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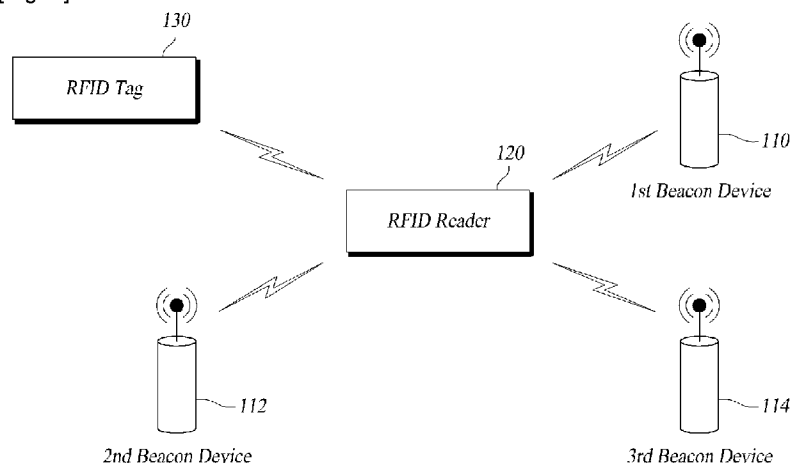
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(54) Title: METHOD FOR MEASURING LOCATION OF RADIO FREQUENCY IDENTIFICATION READER BY USING BEACON

[Fig. 1]



(57) Abstract: The present invention relates to a method for measuring a location of a radio frequency identification (RFID) reader by using beacons, and an RFID system for the method. The present invention provides a radio frequency identification (RFID) system for measuring a location of an RFID reader by using a beacon, the system including: a plurality of beacon devices for emitting beacons; an RFID tag for transmitting pre-stored information by using radio frequency identification; and an RFID reader for calculating a current location by using a plurality of beacons when the RFID reader 120 receives the plurality of beacons from the plurality of beacon devices while moving, and receiving the information from the RFID tag by using the radio frequency identification. According to the present invention, it is possible to measure the location of a moving RFID reader in an RFID system, and it is possible to increase the accuracy of the location measurement because the location of the RFID reader is measured in consideration of propagation environments.

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## **Description**

# **METHOD FOR MEASURING LOCATION OF RADIO FREQUENCY IDENTIFICATION READER BY USING BEACON**

### **Technical Field**

- [1] The present invention relates to a method for measuring a location of a radio frequency identification (RFID) reader by using beacons, and an RFID system for the method. More particularly, the present invention refers to a location measurement method for easily and accurately measuring a location of a moving radio frequency identification (RFID) reader in an RFID system, and the same RFID system, in such a manner that the RFID system includes a plurality of beacon devices, which are fixed at predetermined locations and emit beacons including reference location information about their own locations and, signal-intensity-to-distance information, and that the RFID reader receives beacons from at least three beacon devices, identifies relative distances from the respective beacon devices by using signal-intensity-to-distance information included in the beacons, and calculates its own location through a triangulation method.

### **Background Art**

- [2] Location-based technology is a technology of acquiring information about the physical, geographical, and logical locations of an object (a person or thing) placed at a specific location, and appropriately reacting according to the acquired information. The conventional positioning methods include a triangulation method of determining a location by measuring a difference of distances between objects, an angle between them, or an azimuth angle between them, a scene analysis method using a scene viewed from a specific vantage point, and a proximity method of finding an object by approaching a specific location.
- [3] Recently, with the development of wireless communication technologies, a radio frequency identification (RFID) system has been highlighted as new wireless network technology, and has been widely used. It has been required to develop a technology of measuring a location indoors or outdoors by using the RFID system, and such a technology can be utilized for various purposes, such as collecting data by means of RFID in an inaccessible area, transmitting the collected data to users, etc.
- [4] Meanwhile, conventionally, there are various location measurement technologies, including a location measurement technology using a global positioning system (GPS), a location measurement technology using a received signal strength indication (RSSI) of a radio frequency signal, a location measurement technology using local-area wireless communication, etc.

- [5] The location measurement technology using a GPS is a technology of measuring a distance to a GPS satellite, which orbits the earth, by measuring the phase of a carrier signal sent from the GPS satellite (i.e. by absolute positioning) or by tracking the code of the carrier signal (i.e. by relative positioning). Since the location measurement technology using a GPS has wide signal coverage, and can stably provide service through a fixed satellite, it is currently the most widely used. However, the location measurement technology using a GPS has disadvantages in that precision is low, and that service is unavailable in shadow areas or indoors where GPS satellite signals cannot be received.
- [6] The location measurement technology using mobile communication is a technology of obtaining information about the geographical location of a mobile terminal through the triangulation method using a mobile communication system which has been constructed. The location measurement technology using mobile communication includes a network-based scheme of finding the location of a terminal through co-operation between a base station of a serving cell of the terminal and a neighboring base station, a terminal-based scheme in which a terminal having a GPS receiver, separately from a base station, transmits location information to a network, and a mixed scheme in which the two schemes are combined. These technologies do not require a separate infrastructure, and have wide service coverage, similar to the GPS, thereby being widely utilized as a macro-positioning technology. However, the technologies have a disadvantage in that the technologies can be used only within a cell radius around a base station and in metropolitan areas where radio waves can be received, and accuracy is degraded indoors due to diffraction by propagation characteristics, multiple paths, and signal attenuation.
- [7] The location awareness technologies using the satellite communication or mobile communication are suitable for an outdoor environment because of wide service coverage, but the location awareness technologies are restricted in shadow areas or indoors. Therefore, recently, research is being actively conducted into positioning methods using various wireless communication technologies, such as diffuse-infrared, ultrasonic wave, radio frequency (RF), ultra wideband (UWB), and radio frequency identification.

