(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 June 2010 (03.06.2010)

PCT

(10) International Publication Number
WO 2010/062108 A2

(51) International Patent Classification:
H04W 64/00 (2009.01) *G01S 5/02* (2010.01)

(21) International Application Number:
PCT/KR2009/006982

(22) International Filing Date:
25 November 2009 (25.11.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
200810177976.0 26 November 2008 (26.11.2008) CN

(71) Applicants *(for all designated States except US)*: **SAMSUNG ELECTRONICS CO., LTD.** [KR/KR]; 416, Maetan-dong, Yeongtong-gu, Suwon-si, Gyeonggi-do 442-742 (KR). **BEIJING SAMSUNG TELECOM R & D CENTER** [CN/CN]; 12F Zhongdian Fazhan Building No.9, Xiaguangli, Chaoyang District, Beijing 100125 (CN).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ZHONG, Chuan** [CN/CN]; 12F Zhongdian Fazhan Building No.9, Xiaguangli, Chaoyang District, Beijing 100125 (CN). **ZHOU, Lei** [CN/CN]; 12F Zhongdian Fazhan Building No.9, Xiaguangli, Chaoyang District, Beijing 100125 (CN).

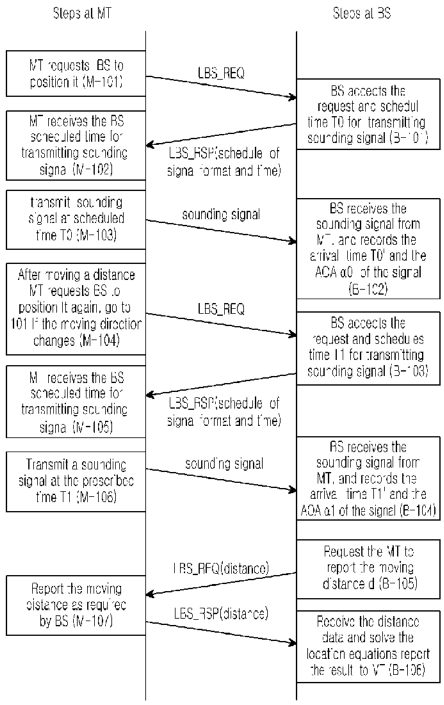
(74) Agent: **LEE, Keon-Joo**; Mihwa Bldg. 110-2, Myongryun-dong 4-ga, Chongro-gu, Seoul 110-524 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR POSITIONING MOBILE TERMINAL'S LOCATION

[Fig. 1]



(57) Abstract: A method by a mobile terminal (MT) for positioning the MT comprising steps of: requesting to allocate a first transmission time for transmitting a first sounding signal for the MT to a base station (BS); receiving the first transmission time from the BS; transmittingthe first sounding signal at the first transmission time to the BS; requestingto allocate a second transmission time of a second sounding signal for the MT to the BS again after the MT moves; receiving the second transmission time form the BS; transmitting the second sounding signal at the second transmission time to the BS; reporting a moving distance moved during the period between the two transmissions of the first sounding signal and the second sounding signal; and receiving a positioning result of the MT determined by using the first sounding signal, the second sounding signal and the moving distance.

WO 2010/062108 A2

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Description

Title of Invention: METHOD AND APPARATUS FOR POSITIONING MOBILE TERMINAL'S LOCATION

Technical Field

[1] The present invention relates to method and apparatus for positioning a mobile terminal's location.

Background Art

[2] The wireless positioning service is also called Location-ased Services (LBS). A mobile communication network retrieves information on the location of a mobile communication gateway by use of a series of positioning techniques, and provides the information to a subscriber or others and the communication system, and thus implements value-dded service related to the location.

[3] Generally speaking, all location-based services belong to LBS. Some services may have nothing to do with the location of the subscriber e.g., weather at a fixed location, traffic routes between fixed start and end locations. However, in a mobile communication network, most LBS-relevant services have tight relationship with the location of the subscriber who holds the mobile terminal.

[4] Before the implementation of mobile LBS, Global Positioning System (GPS) is the technique first applied in navigation and positioning services. With the development of mobile communication network technology, the mobile LBS has been gradually applied and matured since 1999. Now, the mobile LBS realized via the mobile communication network is not only widely applied in special fields such as logistics management, traffic scheduling, medical rescue, field exploration and so on, but also make great stride on the way to normal life.

