

An Optimal Viewable Area Searching Method for Supporting User Mobility

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Abstract—In this paper, we propose an optimal viewable area searching method for supporting user mobility using Received Signal Strength Indicator (RSSI) values. In order to search an optimal viewable area, the home multimedia system determines a viewable area of each terminal based on viewable angle and viewable distance. We implement an optimal viewable area searching system which includes the mobile station, media server and home gateway. Through the implementation, we verify that the proposed method can support the user mobility with an optimal viewable distance and angle.

Keywords—Seamless Multimedia Service, Indoor Positioning System, Service Mobility, Home Network, Received Signal Strength Indicator (RSSI)

I. INTRODUCTION

Many researchers have developed a ubiquitous video streaming service based on user context to let people enjoy continuous multimedia services in home network [1]. During recent years, many indoor position sensing systems have been investigated in ubiquitous network environment. The position sensing system enables a mobile device to determine its position and makes the position of the device available for position-based services such as navigating, tracking or monitoring, etc. These systems provide a new layer of automation called automatic object location detection [2]-[3].

However, common position sensing methods can't be expected to high accuracy or performance. In addition, some kinds of automatic systems based on position sensing information can't provide appropriate service for users because they consider only the information of position without considering user context information and terminal's features such as user preference, user status, user location and terminal viewable area and terminal's type.

For example, if a user is faced with following conditions, he can't watch TV.

- The user located too close to TV.
- The user located too far from TV.
- The user located outside from display viewing angle.

As mentioned above, previous studies did not consider the user context information and the terminal's features. However, to provide the optimal service environment, apart from the information of position, the technique reflecting user context information and terminal's features is required. In addition, the position sensing system takes advantage of combining some of these technologies to improve the accuracy, which also inherits the limitations of these technologies with requirements and more problems.

To meet these requirements, we propose an optimal viewable area searching method for supporting user mobility using Received Signal Strength Indicator (RSSI) values. In order to search an optimal viewable area, the home multimedia system determines a viewable area of each terminal based on viewable angle and viewable distance. We implement an optimal viewable area searching system which includes the mobile station, media server and home gateway. Through the implementation, we verify that the proposed method can support the user mobility with an optimal viewable distance and angle.

This paper is organized as follows. In section II, we describe the related works. The proposed method is explained in section III. In section IV and V, we shows implementation result of the proposed method and implementation issues. Finally, conclusion is given in section VI.

II. RELATED WORKS

In this section, the user mobility mechanism and service mobility mechanism are introduced. And we investigate the indoor positioning system.

A. Mobility mechanism

Many mobility mechanisms have been developed to provide seamless multimedia streaming services such as session mobility, service mobility, terminal mobility and user mobility [4]-[8].

An agent-based user mobility mechanism can provide that a user who enjoys multimedia service using mobile station like PDA, laptop computer and smartphone in the outer wireless network moves into the home network, and then, the service

needs to be continuous on another terminal in the home network [5]. When the user moves to another terminal within the same home network, the terminal needs to be able to recognize the information of user identification and location which can be served from the home gateway (HG) to provide seamless service continuously. There are many methods that HG and multimedia streaming server (MSS) recognize a user identification and location [4]-[8].

However, these methods have problems that all mobile station has a RFID Reader or a user needs to be located in the place where sensors can sense a user.

B. Received Signal Strength Indicator (RSSI)

RSSI is a geometrical or trigonometric approach of estimating object location; this technique is based on measurement of signal attenuation, the decrease of the signal strength relative to its original intensity. The amount of signal power received at the receiver antenna depends on the distance measured based on the fact that power transmitted reduces with respect to distance travelled by the signal within a complicated channel. Equations or functions describing the expected decrease in signal strength given the distance like the Friis equation can be used to estimate location relative to the source of the signal [2]-[3].

C. Triangulation

Triangulation uses the geometric properties of triangles to estimate the target location. It has two derivations: lation and angulation. Lation estimates the position of an object by measuring its distances from multiple reference points. So, it is also called range measurement techniques. Instead of measuring the distance directly using received signal strengths (RSS), time of arrival (TOA) or time difference of arrival (TDOA) is usually measured, and the distance is derived by computing the attenuation of the emitted signal strength or by multiplying the radio signal velocity and the travel time. Roundtrip time of flight (RTOF) or received signal phase method is also used for range estimation in some systems. Angulation locates an object by computing angles relative to multiple reference points [2]-[3].