## **Disclosure of Invention**

### **Technical Solution**

- [8] Most of these technologies calculate locations by using a difference between transmission speeds of ultrasonic waves, or by measuring a signal transmission distance according to signal attenuation obtained through measurements of the signal strength (i.e. RSSI) of an RF signal. In the case of using the RSSI, since the charac-

teristics of the RF signals vary depending on the environments, there are defects in that it is difficult to accurately measure a location, and that an error rate is high. In the case of using the ultrasonic waves, there are defects in that the ultrasonic waves are sensitive to directions due to the characteristics of sound waves, and that equipment is heavy.

- [9] Therefore, the present invention has been made in view of the above-mentioned problems, and it is an object of the present invention to provide a location measurement method for easily and accurately measuring a location of a moving radio frequency identification (RFID) reader in an RFID system, and the same RFID system, in such a manner that the RFID system includes a plurality of beacon devices, which are fixed at predetermined locations and emit beacons including reference location information about their own reference locations and signal-intensity-to-distance information, and that the RFID reader receives beacons from at least three beacon devices, identifies relative distances from the respective beacon devices by using signal-intensity-to-distance information included in the beacons, and calculates its own location through a triangulation method.
- [10] In order to achieve the above-mentioned object, there is provided a radio frequency identification (RFID) system for measuring a location of an RFID reader by using a beacon, the system including: a plurality of beacon devices for emitting beacons; an RFID tag for transmitting pre-stored information by using radio frequency identification; and an RFID reader for calculating a current location by using a plurality of beacons when the RFID reader 120 receives the plurality of beacons from the plurality of beacon devices while moving, and receiving the information from the RFID tag by using the radio frequency identification.
- [11] According to another aspect of the present invention, there is provided a method for calculating a current location by a radio frequency identification (RFID) reader in an RFID system, which includes an RFID tag, the RFID reader, and a plurality of beacon devices, the method including the steps of: (a) receiving a plurality of beacons from the plurality of beacon devices; (b) calculating relative distances from the plurality of beacon devices by analyzing the plurality of beacons; and (c) identifying reference locations of the plurality of beacon devices by analyzing the plurality of beacons, and calculating the location by using the reference locations of the plurality of beacon devices and the relative distances from the plurality of beacon devices.

### **Brief Description of the Drawings**

- [12] FIG. 1 is a block diagram schematically illustrating the configuration of a radio frequency identification (RFID) system for measuring the location of an RFID reader by using beacons according to an exemplary embodiment of the present invention;

- [13] FIG. 2 is a flowchart illustrating a method for measuring the location of an RFID reader by using beacons according to an exemplary embodiment of the present invention;
- [14] FIG. 3 is a view illustrating a situation where a beacon device emits a beacon according to an exemplary embodiment of the present invention;
- [15] FIGs. 4A and 4B are views explaining an example of a procedure of measuring the current location by an RFID reader according to an exemplary embodiment of the present invention; and
- [16] FIG. 5 is a view explaining an example of a procedure of measuring a moving speed and a moving direction by an RFID reader according to an exemplary embodiment of the present invention.

### **Mode for the Invention**

- [17] Hereinafter, preferred embodiments of the present invention will be described with reference to the accompanying drawings. First, it is to be noted that the same elements are indicated with the same reference numerals throughout the drawings. In the following description, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.
- [18] FIG. 1 is a block diagram schematically illustrating the configuration of a radio frequency identification (RFID) system for measuring the location of an RFID reader by using beacons according to an exemplary embodiment of the present invention.
- [19] According to an exemplary embodiment of the present invention, the RFID system for measuring the location of an RFID reader by using beacons includes a first beacon device 110, a second beacon device 112, a third beacon device 114, an RFID reader 120, and an RFID tag 130.
- [20] The first to third beacon devices 110, 112, and 114 according to an exemplary embodiment of the present invention are fixedly installed at predetermined locations in the RFID system and emit their respective beacons so that the RFID reader 120 can measure its own current location. In this case, the beacon may be emitted as various wireless signals, such as an RF signal, a Zigbee signal, a Bluetooth signal, etc.
- [21] Also, each of the first to third beacon devices 110, 112, and 114 according to an exemplary embodiment of the present invention emits a beacon, including reference location information about a reference location where the beacon device is positioned, and signal-intensity-to-distance information, in which the circumstances of an area where the beacon device is positioned are reflected.
- [22] To this end, each of the first to third beacon devices 110, 112, and 114 according to an exemplary embodiment of the present invention includes a beacon emission means

for emitting a beacon, a memory for storing reference location information and signal-intensity-to-distance information, and storing software which controls the pieces of information to be included in a beacon and to be emitted and which controls the entire operation of the corresponding beacon device, and a microprocessor for executing the software stored in the memory.

- [23] Here, the reference location information represents three-dimensional coordinates (x axis, y axis, z axis) of a location where each beacon device is positioned. The signal-intensity-to-distance information represents information about relative distances (i.e. straight distances regardless of direction) from the reference location of each beacon device to the RFID reader 120 according to signal intensities of beacons received by the RFID reader 120 from the beacon device, where the propagation environment of an area where the beacon device is positioned is reflected in the information. The reference location information and the signal-intensity-to-distance information will be described later in detail with reference to FIG. 3.
- [24] Meanwhile, although FIG. 1 shows the case where the RFID system for measuring the location of a RFID reader using beacons according to an exemplary embodiment of the present invention includes only three beacon devices 110, 112, and 114, four, five, or more beacon devices may be distributed in the RFID system.
- [25] The RFID reader 120 according to an exemplary embodiment of the present invention communicates with the RFID tag 130, and acquires information stored in the RFID tag 130 through the communication.
- [26] Also, receiving beacons from the first to third beacon devices 110, 112, and 114, the RFID reader 120 according to an exemplary embodiment of the present invention analyzes beacons received from each beacon device 110, 112, and 114, identifies the reference location information of each beacon device 110, 112, and 114, and the signal-intensity-to-distance information of each beacon device 110, 112, and 114, and calculates its own current location by using the reference location information and the signal-intensity-to-distance information.
- [27] In this case, the RFID reader 120 measures the signal intensity of each beacon received from each beacon device 110, 112, and 114, calculates relative distances from the beacon devices 110, 112, and 114 by associating the measured signal intensity of each beacon with the signal-intensity-to-distance information of each corresponding beacon device 110, 112, and 114, and calculates the current location through the triangulation method using the relative distance from each beacon device 110, 112, and 114 and the reference location information of each beacon device 110, 112, and 114. A procedure where the RFID reader 120 calculates the current location through the triangulation method will be described later in detail with reference to FIGs. 4A and 4B.
- [28] Also, the RFID reader 120 according to an exemplary embodiment of the present