[5] At present, severity competition exists in telecommunication industry. Mobile service operators are constantly striving to find new approaches to create new profit points or profit increase points. Among all kinds of mobile value-added services, the mobile LBS is one of the services that bear the greatest potential market. On the other hand, with continuous increase in the market of private car, requirements on on-vehicle mobile communication platform bring up potential of great development. LBS for vehicle navigation, tracking represents a market with great development potential.

[6] Practical applications of LBS include but not limited to the following aspects:

[7] 1. **Security application**, e.g., emergency service and roadside help seeking, etc.. If a subscriber becomes in danger at an unacquainted site, user of the subscriber can call the number of a rescue center (e.g., 110 in China, 911 in the U.S., 411 in Japan) as long as the user mobile phone supports LBS. The mobile communication network will

automatically send information on the subscriber's location together with user's voice information to the rescue center. Upon receiving the call of the subscriber, the rescue center carries out rescue action rapidly and efficiently according to the obtained location information. In this way, probability of successful rescue is drastically improved.

[8] 2. **Information service application**, e.g., daily life information and traffic information, etc. LBS can provide subscribers with map coordinates-related information service and interactive map information service. It can also provide subscribers with traffic conditions and optimal routes for car driving. It can help subscribers to locate nearby accommodates, e.g, restaurants, cinemas, companies around specified location. It can further provide value-added services like ticket booking and seat reservation. Also, it can be used in mobile yellow pages and mobile advertisements.

[9] 3. **Tracking application**, e.g., tracking vehicles or properties, etc.. In a big city with high population density, it is urgent to solve the problem of traffic jam, and growing requirements are put on vehicle navigation and intelligent transportation. As core of an intelligent transportation system (ITS), automatic vehicle positioning system provides functions such as dynamic traffic stream allocation, location navigation, emergent handling of accidents, safety precaution, vehicle tracking, vehicle scheduling and so on.

[10] Early development of LBS dates back to the year of 1996. At that time, US Federal Communications Committee (FCC) publicized location requirements E-911, and required that before October 1, 2001, network operators should provide a positioning service with a precision of less than 1.25 feet to subscribers of mobile devices sending out E911 emergent calls. The network operators were required to provide the caller's orientation, phone number to be called back together with public emergency services. Later, similar requirements were introduced in Europe and Japan, which eventually brought up the appearance of LBS — calling equipment-based geography location service. After that, rapid development of fields of Positioning Systems, Communication and GIS (Global Information System) stimulated the industrial's imagination on LBS. The service was initially widely adopted by telecom companies to provide customized services to mobile subscribers according to their geography locations.

[11] LBS is important subject in most existing mainstream standards at present.

[12] Positioning technique is the key of LBS, it may includes:

[13] a)Network-based positioning techniqueA mobile terminal (MT), while receiving a signal from a current serving base station (BS), always searches for signals from other BSs. If it finds that any signal from any other BS is stronger than a predetermined threshold, it is necessary for the MT to determine the difference of the arrival time of the signals from the BSs, so as to prepare for the combination of the two signals. Such

capability of the MT lays a technical foundation for implement positioning. The positioning operation platform can obtain the MT's information (e.g., information on pilot strength) through CDMA network and implement positioning. Some other network-based techniques can offer better positioning precision, such as measurement of the MT's round trip delay, Angle of Arrival (AOA) of a signal. These techniques, however, require addition of measurement equipments on the BS, thus increases the cost.

[14] b)Assistant GPS technique (AGPS)The assistant GPS technique implements positioning operation primarily depending on GPS satellites. A MT has to receive signals from at least 4 GPS satellites, perform positioning calculation based on the signals and report the calculation result to the network. For general GPS technique, the GPS receiver has to search for available GPS satellites in a global space domain. Such satellite search requires such a long time that this technique can not meet the demand of rapid mobile positioning. In the assistant GPS technique, the network can determine the GPS satellites over a cell where the MT locates according to the location of the cell and provide the information to the MT. Based on the information received, the MT can narrow down the scope of search area to implement the search process more quickly. After the search process, the MT needs to transmit the information for calculating the MT's location to the network by interacting with the network. Then, the network calculates the MT's location.