D. Trilateration Algorithm

In this algorithm, the distance of the mobile node from three fixed nodes whose positions are already known is first calculated using the radio propagation model. Figure 1 shows diagrammatic representation of Trilateration approach.

Consider the case if the positions of three fixed nodes and their radii say r_1, r_2, r_3 from the three fixed base stations say P_1, P_2, P_3 are known, and we also know in advance their coordinates say (X_0, Y_0, Z_0) , (X_1, Y_1, Z_1) , and (X_2, Y_2, Z_2) , then the coordinates of the mobile node B can be estimated using Trilateration [9]. Consider the coordinates of the mobile nodes are (x, y, z) then the radii R_i can be expressed by the following equation.

In order to compute an object in three coordinates system we need to arrange four base stations. We can obtain the linear equation using the following equation.

$$R_i = \sqrt{(x - X_i)^2 + (y - Y_i)^2 + (z - Z_i)^2} \quad (1)$$

$$\text{for } i(1) = 1, 2, 3 \dots n - 1$$

$$A\vec{x} = \vec{b} \quad (2)$$

After simplification and applying Minimum Mean Square Error (MMSE), the equation becomes [9].

$$\vec{x} = (A^T A)^{-1} A^T \vec{b} \quad (3)$$

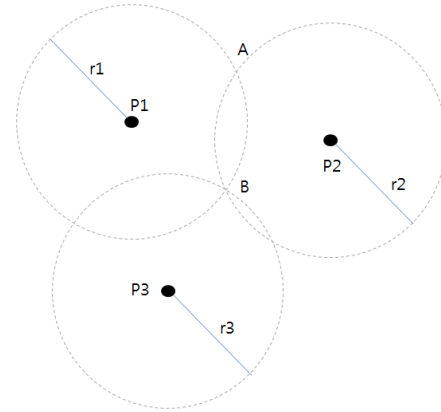


Figure 1 Trilateration algorithm

III. PROPOSED SEARCHING METHOD

This section presents the method which searches the viewable area to provide optimal service environment in home network.

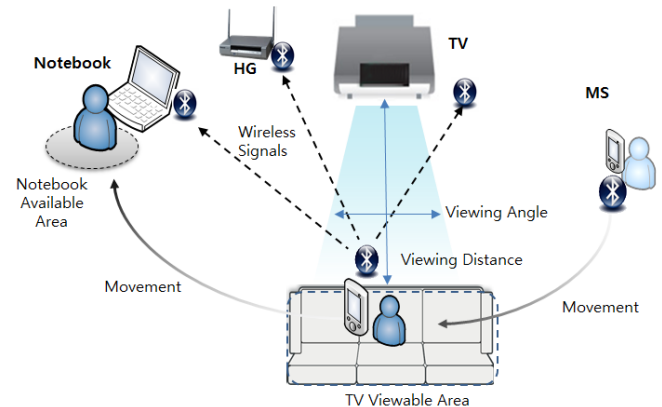


Figure 2. The service mobility concept according to the user movement

Fig. 2 shows the service environment for supporting user mobility in home network. For example, when a user who enjoys multimedia service using smartphone moves to another location to enjoy better environment, the smartphone measures a viewable distance and angle between smartphone and TV. If the user is located in the viewable area of the better environment, the service moves to the better terminal.

Here, each terminal has a different viewable area according to viewable distance and angle because each terminal has

different screen size and type. So, we considered the terminal information to support user mobility.

A. Proposed mechanism

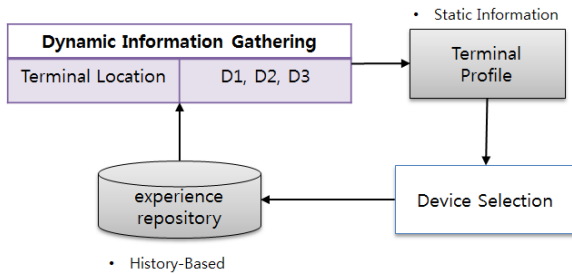


Figure 3. Structure of the management information

Fig. 3 shows the method and structure of the device selection. The experience repository (ER) manages the information of each terminal such as terminal resolution, viewable distance, terminal ID, etc. The optimal viewable area depends on the panel type, screen size and user preferences [9].