invention receives beacons from at least three beacon devices among a plurality of beacon devices in order to calculate the current location. That is, as described above, the RFID system for measuring the location of an RFID reader using beacons according to an exemplary embodiment of the present invention may include three or more beacon devices. The RFID reader 120 must receive beacons from at least three beacon devices in order to calculate the current location. Therefore, when receiving beacons from four or more beacon devices, the RFID reader 120 uses beacons received from three beacon devices, from which relatively higher signal intensities of beacons have been received, in order to calculate the current location.

- [29] Also, the RFID reader 120 according to an exemplary embodiment of the present invention measures the locations thereof while moving, and calculates a moving speed and a moving direction. That is, when the RFID reader 120 has moved after measuring a current location (pre-moving location), the RFID reader 120 measures a current location (post-moving location) at a location after the movement, measures a movement time from the pre-moving location to the post-moving location, measures a moving distance from the pre-moving location to the post-moving location, and calculates a ratio of the moving distance to the movement time as a velocity. In addition, the RFID reader 120 calculates a vector from the pre-moving location to the post-moving location, thereby calculating a moving direction. A method of calculating a moving speed and a moving direction by the RFID reader 120 will be described later in detail with reference to FIG. 5.
- [30] FIG. 2 is a flowchart illustrating a method for measuring the location of an RFID reader by using beacons according to an exemplary embodiment of the present invention.
- [31] Each of the first to third beacon devices 110, 112, and 114, which are separately and fixedly installed in the RFID system, continuously emits a beacon, including its own reference location information and the signal-intensity-to-distance information according to the propagation environments thereof (step 210).
- [32] The RFID reader 120, which is moving within the RFID system, receives the beacons emitted from the first to third beacon devices 110, 112, and 114 (step 220), and identifies relative distances from the beacon devices 110, 112, and 114 by analyzing the beacons received from the beacon devices 110, 112, and 114 (step 230).
- [33] The RFID reader 120 calculates the current location through the triangulation method using the relative distances from the beacon devices 110, 112, and 114 and the reference location information of each beacon device 110, 112, and 114 (step 240).
- [34] Meanwhile, when the RFID reader 120 has moved after calculating the current location, the RFID reader 120 can measure a current location even at the post-moving location according to the procedure of steps 210 to 240.



- [35] Therefore, when the RFID reader 120 has moved (step 250), the RFID reader 120 measures a movement time from the pre-moving location to the post-moving location (step 260), and measures the post-moving location (step 270). Then, the RFID reader 120 calculates a moving speed by dividing a distance from the pre-moving location (i.e. the current location measured in step 240) to the post-moving location (i.e. the location measured in step 270) by the movement time measured in step 260, and calculating a moving direction by calculating a vector from the pre-moving location to the post-moving location (step 280).
- [36] FIG. 3 is a view illustrating a situation where a beacon device emits a beacon according to an exemplary embodiment of the present invention.
- [37] Each beacon device 110, 112, and 114 emits a beacon so that the RFID reader 120 can measure the location of the RFID reader 120, wherein the beacon is attenuated according to distance, so that the power of an emitted beacon decreases as the emitted beacon becomes more distant from each corresponding beacon device 110, 112, and 114.
- [38] In this case, the signal attenuation is influenced mostly by the propagation environment according to circumstances of each beacon device 110, 112, and 114. That is, when there is a factor causing large signal attenuation, such as a case where buildings and/or structures are distributed or a high power line passes around a specific beacon device, a signal attenuation rate is very high, so that an available emission distance is shortened. In contrast, when such an attenuation factor is small, a corresponding beacon device can emit a beacon for a longer distance.
- [39] Therefore, since each beacon device 110, 112, and 114 is fixedly installed, it is possible to create a database by measuring signal intensities of a beacon according to distance based on a propagation environment when each beacon device has been installed and the circumstances of the beacon has been determined.
- [40] That is, when a specific beacon device emits a beacon, as shown in FIG. 3, a database of signal-intensity-to-distance information can be created as Table 1 below.
- [41] Table 1

[Table 1]

Power (dbm)	Range (m)
0	1
-1	1.5
-3	6.3
-5	10.3
-7	14
-10	21
-15	35
-25	44

[42] Therefore, the specific beacon device emits a beacon, including its own reference location information and the signal-intensity-to-distance information as shown in Table 1.

[43] In a state where the specific beacon device emits a beacon, as shown in FIG. 3, when the RFID reader 120 receives the beacon from the specific beacon device and obtains -10 dBm as a result of measurement of the signal intensity of the beacon, the RFID reader 120 can identify a distance of 21 meters corresponding to -10 dBm by checking the signal-intensity-to-distance information included in the beacon, so that the RFID reader 120 can recognize that the RFID reader 120 is located at a distance of 21 meters from the specific beacon device. It goes without saying that a distance of 21 meters is a relative distance because it is not a two-dimensional distance, but a three-dimensional distance.