[15] c)Hybrid positioning techniqueThe hybrid positioning technique applied in a Code Division Multiple Access(CDMA) system primarily adopts the two kinds of MT-based positioning techniques mentioned above, Network-based positioning technique and AGPS. In general, GPS technique can offer high positioning precision. However, in many scenarios, a MT can not capture enough GPS satellites. In this case, signals from BSs can be used by the MT to supplement the signals from satellites. In this way, practicability of such positioning is improved and indoor positioning can be realized at the expense of certain accuracy degradation.

[16] d)MT-based GPS techniqueFor some LBS services requiring quick and continuous positioning (e.g., real time dynamic vehicle navigation), it is necessary to refresh information on the MT location at the interval of several seconds. In this case, AGPS technique can hardly meet the time requirement. In order to reduce the time interval between two consecutive positioning processes, MT-based GPS technique is introduced. As a difference from AGPS, calculation of the location is entirely performed by the MT itself in the MT-based GPS technique. Further, the MT is always in GPS tracking state so that time for interacting with the network can be reduced. Unfortunately, time to first fix (TTFF) is substantially the same as that in AGPS. It is also necessary to obtain information on GPS satellites from the network side.

[17] e)Dead reckoning(DR)

[18] With reference to a known relative reference point or start point, the direction and distance of a target object are calculated continuously during its movement. And with the help of map matching algorithm, the location of the moving target can be determined. This approach is suitable for continuous positioning of a moving object.

[19] DR depends on measurement precision on the MT's acceleration, velocity and moving direction. Corresponding measurement information can be provided by means of a odometer, gyroscope, accelerometer, etc..

[20] f)Approaching-type positioning

[21] The location of a moving object is determined by estimation based on the nearest fixed reference detection point. The cell ID-based approach can be regarded as one branch of the approaching-type positioning technique. Estimation of the MT can be obtained with the nearest BS or sector.

Disclosure of Invention

Technical Problem

[22] The existing techniques have their own advantages and disadvantages. In the case of a single cell, including the case that signals from other cells are overlaid in the cell, positioning approaches based on multi-cell signal detection can not work. The cell ID-based positioning approach has poor precision, and the GPS-based solution has relatively higher cost.

Solution to Problem

[23] An object of the present invention is to provide a positioning method using AOA and terminal moving track in a single cell environment.

[24] The present invention provides that a method by a mobile terminal (MT) for positioning the MT comprising steps of: requesting to allocate a first transmission time for transmitting a first sounding signal for the MT to a base station (BS); receiving the first transmission time from the BS; transmittingthe first sounding signal at the first transmission time to the BS; requestingto allocate a second transmission time of a second sounding signal for the MT to the BS again after the MT moves; receiving the second transmission time form the BS; transmitting the second sounding signal at the second transmission time to the BS; reporting a moving distance moved during the period between the two transmissions of the first sounding signal and the second sounding signal; and receiving a positioning result of the MT determined by using the first sounding signal, the second sounding signal and the moving distance.

[25] The present invention provides that A method by a base station (BS) for positioning a mobile terminal (MT) comprising steps of: transmtting a first transmission time of a first sounding signal for the MT to the MT; receiving the first sounding signal

transmitted from the MT at the first transmission time; recording a first arrival time of the first sounding signal and a Angle of Arrival (AOA) of the first sounding signal; transmtting a second transmission time of a second sounding signal for the MT to the MT; receiving the second sounding signal transmitted from the MT at the second transmission time; recording a second arrival time of the second sounding signal and a AOA of the second sounding signal; receiving from the MT a moving distance moved by the MT during the period between the two transmissions of the first sounding signal and second sounding signal; and positioning the MT by using the first arrival time, the AOA of the first sounding signal, the second arrival time, the AOA of the second sounding signal and the moving distance.