First of all, the mobile station (MS) checks the information of fixed terminal location from the experience repository (ER) whether the fixed terminal has changed or not. If the fixed terminal has changed the location or there is no information about the viewable area, the fixed terminal needs to be search a new viewable area. And then, the terminal records the viewable area information to the ER.

Fig 4. presents a method which searches the viewable area.

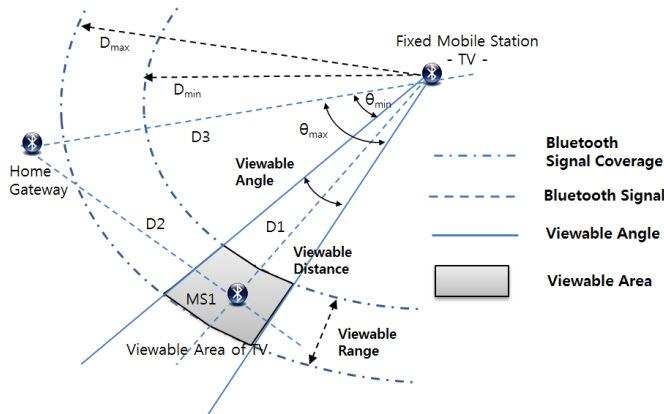


Figure 4. Proposed method to calculate the viewable area

First of all, each terminal measures a distance (D_1 , D_2 , D_3) using RSSI values among terminals. Then, MS_1 receives D_3 information from home gateway.

MS_1 compares the distance whether D_1 is the value between D_{min} and D_{max} or not. If D_1 is the value between D_{min} and D_{max} , MS_1 recognizes that a user is located in viewable distance. And then, MS_1 calculates the angle between D_3 and D_1 . If the MS_1 knows D_1 , D_2 and D_3 , MS_1 can easily calculate angle (θ) between D_1 and D_3 using Triangulation method [2]. If the θ is bigger than θ_{min} and smaller than θ_{max} , it means that a user is located to viewable angle.

Finally, if the MS_1 satisfy two conditions which are viewable distance and angle, it means that MS_1 is located to TV viewable area and can enjoy multimedia service continuously via TV [4].

The θ_{min} , θ_{max} , D_{min} and D_{max} the criterion of these values, rely on the terminal profiles like terminal type and terminal screen size.

Fig. 5 presents the procedures of the service mobility method.

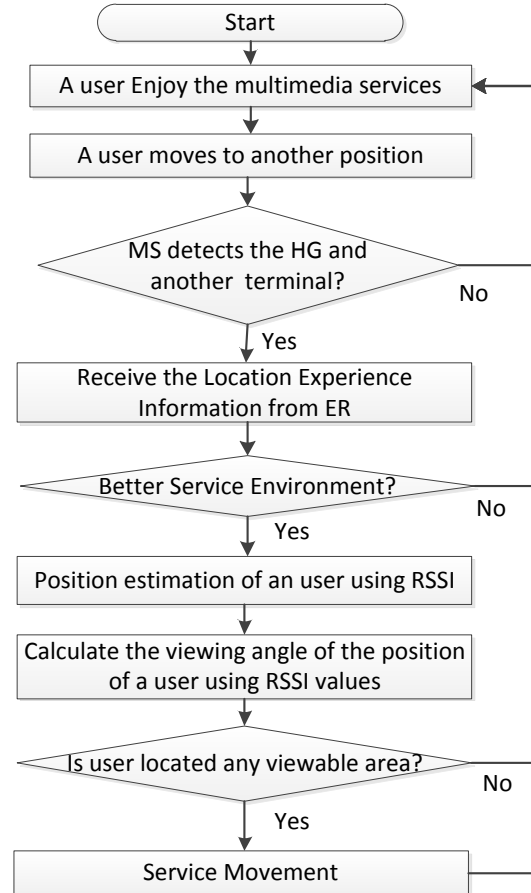


Figure 5. Procedures of the proposed service mobility method

Firstly, a user enjoys the multimedia service using the smartphone. When the user moves to another position, the smartphone detects the terminals. If the smartphone detects both the home gateway and another terminal, the smartphone estimates the user location using RSSI.

