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Research Paper

Access control system using beacon-based indoor location data pattern analysis

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Abstract

Background/Objectives: With the development of IT, accidents of industrial secret leakage have occurred more than before. Such accidents are mostly caused by insiders.
Methods/Statistical analysis: An existing access control system uses RFID and NFC tag. The system saves only the final location information in DB. For the reason, it is hard to track a user's location data in real time. However, a beacon-based access control system saves a user's location information in DB in real time. By analyzing the location information of DB, it is possible to track a user.
Findings: Beacons are used for determining a user's location. The determined location information is converted into location data which is saved into DB. The location data is converted into coordinates. The converted coordinate data is analyzed for understanding a user's behavior pattern. In the pattern analysis, if a user takes an abnormal behavior, policy-based response is performed. The user behavior pattern analysis system proposed in this study is able to respond to an accident in real time. Therefore, it is expected to contribute to reducing the number of industrial secret leakage accidents caused by insiders.
Improvements/Applications: This study designs a model that analyzes behavior pattern by using the indoor location data of a user based on beacon.

Keywords: *IPS; Beacon; Indoor Position; Security Control System; Pattern Analysis*

1. Introduction

With the development of IT, Internet of Things and convergence environments have emerged in various fields. In addition,corporate technologies have become informationized. With the emergence of the new environments, core assets of firms have informationized. However, in their convergence with IT, the industrial secrets that should be protected safely have more leaked to competitive firms or overseas[1,2]. A security system had mostly responded to such threats as virus and hacking. These days, a security system has expanded to responses to industrial secret leakage, going beyond traditional responses[3,4]. According to National Industrial Security Center of National Intelligence Service, the number of the domestic industrial spies caught was 29 in 2005, 31 in 2006, 32 in 2007, 42 in 2008, 43 in 2009, 41 in 2010, and 46 in 2011. As such, it was on the steady rise annually. Regarding the entities of technology leakage from 2005 to 2011, former employees accounted for 62%(127 cases), and present employees 17%(34 cases). It indicates that recent industrial secrets are mostly leaked by insiders. As firms have raised their awareness of industrial security, they have enhanced security measures of core technologies. As a result, it is relatively hard for outsiders to make access[5]. With an increase in industrial security accidents, access control has drawn a lot of attention. As of now, the purpose of an access control system is to control a user's access and keep industrial security. Unfortunately, the security level of a domestic access control system far falls behind an access control system in foreign countries. There is a relative lack of awareness of security in various areas, except for IT security and video monitoring[6,7]. Most access control systems use RFID, QRcode and NFC tag[8,9]. However, such systems are unable to track a user's location and have the log of the initial location and the final location saved in a server. An existing access control system take measures by analyzing logs. A beacon-based IPS (Indoor Positioning System) analyzes a user's location in real time. Since the analyzed indoor location information is saved into a server, it is possible to analyze a user's location in real time. In addition, such a system is able to prevent and respond to an abnormal condition through the real-time analysis. Therefore, this study designs an access control system model using beacon-based indoor location data pattern analysis.

2. Literature review

2.1. A Method for stable indoor positioning using beacons (more than three beacons)

To track a user's location, the method is based on weighted averaging. To obtain a user's location, more than 3 beacons are used for triangulation. Based on two beacons, all intersection points of circles are calculated.The mean point (C) of all intersection points can be obtained. With the use of the point, it is possible to track a user's location (Figure.1) [10]. To analyze estimated location information with the use of more than 3 beacons, it is required to save either in an image type, or in a coordinate type. In the case of the image type, a lot of storage is needed. Therefore, this study uses the coordinate typed saving method.

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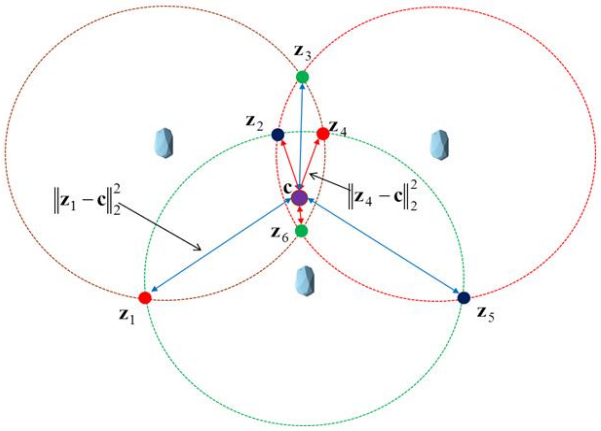


Fig. 1:.Estimating The Position Using 3 Beacons10.

2.2. A Method for stable indoor positioning using beacons (more than three beacons)

To provide QR code based access service to a user, this study suggests the process of issuing a new QR code and the QR code access process. Figure.2 is illustrates the flow of the QR code based access control system.