[26] The present invention provides that A communication system for positioning a mobile terminal (MT) comprising: a MT; and the BS for transmtting a first transmission time of a first sounding signal for the MT to the MT, receiving the first sounding signal transmitted from the MT at the first transmission time, recording a first arrival time of the first sounding signal and a Angle of Arrival (AOA) of the first sounding signal, transmitting a second transmission time of a second sounding signal for the MT, receiving the second sounding signal transmitted from the MT at the second transmission time, recording the second arrival time of the second sounding signal and a AOA of the second sounding signal, receiving a moving distance of the MT, and positioning the MT by using the first arrival time, the AOA of the first sounding signal, the second arrival time, the AOA of the second sounding signal and the moving distance.By using combination of time difference (TD), AOA and the inference calculation for positioning, the present invention solves the problem due to the situation where a terminal cannot obtain more than one signal reference sources. Meanwhile, the problem of absolute positioning for moving track in the inference calculation for positioning can be addressed.

Advantageous Effects of Invention

[27] The present invention solves the problem due to the situation where a terminal cannot obtain more than one signal reference sources. Meanwhile, the problem of absolute positioning for moving track in the inference calculation for positioning can be addressed.

Brief Description of Drawings

[28] Figure 1 is a flowchart showing the method of the present invention.

[29] Figure 2 illustrates a tracking process of a terminal's moving track and BS's azimuth.

[30] Figure 3 is a schematic diagram showing an embodiment of the present invention.

Best Mode for Carrying out the Invention

[31] The present invention is implemented by cooperation of BS capable of obtaining

AOA of a sounding signal and a mobile terminal (MT). Thanks to association with a object's moving track, the present invention is suitable for on-vehicle applications, in which data can be obtained by means of distance-measuring instruments like odometer, as shown in Figure 1.

[32] Figure 1 is a flowchart showing the method of the present invention.

[33] Referring to Figure 1, in step At M101, the MT initiates an initial positioning request, i.e the MT transmits LBS_REQ(request)to the BS. After receiving the LBS_REQ, in step B101, the BS indicates, via a signaling, a transmission time T0 at which a sounding signal is to be transmitted by the MT(). In step M102, The MT receives the signaling, i.e LBS_RSP(response)and in step M103, the MT transmits a sounding signal at the indicated time T0.

[34] In step B102, The BS receives the sounding signal and records the arrival time T0'and the AOA

α_0

of the sounding signal. In step M104, the MT records its moving track, and transmits LBS_REQ to the BS again after a period of movement). Here, it requires that the BS must not be located in a line passing through the two end points of the moving track. On such premise, the length can be arbitrarily chosen as long as the BS and the two end points of the moving track can form a triangle. After receiving the LBS REQ, in step B103, the BS indicates, via a signaling i.e LBS_RSP, a transmission time T1 at which a sounding signal is to be transmitted by the MT. In step M105 the MT receives the LBS_RSP and in step M106, the MT transmits a sounding signal at the indicated time T1; in step B104, the BS receives the sounding signal and records the arrival time T1' and the AOA

α_1

of the sounding signal. In step B105, via a signaling, LBS_REQ, the BS requests to obtain a straight-line distance d between the two end points of the MT's moving track, and in step M107, MT reports it, LBS_RSP to the BS.

[35] With these obtained parameters, in step B106, the BS establishes and solves equations, in which the respective locations are associated as shown in Figure 2.

[36] Figure 2 illustrates a tracking process of a terminal's moving track and BS's azimuth.

[37] Referring to figure 2, a location of the MT represents by an math figure 1.

[38] MathFigure 1

[Math.1]

$$r_2 - r_1 = ((T_1^{'} - T_1) - (T_0^{'} - T_0)) * C_{light}$$
$$\alpha_2 - \alpha_1 = \alpha$$
$$r_1^2 + r_2^2 - 2r_2 * r_1 * \cos(\alpha) = d^2$$

[39] Here, C_{light} is a velocity of the sounding signal transmitted in step M103 and in the step M106, if a velocity of each of the sounding signals transmitted in step M103 and in the step M106 is the same, the r_1 is a distance between the MT in step M103, MT1(210), and the BS(220), r_2 is a distance between the MT in the step M106, MT2(205) and the BS(220) after moving of the MT1(210),

α_1

is a from a predetermined reference(200) phase to the MT1(210),

α_2

is a phase from the predetermined reference(200) to the MT(205), d is a distance between the MT 1(210) and the MT 2(205).

