THREE DIMENSIONS POSITIONING BASED LOCATION TRACKING TEHCNIQUE FOR INDOOR ENVIRONMENT

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This thesis is dedicated to

Dad, Abu Hassan Bin Haji Mat Saman,

Mum, Sharifah Binti Jalil

Also my siblings and my fiancé Habib Sandriawan

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ABSTRACT

Traditional tracking system with Two Dimensions-image (2D-image) standard presents only few and dull information to users. In addition, 2D localization only supports one level platform (i.e. horizontally). Thus, the Three Dimensions (3D) location tracking system has been developed to support multilevel building. The aim of this research is to develop a positioning based indoor tracking system with 3D locations which are able to provide more useful location tracking information to users using radio signals. In this research, a Wireless Fidelity (Wi-Fi) based indoor location tracking approach is introduced. We used the existing Wireless Local Area Network (WLANs) attached devices called the Access Point (AP) to the edge of the wired network. Mobile Node (MN) communicates with the three APs to receive signals. The Receive Signal Strength Indicator (RSSI) is used to calculate the distance between MN and APs. To determine the location of the MN the trilateration method is used. Finally, the database file is developed to store all the results calculated by the location server. The location tracking system is able to detect positions of MN without using Global Positioning System.

ABSTRAK

Sistem penjejak tradisional dengan imej piawai Dua Dimensi (2D) hanya mempersembahkan maklumat yang sedikit dan pudar kepada para pengguna. Tambahan pula penyetempatan 2D hanya menyokong satu aras pelantar (contohnya melintang). Maka, sistem penjejak kedudukan Tiga Dimensi (3D) telah dibangunkan untuk menyokong bangunan yang mempunyai pelbagai aras. Sasaran kajian ini adalah untuk membangunkan kedudukan berdasarkan sistem penjejak dalaman dengan kedudukan 3D yang berupaya menyediakan maklumat penjejakan kedudukan yang lebih berguna kepada pengguna menggunakan isyarat radio. Dalam kajian ini, pendekatan penjejak kedudukan dalaman berdasarkan Sistem Rangkaian Pautan tanpa Wayar (Wifi) diperkenalkan. Kami menggunakan alat Rangkaian Kawasan Tempatan tanpa Wayar (WLAN) yang sedia ada yang dipanggil Titik Capaian (AP) pada rangkaian berwayar. Titik Mobil (MN) berkomunikasi dengan tiga titik capaian untuk menerima isyarat. Penunjuk Kekuatan Isyarat Menerima (RSSI) digunakan untuk mengira jarak antara titik mobil dan titik capaian. Untuk menentukan kedudukan titik mobil kaedah *trilateration* digunakan. Akhirnya, fail pangkalan data dibangunkan bagi menyimpan semua keputusan yang dikira oleh pemberi kedudukan. Sistem penjejak kedudukan berupaya mengesan kedudukan-kedudukan MN tanpa menggunakan Sistem Kedudukan Sejagat.

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LIST OF ABBREVIATIONS

AOA	-	Angle of Arrival
AP	-	Access Point
GPS	-	Global Positioning System
IEEE	-	Institute of Electrical and Electronics Engineers
IETF	-	Internet Engineering Task Force
IP	-	Internet Protocol
IPng	-	IP next generation
IPv4	-	Internet Protocol version 4
IPv6	-	Internet Protocol version 6
MN	-	Mobile Node
NAT	-	Network Address Translation
NIC	-	Network Interface Card
RSSI	-	Received Signal Strength Indicator
SIP	-	Session Initiation Protocol
TOA	-	Time of Arrival
VoIP	-	Voice over Internet Protocol
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

1.1   Overview

Nowadays, wireless technology becomes very important in life which enables humans to communicate around the world either in short distance or long distance without having to plug in any cable. All sectors including universities, companies, stations as well as airports and cafeteria provide wireless communication facilities. The networks are developed using a devices called access point that provide total connectivity surround the area and connection to internet. Some devices are necessary to cover a big area including outside a building and small area like an office, a lab or an airport. The signal strength of the access point influence the number of users supported. If the signal strength is high, large number of users can be supported and vice versa. However, the numbers of access point is not influenced the signal strength. Even single wireless internet access point can support a large number of users simultaneously.

Besides internet access, wireless communication supports the world community with variety of applications in the military, consumer, government and

business such as radio and television broadcasting, HF radio and satellite communication, home accessories, GPS service, television and many more. These advantages bring the idea to implement user location tracking on the premises using this network. Localization is the process of determining an object's location in space. Location tracking can be categorized as indoor and outdoor localization. Location tracking and positioning systems can be classified by the measurement techniques applied to determine mobile device location. The approaches differ in terms of the technique used to sense and measure the position of the mobile device in the target environment.

Real Time Location System (RTLS) that determine position of the mobile device can be classified as below[1]:

    (i)   Cell of origin (nearest cell)

    (ii)   Distance (lateration)

    (iii)   Angle (angulation)

    (iv)   Location patterning (pattern recognition)

The implementation of location tracking system can be used one or more of this techniques. Some of the methods are able to optimize performance in two or more environments with very different propagation characteristics. The techniques give an advantage where at least two of this methods can be combined to sense and measured the position of mobile device. Regardless of the underlying positioning technology, the real time nature of an RTLS is only as real-time as its most current timestamps, signal strength readings, or angle-of-incidence measurements. The timing of probe responses, tag transmissions, and location server polling intervals can introduce discrepancies between the actual and reported device position observed during each reporting interval.