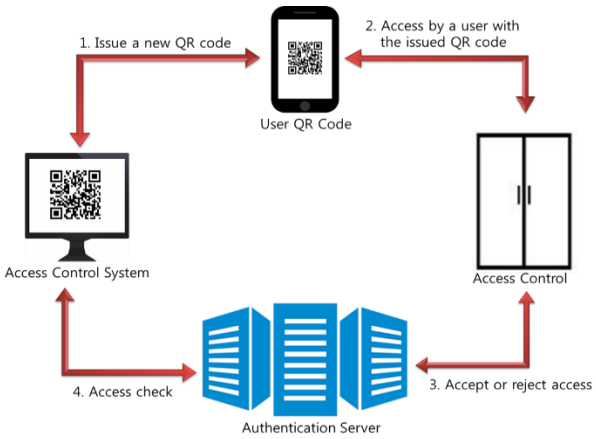


Fig. 2: QR Code Based Access Control System Flow [11].

A new user installs QR code app and makes a request to the access control system which generates a QR code with encrypted user information and displays the code on screen. By using the already-registered QR code app, the user takes a shot of the QR code and has its encrypted user information. For access, the QR code app user clicks 'refresh' button on the QR code app and puts it on QR scanner for authentication. When the QR code is well recognized by QR scanner, the authentication server determines whether the access is permitted. All of the user access information can be checked by the access control system via the authentication server[11]. An access control system based on QR has difficulty tracking a user's location. In other words, in the case of access without QR code recognition, it is hard to track a user's location. In addition, such a system has a user's initial location and final location so that it is difficult to understand a user's behavior pattern.

2.2. A Method for stable indoor positioning using beacons (more than three beacons)

A beacon-based IPS (Indoor Positioning Systems) uses beacons and heterogeneous sensors to measure a user's location. Access Location Logging DB Serer saves a user's location information sent from Indoor Positioning System. The saved information is analyzed, and then a user's location information and control zone information are transmitted to Security Policy Server which requests Authentication Server to send a user's information. The server analyzes user information in the categories of insider, visitor, title, and job and transmits a policy. With the use of the analyzed data, a policy is transmitted to a user's smartphone. In this way, access is controlled (Figure. 3).

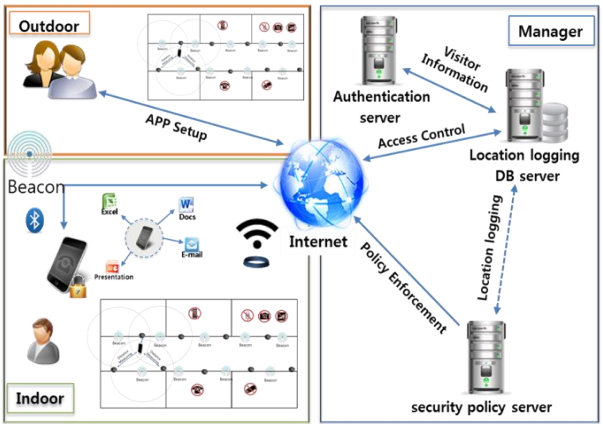


Fig. 3:.Indoor Location Determination12.

However, if a user takes an unpredicted behavior, the system has difficulty determining whether or not it is accidental and fails to make a response. Therefore, it is necessary to design a model that can recognize a user's accidental behavior by analyzing a user's location data12.

3. Model design

In the beacon-based IPS, Location Data DB is required for analyzing a user's behavior pattern with the use of more than 3 beacons. However, the current beacon-based IPS provides location information only. Prior to the analysis on behavior pattern, it is necessary to convert the location information into location data. There are two methods of converting into location data. One is to use an image. The other is to use coordinates. In the method of using an image, data are massive so as to lower analysis speed. Therefore, this study uses the method of coordinates

3.1. Indoor position estimation

To obtain a user's location data, it is required to estimate a location accurately. For location estimation, the intersection points of two circles are calculated and the points at which lines of the intersection points are crossed are used. For more accurate estimation, more than six beacons are used. The formula of calculating the intersection points of two circles is written below. D is the distance between the centers of the two circles.

$$a_1 = \frac{l}{d}(x_2 - x_1) + \frac{h}{d}(y_2 - y_1) + x_1 \quad (1)$$

$$b_1 = \frac{l}{d}(y_2 - y_1) + \frac{h}{d}(x_2 - x_1) + y_1 \quad (2)$$

$$a_2 = \frac{l}{d}(x_2 - x_1) + \frac{h}{d}(y_2 - y_1) + x_1 \quad (3)$$

$$b_2 = \frac{l}{d}(y_2 - y_1) + \frac{h}{d}(x_2 - x_1) + y_1 \quad (4)$$

$$l = \frac{r_1^2 + r_2^2 + d^2}{2d} \quad 5)$$

$$h = \sqrt{r_1^2 - l^2} \quad (6)$$

Figure.4 shows the method of calculating the intersection points of two circles and the method of estimating a user's location.

