it possible that valid signal detection is available by inserting repeated unique pattern. This method will support the evolved mobile technology by using smart antenna.

We are supposed to research that this method will be available in other areas by improving its applicability in various mobile communication environments.

**REFERENCES**