[44] Here, when it is assumed that the specific beacon device corresponds to the first beacon device 110, the second beacon device 112 and the third beacon device 114 also can emit beacons, as shown in FIG. 3. However, since the second beacon device 112 and the third beacon device 114 may be under different propagation environment from the first beacon device 110, signal attenuation rates may be different, so that each piece of signal-intensity-to-distance information included in beacons by the second beacon device 112 and third beacon device 114 may be different from that shown in Table 1.

[45] That is, since the first to third beacon devices 110, 112, and 114 are under different propagation environments, and thus attenuation rates of beacons emitted from the beacon devices 110 to 114 are different, distances to which beacons having the same signal intensity can reach may be different. Therefore, each of the first to third beacon devices 110, 112, and 114 makes a database of signal-intensity-to-distance information through measurements in advance, creates a table shown in Table, and emits the

signal-intensity-to-distance information through a beacon so that the RFID reader 120 can exactly measure the current location.

[46] FIGs. 4A and 4B are views explaining an example of a procedure of measuring the current location by an RFID reader according to an exemplary embodiment of the present invention.

[47] FIG. 4A is a view explaining an example of a procedure of identifying, by an RFID reader, relative distances from beacon devices according to an exemplary embodiment of the present invention.

[48] In a state where the first to third beacon devices 110, 112, and 114 are fixedly installed, the RFID reader 120 is located within beacon emission ranges of the three beacon devices, as shown in FIG. 4A, and the RFID reader 120 receives a first beacon, a second beacon, and a third beacon from the beacon devices 110, 112, and 114.

[49] The RFID reader 120 measures the signal intensities of the first to third beacons received from the beacon devices 110, 112, and 114, respectively. When it is assumed that the signal intensity of the first beacon is 0 dBm, the signal intensity of the second beacon is -25 dBm, and the signal intensity of the third beacon is -7 dBm, as shown in FIG. 4A, the RFID reader 120 can identify distance "d1" corresponding to 0 dBm by checking first signal-intensity-to-distance information included in the first beacon, can identify distance "d2" corresponding to -25 dBm by checking second signal-intensity-to-distance information included in the second beacon, and can identify distance "d3" corresponding to -75 dBm by checking third signal-intensity-to-distance information included in the third beacon.

[50] FIG. 4B is a view explaining an example of a procedure where the RFID reader 120 calculates the current location by using the relative distances from the beacon devices and the reference location of each beacon device according to an exemplary embodiment of the present invention.

[51] After identifying relative distances from the beacon devices 110, 112, and 114 by measuring the signal intensity of each beacon (i.e. each of the first to third beacons) received from each beacon device 110, 112, and 114, as described above with reference to FIG. 4A, the RFID reader 120 identifies first reference location information, second reference location information, and third reference location information included in the beacon, i.e. in the first beacon, the second beacon, and the third beacon, respectively.

[52] Here, the first reference location information, the second reference location information, and the third reference location information correspond to three-dimensional coordinate information about the x-axis y-axis and z-axis coordinates of the beacon devices 110, 112, and 114, respectively.

[53] Here, when it is assumed that the first reference location information corresponds to

coordinates (x1, y1, z1), the second reference location information corresponds to coordinates (x2, y2, z2), and the third reference location information corresponds to coordinates (x3, y3, z3), as shown in FIG. 4B, the RFID reader 120 can calculate the current location through the triangulation method by means of the relative distances from the beacon devices 110, 112, and 114, identified as described above, and the three-dimensional coordinate information of each beacon device 110, 112, and 114.

[54] That is, when the three-dimensional coordinates of the current location of the RFID reader 120 correspond to (x, y, z), an equation for the current location can be derived as equation 1 below by using the triangulation method.

[55] MathFigure 1  
[Math.1]

$$(x1 - x)^2 + (y1 - y)^2 + (z1 - z)^2 = (d1 - \text{err})^2$$

$$(x2 - x)^2 + (y2 - y)^2 + (z2 - z)^2 = (d2 - \text{err})^2$$

$$(x3 - x)^2 + (y3 - y)^2 + (z3 - z)^2 = (d3 - \text{err})^2$$

[56] In equation 1, "err" represents an error with respect to distance, and is a constant which can be determined according to a tolerable error rate in the current location.

[57] Also, "x1," "y1," "z1," and "d1" correspond to the first reference location information and the relative distance from the first beacon device 110, and are constants which can be identified from the first beacon. "x2," "y2," "z2," and "d2" correspond to the second reference location information and the relative distance from the second beacon device 112, and are constants which can be identified from the second beacon. "x3," "y3," "z3," and "d3" correspond to the third reference location information and the relative distance from the third beacon device 114, and are constants which can be identified from the third beacon.

[58] Therefore, since only "x," "y," and "z" correspond to variables to be found in three equations shown in equation 1, the three-dimensional coordinates (x, y, z) of the current location of the RFID reader 120 can be obtained by solving the three simultaneous equations.

[59] As described above, according to the present invention, at least three beacon devices emitting beacons are fixedly installed in the RFID system, and each beacon device 110, 112, and 114 emits a beacon, including reference location information of the beacon device and signal-intensity-to-distance information where the propagation environment of the circumstances of the beacon device is reflected, which helps the RFID reader 120 to determine the current location. Then, the RFID reader 120 measures the signal intensities of a first beacon, a second beacon, and a third beacon,

which have been received from the beacon devices 110, 112, and 114, respectively, identifies relative distances corresponding to the signal intensities of the beacons, respectively, and calculates the current location by using three-dimensional coordinates of each beacon device 110, 112, and 114, so that the moving RFID reader 120 can measure its own location, and furthermore, can exactly measure the location because the propagation environment of circumstances of each beacon device 110, 112, and 114 can be reflected.