[40] As can be seen here, the equation 1 can be simplified as an math figure 2 with a single variable r1.

[41] MathFigure 2

[Math.2]

$$r_1^2 + T_d * C_{light} * r_1 + ((T_d * C_{light})^2 - d^2)/(2(1-\cos(a))) = 0$$

[42] where Td=(T1'- T1)- (T0'- T0). Although the timing clock may vary between the BS and the MT, effects from such difference can be counteracted by the use of the difference value, Td.

[43] By solving a set of quadratic equations is represented by a math figure 3,

[44] MathFigure 3

[Math.3]

$$r_1 = \frac{-T_d * C_{light} \pm \sqrt{(T_d * C_{light})^2 - 4 * ((T_d * C_{light})^2 - d^2)/(2(1-\cos(\alpha)))}}{2}$$

[45] Generally, only one solution is practical in consideration of information on actual cell radius. The location of the MT can be determined in connection with information on AOA, after r1 is obtained and r2 is inferred.

[46] Assuming that the BS's location is the origin, and the reference direction of the antenna array is the direction of X axis, the location coordinates (x1,y1), (x2,y2) of the two end points can be calculated as a math figure 4.

[47] MathFigure 4

[Math.4]

$$x_1 = r_1 * \cos(\alpha_1), y_1 = r_1 \sin(a_1), x_2 = r_2 * \cos(a_2), y_2 = r_2 * \cos(a_2)$$

[48] The BS sends the calculation result to the MT. Alternatively, the BS can, based on its own latitude and longitude coordinates, convert the calculation result into actual latitude and longitude coordinates and then sends them to the MT.

[49] Here, different methods can be adopted to obtain the moving distance d with different situations. In the situation of a walking movement, the distance can be estimated by referring to a reference object on the ground. Alternatively, the subscriber can estimate an approximate distance according to road distance indication, and input the distance data into the MT through a man-machine interface application. In the situation of on-vehicle movement, the distance can be obtained by DR calculation positioning algorithm. The DR calculation system is a system that has been already in practice, and the algorithm is a commonly used vehicle positioning algorithm. The DR calculation system primarily comprises sensors for measuring flight azimuth and sensors for measuring distance. The sensors for measuring flight azimuth mainly include compass, angular speed gyroscope and the like. The sensors for measuring distance mainly include odometer and accelerometer. The gyroscope outputs the angular speed of the flight azimuth. The integral of angular speed can be taken as a relative rotating angle of the carrier. The vehicle's moving track can be obtained through a real- time measurement and recording of moving distance and relative rotating angle, and the straight-line distance between the two end points for sounding signaling can be calculated With the moving track.

[50] **Embodiment**

[51] Figure 3 is a schematic diagram showing an embodiment of the present invention.

[52] Referring to figure 3, an MT sends a LBS request to a BS. The BS informs the MT of a time T=TA for transmitting a sounding signal, and then receives the sounding signal from the MT at time TA+1.414us. At this moment, the AOA is recorded as -45° After moving 300m (not limited to this distance), the MT requests again for positioning. The BS informs the MT it of a time T=TB for transmitting a sounding signal, and then receives the sounding signal at time TB+1us from the MT. The AOA is recorded as -90° at this moment. Via a signaling, the BS obtains that the MT has moved a distance of 300m. With Td= -0.414us and t light velocity of 300m/us, an math figure 5 is obtained as:

[53] MathFigure 5

[Math.5]

$$r_1^2 - 0.414 * 300 * r_1 + ((0.414 * 300)^2 - 300^2)/(2(1 - 0.707)) = 0$$

[54] The solution of the equation is obtained as r1=424.2m, with removal of an un-

reasonable root of r1=-300m. Further, r2 is inferred as r2=300m. With information on the angle, the location coordinates corresponding to points A and B can be determined as (300,-300), (0,-300).