And then, when the user moves closer to another terminal, the smartphone measures a viewable distance and angle between smartphone and the terminal. At the same time, home gateway checks the information of fixed terminal location from the experience repository (ER) whether there is available information about previous measured viewable area. If there is any available location information about the target terminal, the smartphone receives the fixed distance (D_3) between home gateway and target terminal to calculate the angle.

And then, the smartphone compares whether the current terminal is better than target terminal profiles like screen size and battery life. If the user is located in the viewable area of

the better terminal, the multimedia service moves to the target terminal [4]. Finally, the user can enjoy the multimedia in better environment continuously.

Table 1 shows the Pseudo-code of the proposed searching method.

TABLE 1. PSEUDO-CODE OF A PROPOSED SEARCHING METHOD

/* Data : Viewable Angle θ , Distance D_1 , D_2 , D_3 */	
/* preD3 : Previous Measured D_3 */	
1.	Measure D_3
2.	If $D_3 == \text{preD}_3$ then
3.	Send D_3 to the MS_1
4.	end If
5.	While MS_1 detects home gateway && user movement do
6.	Measure D_1 , D_2
7.	If $D_1 < D_{\max}$ && $D_1 > D_{\min}$ then
8.	Calculate θ using triangulation method
9.	If $\theta < \theta_{\max}$ && $\theta > \theta_{\min}$ then
10.	Service movement
11.	end If
12.	end If
13.	end While

IV. IMPLEMENTATION

This section presents implementation issues of proposed searching method.

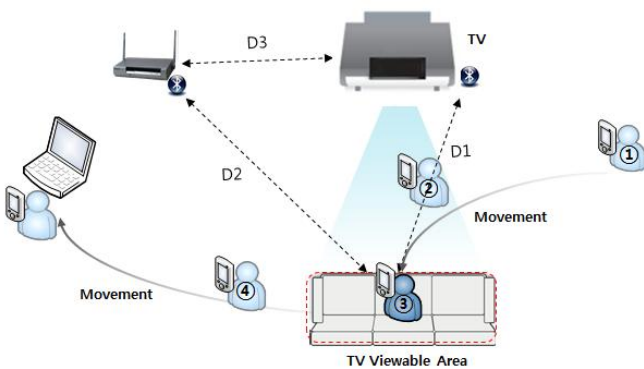


Figure 6. Experiment scenario for searching an optimal viewable area

TABLE 2. SYSTEM PROPERTIES

Object	CPU	RAM	OS	Screen Size
MSS	2.8GHz	4GB	Windows Server 2008	-
HG	2.1GHz	1GB	Linux CentOS 6	-
MS1	1GHz	512MB	Android 2.3.4	7"
TV	2.3GHz	2GB	Linux Suse 11.4	52"
Notebook	2.5GHz	2GB	Linux Suse 11.4	14.1"

Fig. 6 and Table 2 show an experiment scenario for

searching an optimal viewable area and system properties for demonstrating the proposed searching method, respectively.

In fig. 6, we numbered from 1 to 4 according to user location. We measured the distance between the terminals and calculated the viewable angle when user are located in the numbered location.

Table 3 presents the measured RSSI values when a user is located in the numbered location.

TABLE 3. MEASURED RSSI VALUES ACCORDING TO USER MOVEMENT

Numbered Location	Measured RSSI Values (dBm)		
	D_1	D_2	D_3
1	-43	-53	-50
2	-33	-50	-50
3	-52	-54	-50
4	-52	-48	-50

Firstly, we measured the RSSI values among the terminals when a user is located in the numbered location. However, error range is too big to estimate accurate user location. Moreover, researchers have researched the indoor positioning system to reduce the error range [2]-[3]. So, we focused on the actual distance to verify the proposed method. And then, we calculated the viewable distance and angle accurately.

Figure 7 and 8 present the graph of the distance and angle when a user is located to the numbered location in the fig. 6.