[60] FIG. 5 is a view explaining an example of a procedure of measuring a moving speed and a moving direction by an RFID reader according to an exemplary embodiment of the present invention.

[61] As described above with reference to FIGs. 4A and 4B, the RFID reader 120 according to an exemplary embodiment of the present invention can measure its own current location by using at least three beacon devices.

[62] Meanwhile, the RFID reader 120 can freely move in the RFID system, and can continuously measure its own location, even while it is moving. Hereinafter, a procedure where the RFID reader 120 calculates or measures its moving speed and its moving direction while the RFID reader 120 is moving in the RFID system will be described.

[63] When it is assumed that the RFID reader 120 has moved from point A to point B, point A corresponds to three-dimensional coordinates (x1, y1, z1), and point B corresponds to three-dimensional coordinates (x2, y2, z2), as shown in FIG. 5, a moving speed of the RFID reader 120 may be derived as equation 2.

[64] MathFigure 2

[Math.2]

$$\frac{\sqrt{(x2 - x1)^2 + (y2 - y1)^2 + (z2 - z1)^2}}{\text{movement time}}$$

[65] That is, since a speed can be expressed as a ratio of a distance to a time, the RFID reader 120 can calculate a moving speed by dividing its own moving distance by its own moving time. This is to calculate a moving speed by dividing a distance from a pre-moving location to a post-moving location by a moving time.

[66] Also, a moving direction of the RFID reader 120 may be derived as equation 3.

[67] MathFigure 3

[Math.3]

$$\vec{d} = (x2 - x1, y2 - y1, z2 - z1)$$

- [68] That is, a vector from x-axis, y-axis, and z-axis coordinates of a pre-moving location to x-axis, y-axis, and z-axis coordinates of a post-moving location corresponds to a moving direction.
- [69] Therefore, the RFID reader 120 can calculate its moving speed and its moving direction by equations 2 and 3, can use the calculated moving speed and moving direction to confirm if the RFID reader 120 is accurately moving toward a destination, and can utilize the calculated moving speed and moving direction to calculate and estimate a direction and a speed in which the RFID reader 120 is to move to the destination.
- [70] Although an exemplary embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Therefore, the embodiment disclosed in the present invention has been described not for limiting the scope of the invention, but for describing the invention. Accordingly, the scope of the invention is not to be limited by the above embodiment but by the claims and the equivalents thereof. It will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

### **Industrial Applicability**

- [71] As described above, according to the present invention, it is possible to measure the location of a moving RFID reader in an RFID system.
- [72] Also, since the location of the RFID reader is measured in consideration of propagation environments, it is possible to increase the accuracy of the location measurement.
- [73] In addition, since the RFID reader can measure its own location while the RFID reader is moving, it is possible to measure the moving speed and moving direction of the RFID reader.

## Claims

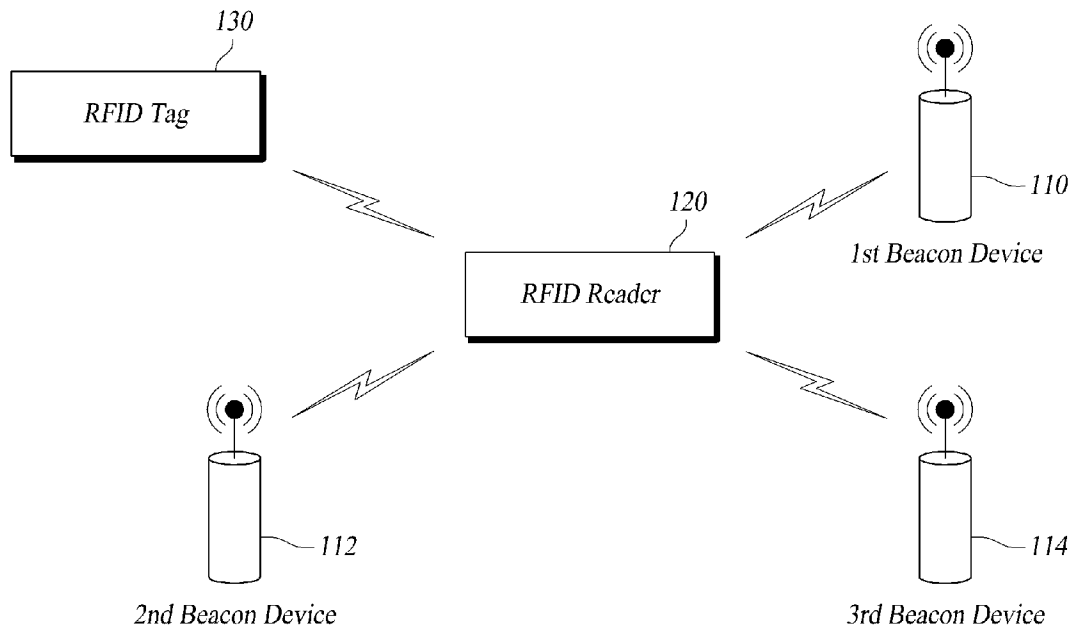
- [1] A radio frequency identification (RFID) system for measuring a location of an RFID reader by using a beacon, the system comprising:  
a plurality of beacon devices for emitting beacons;  
an RFID tag for transmitting pre-stored information by using radio frequency identification; and  
an RFID reader for calculating a current location by using a plurality of beacons when the RFID reader 120 receives the plurality of beacons from the plurality of beacon devices while moving, and receiving the information from the RFID tag by using the radio frequency identification.
- [2] The system as claimed in claim 1, wherein the beacon device is fixed at a reference location, and emits the beacon which includes information about the reference location and information about signal intensities to distances.
- [3] The system as claimed in claim 1, wherein the RFID reader calculates the current location by using information about a reference location and information about signal intensities to distances, which are included in the beacon.
- [4] The system as claimed in claim 3, wherein, when receiving the plurality of beacons, the RFID reader measures a signal intensity of each beacon received from each beacon device, checks relative distances from the beacon devices by using the information about signal intensities to distances, and calculates the current location through a triangulation method using a reference location of each beacon device and the relative distances from the beacon devices.
- [5] The system as claimed in claim 1, wherein the RFID reader receives the plurality of beacons from at least three beacon devices among the plurality of beacon devices.
- [6] The system as claimed in claim 5, wherein, when receiving the plurality of beacons from said at least three beacon devices, the RFID reader calculates the current location by using three beacons having relatively higher signal intensities among the plurality of beacons.
- [7] The system as claimed in claim 1, wherein the RFID reader calculates a pre-moving location and a post-moving location, and calculates a speed and a direction from the pre-moving location to the post-moving location.
- [8] The system as claimed in claim 7, wherein the RFID reader measures a movement time from the pre-moving location to the post-moving location, calculates a distance from the pre-moving location to the post-moving location, and then calculates a ratio of the distance to the time as the speed.
- [9] The system as claimed in claim 7, wherein the RFID reader calculates the

