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Indoor Position Monitoring System Using UWB Module

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***Abstract*—Recently, indoor positioning has been actively researched, and methods using Wi-Fi have been widely studied. However, indoor positioning using Wi-Fi has a lot of problems. Therefore UWB is an alternative method. UWB is suitable for indoor positioning because of its high multipath resolution and good obstacle transmittance. In this paper, we propose a system for indoor positioning and monitoring using UWB module. The system is targeted for smart factories, smart hospital and IoT healthcares.**

Keywords—UWB, BLE; Wi-Fi; indoor positioning

I. INTRODUCTION

Recently, as smart mobile devices are widely activated, location-based services (LBS) have attracted attention. With the success of LBS using Global-positioning system (GPS), service providers begin to pay attention to LBS for indoor environment. Various studies of indoor positioning is conducted, and indoor LBS are also increasing. Most widely known indoor positioning method is a method using Wi-Fi. However, indoor positioning using Wi-Fi has a lot of problems.[1] Therefore, UWB is getting attention. UWB is suitable for indoor positioning because of its high positioning of resolution and good performance on obstacle transmittance.

In this paper, we propose an indoor positioning system, which can calculate user's position using UWB module and monitor on the web client.

II. RELATED RESEARCHES

A. Indoor Positioning Methods

Typical positioning methods include fingerprint and triangulation method. In this study, triangulation is used.

1) Triangulation method

Triangulation is a method of measuring the position from three nodes, which know the distance. The more accurate the distance value, the more accurate point can be calculated. [3] Methods such as AOA, TOA, and TDOA also use triangulation methods.[4]

III. ULTRA WIDE BAND (UWB)

It is usually called UWB, and it is one of the recently attracted communication methods. UWB is less impacted by obstacles and radio interference, and is more energy efficient.[2] Because of these advantages, it is suitable for indoor positioning and error is less than 1m, which is better than other wireless communication methods. The distance is calculated using the Round Trip Time of the signal, not the RSSI value, and the position is measured by triangulation method with the distance.

Figure I shows the method for getting a distance between two UWB nodes.

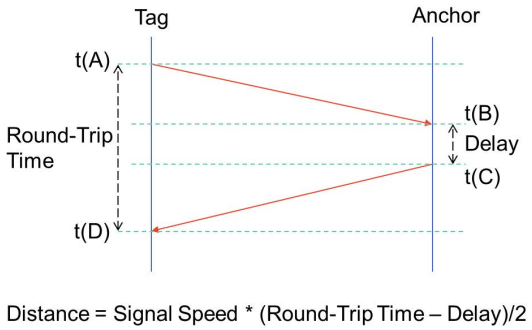

FIGURE I. DISTANCE CALCULATION USING ROUND TRIP TIME

IV. DESIGN OF POSITIONING SYSTEM

A. Concept of the Monitoring System

Figure II shows Communication concept of the indoor monitoring system.

Among the UWB modules, the mobile node that the user has is tag, and the fixed node in the indoor environment is called anchor. tag measures the distances to anchors using UWB signal and transmits distance data to Smartphone using BLE one-way communication. Smartphone application calculates coordinates using triangulation method, displays the position on the map, and transmits to the server using Wi-Fi communication. Server stores coordinate values in the Databases and displays the position via web client.

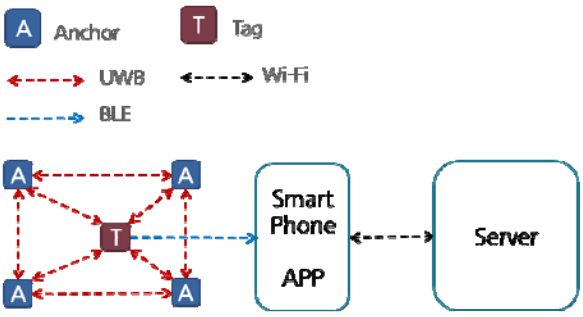

FIGURE II. COMMUNICATION CONCEPT OF THE INDOOR MONITORING SYSTEM

B. *Communication of Tag to Smartphone*

The protocol of distance data that tag sends to the smartphone is shown in Figure III.

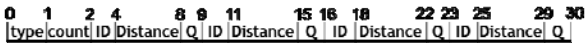

FIGURE III. THE PROTOCOL OF DISTANCE DATA

'Type' is protocol type number, and it has '1' in this protocol. 'Count' is a number of distance values, it has 1~4 value, and total protocol length can be varied from 9 to 30 bytes according to this values. 'ID' is Anchor's ID that tag measured distance. 'Distance' is the distance between the tag and the Anchor in millimeters. 'Q' is quality factor, and it typically has a value of 100.

Communication between tag and smartphone is one-way communication using BLE. Smartphone can receive distance data from multiple tags without pairing.

C. *Processing within the Smartphone Application*

Smartphone application receives three or more distance values, and calculates coordinate values using triangulation methods. And then, the application displays position on the map and sends coordinate values to server.

D. *Server Processing Procedure*

Server has DB server and Web server. DB server receives coordinate values from Smartphone application and stores coordinate values. Web server detects DB data update and apply the update values to the monitoring page. Figure IV shows server processing.