Claims

[Claim 1] A method by a mobile terminal (MT) for positioning the MT comprising steps of:
requesting to allocate a first transmission time for transmitting a first sounding signal for the MT to a base station (BS);
receiving the first transmission time from the BS;
transmittingthe first sounding signal at the first transmission time to the BS;
requesting to allocate a second transmission time of a second sounding signal for the MT to the BS again after the MT moves;
receiving the second transmission time form the BS;
transmitting the second sounding signal at the second transmission time to the BS;
reporting a moving distance moved during the period between the two transmissions of the first sounding signal and the second sounding signal; and
receiving a positioning result of the MT determined by using the first sounding signal, the second sounding signal and the moving distance.
wherein the positioning result of the MT is represented by a equation
<equation>

$$r_2 - r_1 = ((T_1' - T_1) - (T_0' - T_0)) * C_{light}$$

$$\alpha_2 - \alpha_1 = \alpha$$

$$r_1^2 + r_2^2 - 2r_2 * r_1 * \cos(\alpha) = d^2$$

Here, if a velocity for each of transmissions of the first sounding signal and the second sounding signal is the same, C_{light} is the velocity, the r_1 is a distance between the MT which transmits the first sounding signal and the BS, r_2 is a distance between the MT which transmits the second sounding signal and the BS,

α_1

is a phase from a predetermined reference to the MT which transmits the first sounding signal,

α_2

is a phase from a predetermined reference to the MT which transmits the second sounding signal d is a distance between the MT which transmits the first sounding signal and the MT which transmits the second sounding signal.

[Claim 2] The method of Claim 1, wherein the movement of the MT is generated by walking and vehicle driving of a user of the MT.

[Claim 3] The method of Claim 2, wherein if the user of the MT moves by the vehicle driving, the moving distance of the MT is obtained with a Dead reckoning calculation positioning algorithm.

[Claim 4] The method of Claim 2, wherein, if the user of the MT moves by walking, the moving distance of the MT is estimated according to a reference object on the ground, and is input into the terminal through a man-machine interface application.

[Claim 5] A method by a base station (BS) for positioning a mobile terminal (MT) comprising steps of:
transmtting a first transmission time of a first sounding signal for the MT to the MT;
receiving the first sounding signal transmitted from the MT at the first transmission time;
recording a first arrival time of the first sounding signal and a Angle of Arrival (AOA) of the first sounding signal;
transmtting a second transmission time of a second sounding signal for the MT to the MT;
receiving the second sounding signal transmitted from the MT at the second transmission time;
recording a second arrival time of the second sounding signal and a AOA of the second sounding signal;
receiving from the MT a moving distance moved by the MT during the period between the two transmissions of the first sounding signal and second sounding signal; and
positioning the MT by using the first arrival time, the AOA of the first sounding signal, the second arrival time, the AOA of the second sounding signal and the moving distance.

[Claim 6] The method of Claim 5, further comprising the step of transmitting, to the MT, a result information of the step of positioning the mobile terminal.

[Claim 7] The method of Claim 5, wherein the step of the positioning the MT is determining a location of the MT by the equations.
<equation>

$$r_2 - r_1 = ((T_1' - T_1) - (T_0' - T_0)) * C_{light}$$
$$\alpha_2 - \alpha_1 = \alpha$$
$$r_1^2 + r_2^2 - 2r_2 * r_1 * \cos(\alpha) = d^2$$
$$x_1 = r_1 * \cos(\alpha_1), y_1 = r_1 \sin(a_1), x_2 = r_2 * \cos(a_2), y_2 = r_2 * \cos(a_2)$$

Here, if a velocity for each of transmissions of the first sounding signal and the second sounding signal is the same, C_{light} is the velocity, the r_1 is a distance between the MT which transmits the first sounding signal and the BS, r_2 is a distance between the MT which transmits the second sounding signal and the BS,

α_1

is a phase from a predetermined reference to the MT which transmits the first sounding signal,

α_2

is a phase from a predetermined reference to the MT which transmits the second sounding signal d is a distance between the MT which transmits the first sounding signal and the MT which transmits the second sounding signal.

[Claim 8] The method of Claim 5, the step of transmtting a first transmission time of a first sounding signal for the MT to the MT comprise the step of receiving a request to allocate the first transmission time from the MT.