direction by calculating a vector from the pre-moving location to the post-moving location.

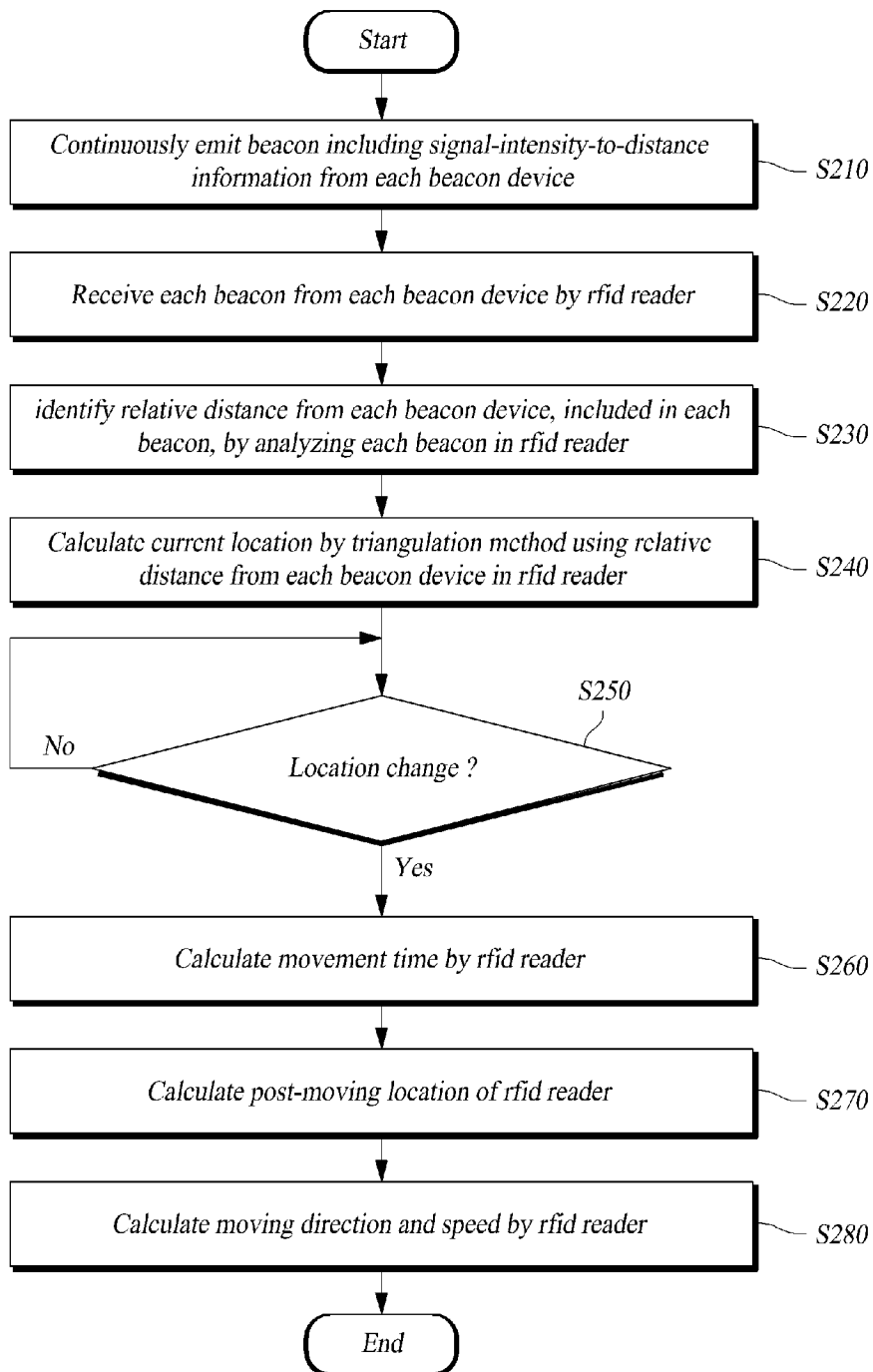
- [10] A method for calculating a current location by a radio frequency identification (RFID) reader in an RFID system, which comprises an RFID tag, the RFID reader, and a plurality of beacon devices, the method comprising the steps of:
- (a) receiving a plurality of beacons from the plurality of beacon devices;
  - (b) calculating relative distances from the plurality of beacon devices by analyzing the plurality of beacons; and
  - (c) identifying reference locations of the plurality of beacon devices by analyzing the plurality of beacons, and calculating the location by using the reference locations of the plurality of beacon devices and the relative distances from the plurality of beacon devices.
- [11] The method as claimed in claim 10, wherein step (b) comprising the steps of:
- (b1) identifying information about signal intensities to distances, which is included in the plurality of beacons, by analyzing the plurality of beacons; and
  - (b2) calculating the relative distances from the plurality of beacon devices by using the information about signal intensities to distances.
- [12] The method as claimed in claim 10, wherein step (c) comprising the steps of:
- (c1) identifying information about the reference locations of the plurality of beacon devices, which is included in the plurality of beacons, by analyzing the plurality of beacons; and
  - (c2) calculating the location through a triangulation method using the reference locations of the plurality of beacon devices and the relative distances from the plurality of beacon devices.
- [13] The method as claimed in claim 10, further comprising, after step (c), the steps of:
- (d) moving the current location to a next location; and
  - (e) calculating a moving speed and a moving direction from the current location to the next location.