Nowadays, many technologies are being used to create location-tracking and location-based systems. The technologies including [2]:

(i) **Geographic Information Systems (GIS)**

For large-scale location-tracking systems, it is necessary to capture and store geographic information. Geographic information systems can capture, store, analyze and report geographic information.

(ii) **Global Positioning System (GPS)**

A constellation of 27 Earth-orbiting satellites (24 in operation and three extras in case one fails) as shown in Figure 1.1. A GPS receiver, like the one in user mobile phone, can locate four or more of these satellites, figure out the distance to each and deduce user location trough trilateration. For trilateration, it must have a clear line of sight to these four or more satellites. GPS is suitable for outdoor positioning, such as surveying, farming, transportation or military used.

(iii) **Radio Frequency Identification (RFID)**

RFID is small and less battery microchips that can be attached to consumer goods, cattle, vehicles and other objects to track their movements. RFID tags are passive and only transmit data if prompted by a reader. Then, the reader transmits radio waves that can activate the RFID tag. The tag transmits information via a pre-determined radio frequency. This information is captured and transmitted to a central database. RFID tags are replacement for traditional UPC bar codes.

(iv) **Wireless Local Area Network (WLAN)**

WLAN is a network of devices that connect via radio frequency, such as 802.11b. These devices pass data over radio waves and provide users with a network with a range of 70 to 300 feet (21.3 to 91.4 meters).

Figure 1.1 Concept of the GPS satellite constellation

1.2 Problem Statement

Location tracking in an indoor environment is possible with various techniques based on mechanical, acoustical, ultrasonic, optical, infrared, inertial or radio signal measurements. Nowadays, location tracking information and visualization of 3D graphics either in outdoor or indoor environment had been presented as one of research issues. Traditional tracking system with 2D image standard presents only few and dull information to users. In addition, 2D localization only supports one level platform. Thus, the 3D location tracking system had been developed to support multilevel building.

There are many approaches to measure the location of the nodes in a network. However the methods need high cost and require specific and complex hardware. In this research, the RSSI method was preferred due to its low cost and simple in

implementation. The focus area in this research which is location tracking at the server side.

1.3   Research Objectives

The objectives of this research are to develop a 3D location tracking system to support multilevel building. The development apply an indoor tracking system with 3D locations which are able to provide more useful location tracking information to user using radio signals. The development including:

(i) To develop an indoor location tracking system in three dimension provisioning based.

(ii) To determine location of a mobile node at several service level using RSSI.

(iii)To implement trilateration method and fingerprint method of tracking system.

1.4   Scope of Work

The scope of this research is to design the location tracking system to determine a mobile unit position in 3 Dimension network. The system presents in IEEE 802.11 infrastructure networks. The system operates in the IPv6 network to provide more reliable network supporting by Ubuntu. Location determination of a mobile unit is based on the RSSI from several access points varies with position of mobile. This system uses a SNMP framework to collect RSSI in the mobile unit and

communicate it to a server where the location of mobile is determined and available via http.

The designs of location tracking system in this work are using trilateration method and fingerprint method. These methods usually work in two phases:

(i)   First phase (offline phase)
        A database of the RSSI in each location is built. The existing Wireless Local Area Network (WLANs) attached devices work as the access point (AP) to the edge of wired network. Nodes communicate with the AP using a wireless network adapter similar in function to a traditional Ethernet adapter. The location server and the mobile node is setup. The mobile node is collected the signals from the APs and send to location server to create a database.

(ii)   Second phase (online phase)
        Given a sample of RSSI and a classification system which uses database information, the location server calculated the mobile node position in terms of coordinate (x, y, z).

Most of works differ in latter phase. The design and implementation of 3D indoor location tracking has been demonstrated in a testbed to determine the position of mobile node in termed of coordinate (x, y, z) displayed at location server.

1.5   Thesis Contribution

The achievement of the research is the design and development of three dimension indoor locations tracking for mobile user. The proposed indoor location tracking consists of the software components which include the OS and the testbed network. The software component has been designed in the Ubuntu by program the system network and the testbed network has been developed by applying office environment using WLANs as a access points, desktop as a location server, laptop as a mobile node and wireless adapter as a hub between location server and mobile node. In general the contribution of the work can be highlighted as follows;

(i)   Development and implementation of indoor location tracking for three dimension (3D) that support multilevel building.

(ii) Development and implementation of IPv6 network that supports the system in IEEE 802.11 infrastructure networks.

(iii) Implementation of the trilateration method and fingerprint method for location tracking.

(iv) Development and implementation of location determination of a mobile node based on the RSSI from several access points.

(v)   Development and implementation of indoor location tracking system testbed for mobile node in the office environment using the RSSI.

1.6   Organization of the Thesis

This thesis has been written in six chapters to highlight the design, development and the implementation of the 3D indoor location tracking. It begins with chapter 1 as the introduction to the thesis. It consists of overview of the

research, problem statement, objectives of the research, scope of the work and significant contribution of the project.

Chapter 2 provides the relevant background for understanding the location tracking systems for indoor environment. Besides that, this chapter presents the other important components including indoor location tracking system application, VoIP, IEEE 802.11 Standard and Internet Protocol version 6 (IPv6). The final part of chapter 2 discusses on the operating system used in the location tracking system.

Chapter 3 describes the designing and implementation of the 3 Dimension of Trilateration system. The system architecture and design is further explained in detailed in Chapter 3.

Chapter 4 elaborates the designing and implementation of the 3 Dimension of fingerprinting system. The system architecture and design is also further explained in detailed in Chapter 4.

Chapter 5 discusses the experimental results on both Trilateration system and Fingerprint system. The final chapter 6 concludes the outcomes of the research.

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