[Claim 9] A communication system for positioning a mobile terminal (MT) comprising:
a MT; and
the BS for transmtting a first transmission time of a first sounding signal for the MT to the MT, receiving the first sounding signal transmitted from the MT at the first transmission time, recording a first arrival time of the first sounding signal and a Angle of Arrival (AOA) of the first sounding signal, transmitting a second transmission time of a second sounding signal for the MT, receiving the second sounding signal transmitted from the MT at the second transmission time, recording the second arrival time of the second sounding signal and a AOA of the second sounding signal, receiving a moving distance of the MT, and positioning the MT by using the first arrival time, the AOA of the first sounding signal, the second arrival time, the AOA of the second sounding signal and the moving distance.

[Claim 10] The system of Claim 9, further comprising:

the BS for transmitting, to the MT, a result information of positioning the mobile terminal.

[Claim 11] The system of Claim 9, wherein the positioning the MT is determining a location of the MT by the equations:

<equation>

$$r_2 - r_1 = ((T_1^{'} - T_1) - (T_0^{'} - T_0)) * C_{light}$$

$$\alpha_2 - \alpha_1 = \alpha$$

$$r_1^2 + r_2^2 - 2r_2 * r_1 * \cos(\alpha) = d^2$$

$$x_1 = r_1 * \cos(\alpha_1), y_1 = r_1 \sin(a_1), x_2 = r_2 * \cos(a_2), y_2 = r_2 * \cos(a_2)$$

Here, if a velocity for each of transmissions of the first sounding signal and the second sounding signal is the same, C_{light} is the velocity, the r_1 is a distance between the MT which transmits the first sounding signal and the BS, r_2 is a distance between the MT which transmits the second sounding signal and the BS,

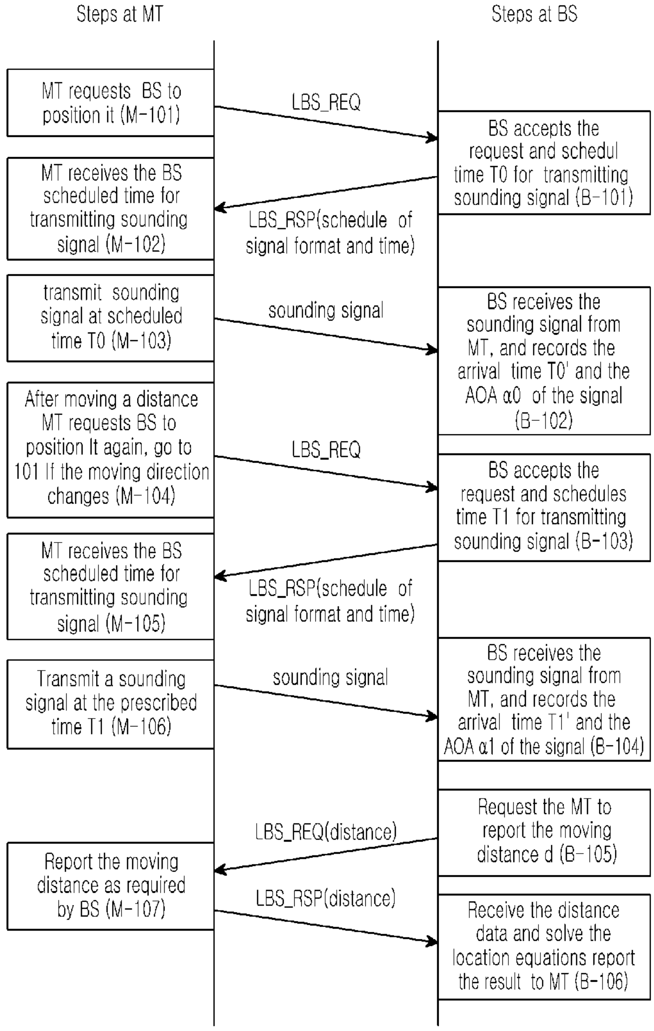
$$\alpha_1$$

is a phase from a predetermined reference to the MT which transmits the first sounding signal,