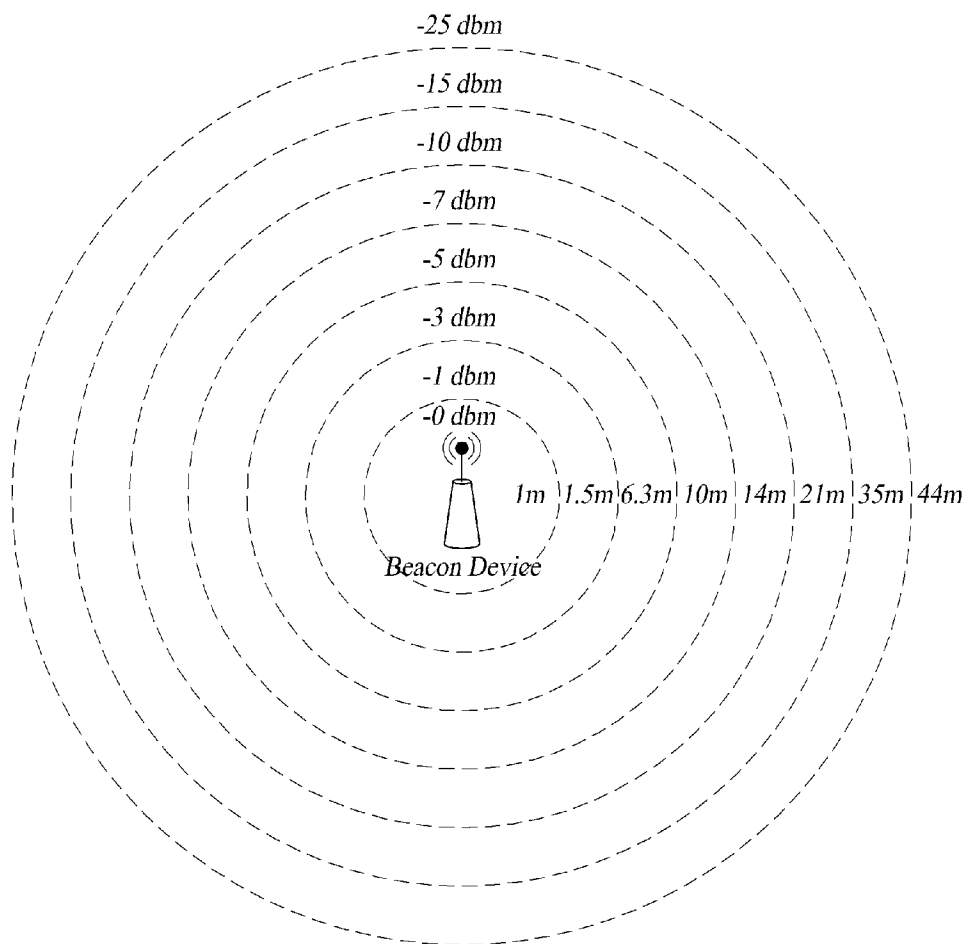
[Fig. 1]



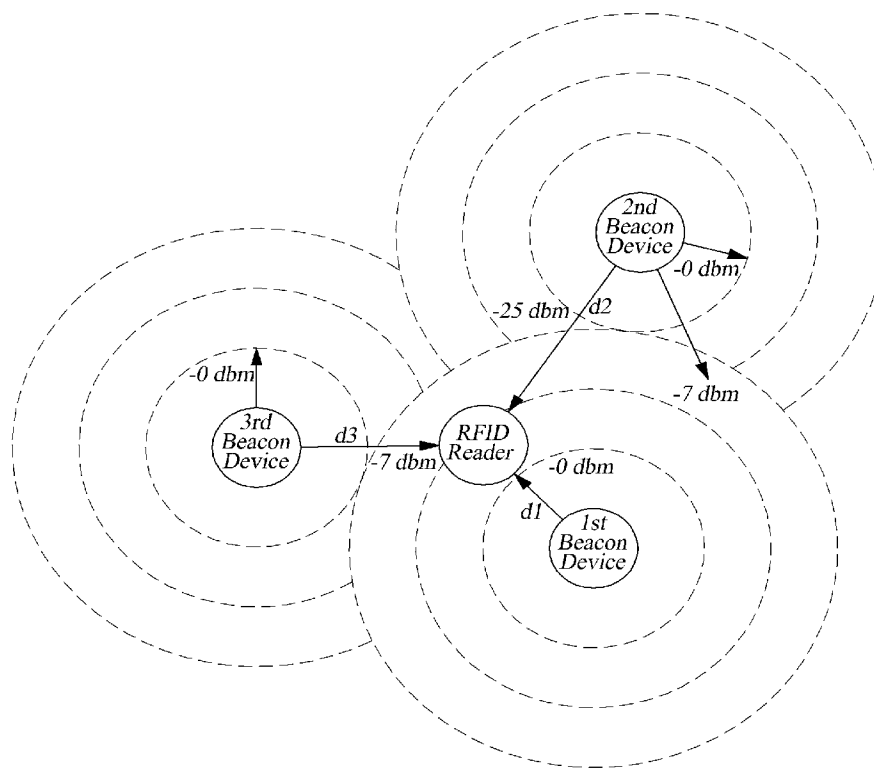
[Fig. 2]