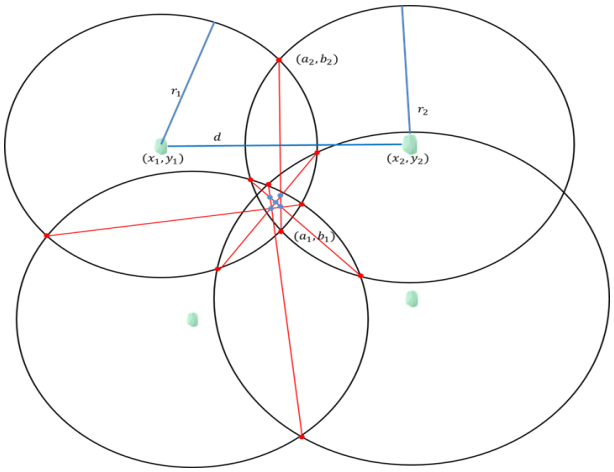


Fig. 4:.The Method of Calculating the Intersection Points of Two Circles and the Method of Estimating a User's Location.

The points at which the straight lines of the intersection points are crossed are calculated. The weighted average value of the points is used for estimating a user's location.

3.2. Conversion of indoor location data

To analyze the pattern of location data, Location Data DB is essential. It is necessary to convert location log data into the two-dimensional x&y coordinates data. The two dimensional coordinate data are converted in the type of 10cm by 10cm grid on the basis of the total map. Figure. 5 illustrates the process of converting location information into location data.

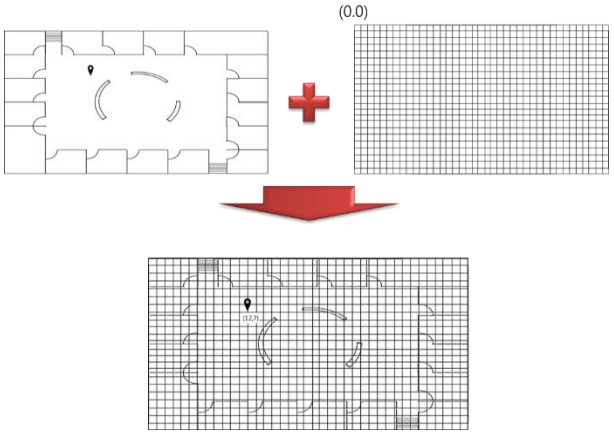


Fig. 5:.Process of Converting Position Information into Location Data.

An existing beacon location is set as coordinates. The reference point (0, 0), user distance, and the distance between beacon and user are calculated. And then, a user's coordinates are calculated. Formula shows the distance between two points.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (7)$$

3.3. Analysis on user pattern with the use of indoor location data

The converted location data are used for analyzing a user's behavior pattern. As a behavior pattern analysis method, the clustering technique 'LBG (Linde-Buzo_Gray) algorithm' is applied. LBG algorithm is created in combination of K-means algorithm and binary split algorithm.

The execution steps are presented as follows:

1) The total mean of location data is generated.
2) A very small value is added once into the cluster central vector, and is subtracted once from the vector. As a result, two central vectors are created. The reason for the very small value is to overcome a distortion limitation and divide very finely.
3) For a set of location data, distances from the two central vectors are calculated. In this way, a cluster to belong to is found.
4) The mean of clusters is calculated, and then a new central vector of each cluster is calculated.
5) The processes of No. (3) and No. (4) Are performed repeatedly until a distortion value is lower than baseline.

LBG (Linde-Buzo_Gray) algorithm formula is written below. In the location data set, x andyj(i)means that it is the central vector of cluster j to which the index i, an element of the data set, belongs.

$$D_j = \frac{1}{n}\sum_{i=1}^{n} d(x_i, y_{j(i)}), j = \{a, b\} \quad (8)$$

LBG algorithm is used for determining a user's coordinates by day and time (set up at a 5-miniute interval).The determined coordinates are used for finding a user's move path and behavior pattern. If a user's exceptional move occurs, an alarm rings to inform the user and a security agent. The proposed pattern analysis method gets more accurate as there are more data.

4. Conclusion

With the development of IT, core assets of firms have informationized. However, in their convergence with IT, the industrial secrets that should be protected safely have more leaked to competitive firms or overseas. With an increase in industrial security accidents, access control has drawn a lot of attention. As of now, most access control systems use RFID, QRcode and NFC tag. However, such systems are unable to track a user's location and have the log of the initial location and the final location saved in a server. They make responses through log analysis after industrial secrets are leaked. A beacon-based IPS (Indoor Positioning System) analyzes a user's location in real time and saves the information in a server. As a result, it is possible to analyze a user's location in real time.Therefore, the method proposed in this study uses more than beacons to track a user's location and converts location information into location data in a coordinate type, rather than image type with large data size. The converted location data is applied to the clustering technique 'LBG algorithm' which analyzes a user's behavior pattern. With the use of the analyzed data, it is possible to detect a user's exceptional move. In the proposed method, the more there are location data of behavior pattern, the more the data are accurate. In addition, it is expected to be capable of responding to exceptional circumstances more accurately. In the future, the proposed model will be implemented and supplemented.

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