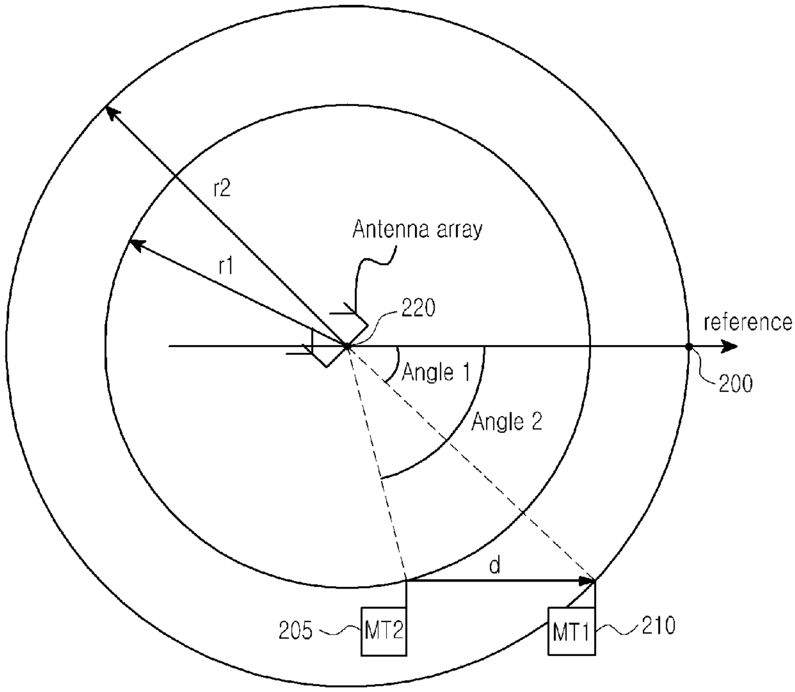
$$\alpha_2$$

is a phase from a predetermined reference to the MT which transmits the second sounding signal d is a distance between the MT which transmits the first sounding signal and the MT which transmits the second sounding signal.

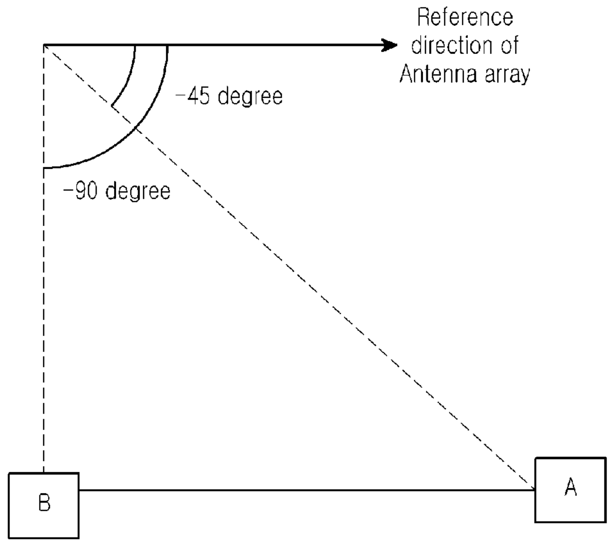
[Fig. 1]


Steps at MT
Steps at BS
MT requests BS to position it (M-101)
LBS_REQ
BS accepts the request and schedul time T0 for transmitting sounding signal (B-101)
MT receives the BS scheduled time for transmitting sounding signal (M-102)
LBS_RSP(schedule of signal format and time)
transmit sounding signal at scheduled time T0 (M-103)
sounding signal
BS receives the sounding signal from MT, and records the arrival time T0' and the AOA α0 of the signal (B-102)
After moving a distance MT requests BS to position It again, go to 101 If the moving direction changes (M-104)
LBS_REQ
BS accepts the request and schedules time T1 for transmitting sounding signal (B-103)
MT receives the BS scheduled time for transmitting sounding signal (M-105)
LBS_RSP(schedule of signal format and time)
Transmit a sounding signal at the prescribed time T1 (M-106)
sounding signal
BS receives the sounding signal from MT, and records the arrival time T1' and the AOA α1 of the signal (B-104)
Request the MT to report the moving distance d (B-105)
LBS_REQ(distance)
Report the moving distance as required by BS (M-107)
LBS_RSP(distance)
Receive the distance data and solve the location equations report the result to MT (B-106)

[Fig. 2]


r2
r1
Antenna array
220
reference
200
Angle 1
Angle 2
d
205
MT2
MT1
210

[Fig. 3]


Reference
direction of
Antenna array
-45 degree
-90 degree
B
A