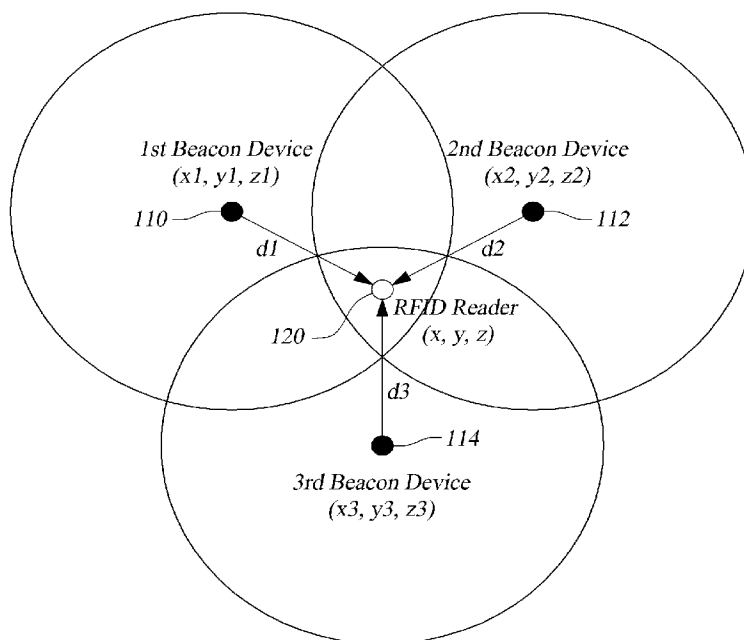
[Fig. 3]



[Fig. 4]

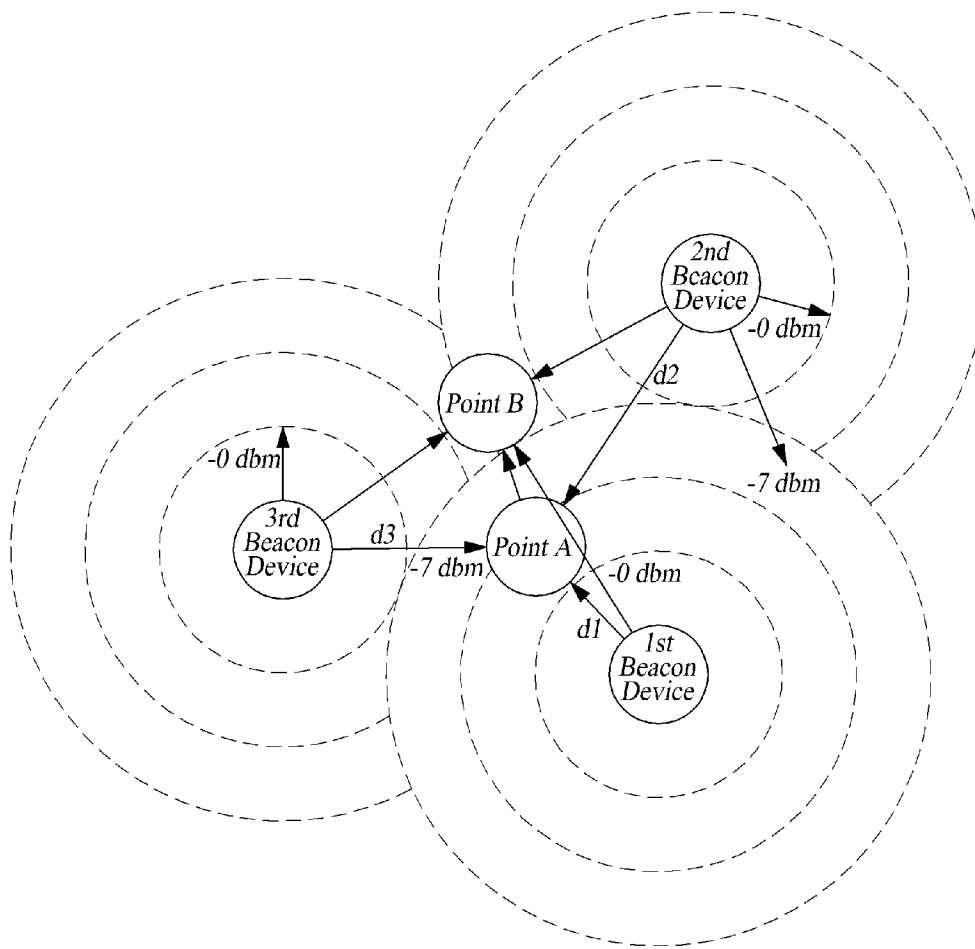


4a



4b

[Fig. 5]



## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/KR2008/002906****A. CLASSIFICATION OF SUBJECT MATTER*****H04L 12/28(2006.01)i***

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 8: H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EKIPASS(KIPO internal)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006/0071790 A1 (DURON et al.) 6 Apr. 2006 See Paragraph [0019] - Paragraph [0041].	1-13
A	US 6707424 B1 (SNYDER et al.) 16 Mar. 2004 See Column 9, Line 13 - Column 14, Line 9.	1-13

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

09 SEPTEMBER 2008 (09.09.2008)

Date of mailing of the international search report

**09 SEPTEMBER 2008 (09.09.2008)**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/KR2008/002906**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-071790 A1	06.04.2006	US 7403120 B2	22.07.2008
US 6707424 B1	16.03.2004	US 7181247 B1	20.02.2007