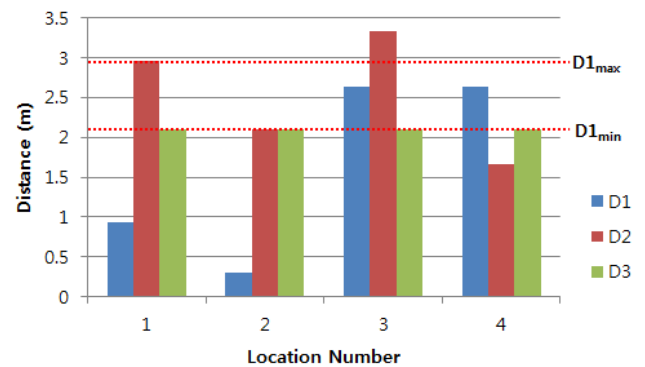


Figure 7. Actual measured distance in numbered location

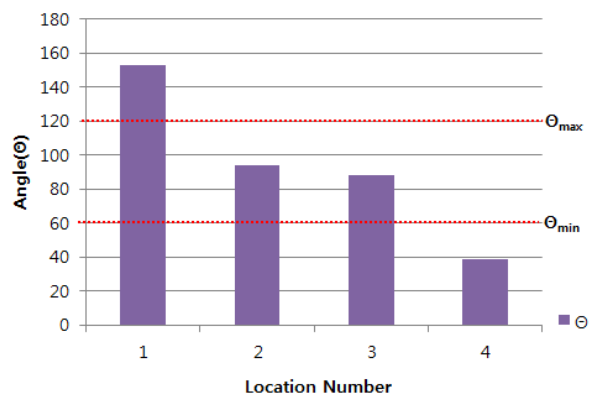


Figure 8. Angle of $D_3(\theta)$ in the numbered location

Fig 7 shows the actual measured distance when a user is located to the numbered location in the fig. 6.

We determined the viewable distance based on the D_1 . According to the [10], the viewable distance of the 52 inches TV is 2.6m. So, we decided that the viewable distance is from 2.1m to 3m. As the experiment results, the smartphone is in the viewable distance when the user is located in the location number 3 and 4. We assume that the viewable angle of the TV is the value between 60 degree and 120 degree. The smartphone is in the viewable angle when the user located in the location number 2 and 3. However, in fig 7, the smartphone is not in the viewable distance when the user is located in the location number 2. Finally, the smartphone is in the optimal viewable area of the TV when the user located in the location number 3.

TABLE 4. SERVICE DELAY TIME OF PROPOSED METHOD

Service Movement	Service Delay Time
MS1 → TV	400ms
TV → Notebook	370ms

Table 4 presents the service switching time when moving a user. We used the tool called wireshark to measure the service delay time.

V. IMPLEMENTATION ISSUES

This section presents implementation issues of proposed searching method. From the demonstration above, we notice that there are the considerations to implement proposed searching method as follows:

A. Optimal viewable distance and angle

Let us consider the home network. The location preferring each people for watching multimedia service may different. Also, the viewable angle of the terminal may different. To solve this problem, we recommend the history-based user mobility mechanism based on proposed searching method.

B. Error range

Radio frequency based positioning has multi-path and reflection effects resulting in a relatively higher error range [3]. For example, Bluetooth RSSI-based position system error range is about 2m to 3m, room level accuracy [2]. It is important that viewable area is determined by considering the error range.

C. Period of inquiry interval

Frequent inquiry for search and distance measurement brings about the problems that the battery life time shortens. So, the standard distance and interval time needs to be determined by controlling the interval of inquiry.

D. Priority of terminal

If the viewable area by two terminals is overlapped, the standard for selecting terminal based on priority is required.

The priority is determined by the characteristics such as a central angle, the type of terminal and application.

VI. CONCLUSIONS

An optimal viewable area searching method is presented in this paper. The optimal viewable area searching method is based on triangulation through RSSI values, and the viewable area determined by viewable angle and viewable distance. We implement an optimal viewable area searching system which includes the mobile station, media server and home gateway. Through the implementation, we verify that the proposed method can support the user mobility with an optimal viewable distance and angle.

For further works, we'll research about the improved context-aware mobility.

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