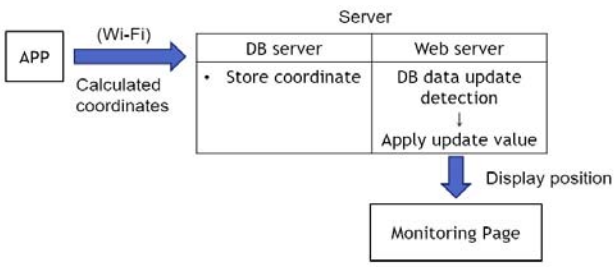

FIGURE IV. SERVER PROCESSING PROCEDURE

Monitoring page includes an indoor map and displays the coordinates stored in the DB on the map. This page can be shown by another user and administrator.

E. *The Structure of DB for the System*

Figure V shows DB design of the server. At 'Current position', only the latest position is stored for each 'Tag ID'. In 'History', all of the coordinate values and event information are stored by time. In 'Map table', 'Map No.' is the unique number of map, which has different values depending on the building or floor. 'Block table' is a table with the coordinates such as obstacles or forbidden zones. It can be set to the shape of the polygon according to the value of the 'Vertex count' and 'Vertex'. 'Map table' and 'Block table' are loaded only once when monitoring page is loaded. 'Current position' and 'History' are loaded each time that server receives data from the smartphone application.

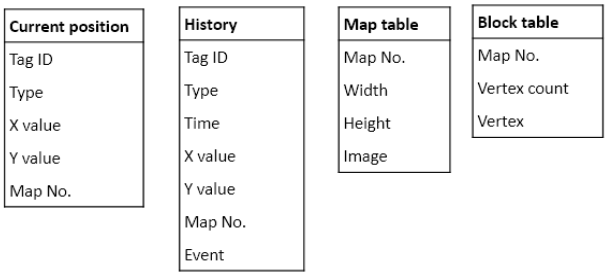

FIGURE V. DB DESIGN OF THE SERVER

V. POSITIONING PERFORMANCE EXPERIMENT

A. *Experimental Environment*

MDEK-1001 kit of Decawave is used as UWB module. As smartphone Voyo i8max is used, and as wireless AP, ipTIME N3 is used. Server is built with Ubuntu, PHP7 and mariaDB.

Figure VI shows an example for positioning. Each anchors are placed a pre-decided position. The position of the moving tag can be calculated using three nearest distance among anchors. The interval metric of coordinate is based on centimeters. We measure the position at any 5 points.

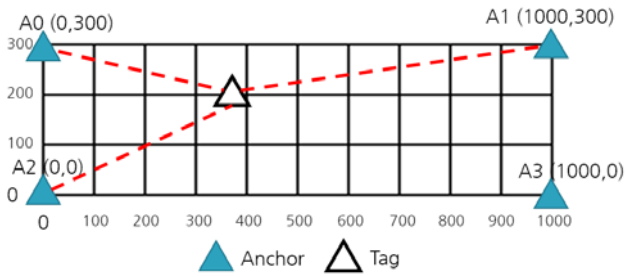

FIGURE VI. EXAMPLE FOR POSITIONING

B. *Experiment Result*

Error of indoor positioning using UWB is shown in Table I. Maximum is 8cm, minimum is 4cm, and average is 6.2cm. This error is tolerable in the monitoring system.

TABLE I. ERROR OF INDOOR POSITIONING USING UWB

Point 1	Point 2	Point 3	Point 4	Point 5	Avg.
6cm	8cm	4cm	8cm	5cm	6.2cm

Figure VII shows position metrics of a floor of whole building.

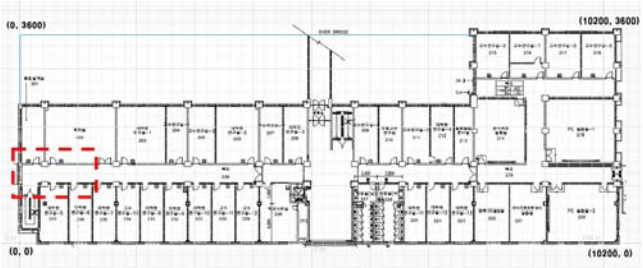

FIGURE VII. POSITION METRIC OF A FLOOR OF WHOLE BUILDING

Figure VIII shows the result expanded screen on real experiment. The Figure VIII is a part of Figure VII which is shown as dotted area. The position is updated in real time whenever the tag moves.

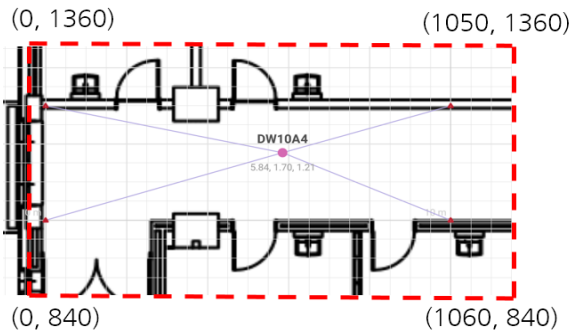

FIGURE VIII. POSITION MONITORING SCREEN

VI. CONCLUSION

In this paper, we designed an indoor position monitoring system using UWB module. UWB is very suitable for indoor positioning system.

For the future research, we design a system that allows a wider area of indoor positioning. Research that can be applied to industrial field or special purpose building such as hospital and sanatorium is required. In addition, qualitative and quantitative improvement is needed.

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