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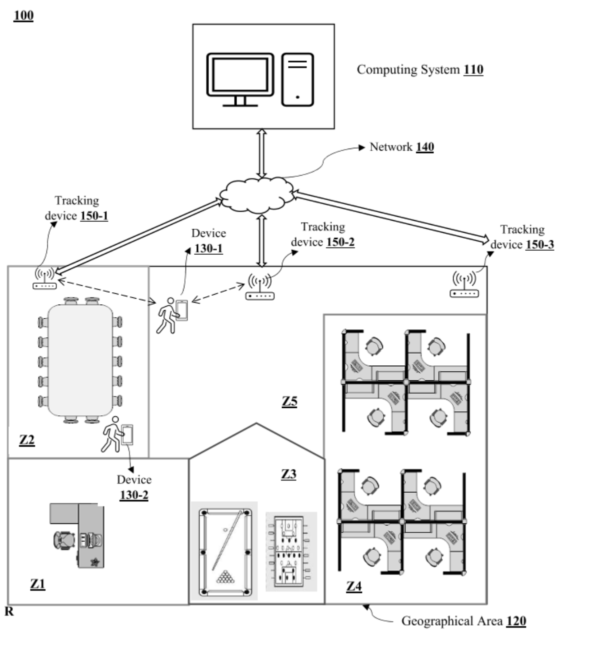
(54) Title: METHOD AND SYSTEM FOR DETECTING ZONE VIOLATION

(57) Abstract: The present disclosure describes a technique for zone violation detection in a geographical area (120). The technique of the present disclosure divides the geographical area (120) into a plurality of zones and a plurality of cells such that each zone is associated with at least one cell. The technique determines a current location of a device (130) traversing through the geographical area and identifies a cell corresponding to the determined current location of the device (130). The technique further identifies a zone associated with the identified cell based at least on pre-stored association information that indicates an association of the plurality of cells with the plurality of zones. The technique of the present disclosure further determines whether the device (130) is authorized to enter inside the identified zone by checking a pre-stored list of devices which are authorized to enter inside the identified zone.



FORM 2

THE PATENTS ACT 1970
(39 OF 1970)
&
The Patent Rules, 2003

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

METHOD AND SYSTEM FOR DETECTING ZONE VIOLATION

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3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification describes the invention and the manner in which it is to be performed

DESCRIPTION

[0001] The present disclosure generally relates to the field of communication. Particularly, the present disclosure relates to an automated zone violation detection method and system.

BACKGROUND

[0002] With the rapidly growing need of surveillance and security in corporate/government offices, factories, buildings, homes, educational institutions, military etc., it becomes essential to monitor real time locations/movements of objects. Conventionally, the locations/movements of objects were monitored manually by human operators. However, with the increasing number of objects, it became very cumbersome for the human operators to manually monitor the movement of each and every object over a geographical area. To assist the human operators in tracking movements of the objects within the geographical area, object location tracking systems were introduced.

[0003] The object location tracking systems can track real time movement/location of an object while the object traverses within the geographical area. The geographical area may be divided into a plurality of small areas (or polygon shaped zones). Further, for security concerns, some of the objects may not be allowed to enter in some zones of the plurality of zones. For example, for a high voltage area/zone in the geographical area, only an authorized electrician may be allowed to enter. Similarly, only an authorized computer operator may be allowed to enter in a server room which has confidential data. Thus, it becomes important to closely monitor the movements of objects inside the geographical area so that only the authorized objects can be allowed to enter inside a particular zone.

[0004] To achieve this and other objectives it is important to first determine a current zone corresponding to a current location of the object and then check whether the object is allowed to enter inside the current zone or not. Hence, the problem of tracking current location of the object further extends to a problem of determining a current zone corresponding to the current location of the object.

[0005] Conventionally, point-in-polygon (PIP) technique is used for determining a zone corresponding to a current location of the object. The PIP technique checks for each of the polygon zones, whether the current location of the object lies inside the polygon or not. Hence, even for an individual location, the PIP technique would perform checks for all polygon zones. Therefore, zone determination becomes a very resource consuming problem if there are a plurality of objects to be tracked in real-time with respect to the plurality of zones and with the increasing numbers of objects, the computational complexity also increases.

[0006] Thus, with the huge and rapidly growing demand of real-time location tracking to detect zone violation, there exists a need for further improvements in the existing techniques. Particularly, there exists a need for optimal and resource efficient zone violation detection technique that can determine a current zone associated with the real-time location of the object.

[0007] The information disclosed in this background section is only for enhancement of understanding of the general background of the disclosure and should not be taken as an acknowledgement or any form of suggestion that this information forms the prior art already known to a person skilled in the art.

SUMMARY

[0008] One or more shortcomings discussed above are overcome, and additional advantages are provided by the present disclosure. Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the disclosure.

[0009] An objective of the present disclosure is to provide an optimal technique for real time tracking of a large number of objects in a geographical area having a large number of restricted zones.

[0010] Another object of the present disclosure is to provide an efficient technique for determining a zone associated with a real-time location of an object.

[0011] Another objective of the present disclosure is to provide a cost effective, and time and resource efficient technique for detecting zone violation.

[0012] Another objective of the present disclosure is to raise an alert upon detecting zone violation by any object.

[0013] In a non-limiting embodiment, a zone violation detection method is disclosed. The method may comprise dividing a geographical area into a plurality of zones, where each zone has an associated list of devices which are permitted to enter inside the zone and dividing the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells. The method may further comprise determining a current location of a device traversing through the geographical area using one or more tracking devices installed within the geographical area, where at least one of the one or more tracking devices may communicate with the device. The method may further comprise identifying a cell, from the plurality of cells, corresponding to the determined current location of the device and identifying a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones. The method may further comprise determining whether the device is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone and providing an alert in response to determining that the device is not authorized to enter inside the identified zone.

[0014] In another non-limiting embodiment of the present disclosure, the step of determining a current location of a device may comprise receiving a signal from each of the at least one tracking device, where the signal may indicate received signal strength indicator (RSSI) measurement data; and determining cartesian coordinates (X, Y) associated with the device based on the received RSSI measurement data, where the cartesian coordinates may indicate the current location of the device traversing through the geographical area.

[0015] In another non-limiting embodiment of the present disclosure, each cell may be a square of side L and may have a unique identity (cell_id). The step of identifying a cell, from the plurality of cells, corresponding to the determined current location of the device may comprise applying modulo operation on the determined cartesian coordinates (X, Y) associated with the device by:

$$Mx = X \% L,$$

$$My = Y \% L;$$

calculating a cell_id based on the determined cartesian coordinates (X, Y) associated with the device by:

$$cell\_id = 10 * ([X-Mx]/L) + ([Y-My]/L); \text{ and}$$

identifying the cell from the plurality of cells based on the calculated cell_id.

[0016] In another non-limiting embodiment of the present disclosure, the step of identifying a zone associated with the identified cell may comprise: when the identified cell is completely inside a particular zone and is associated only with the particular zone, identifying the particular zone as the zone associated with the identified cell; and when the identified cell is associated with a plurality of particular zones, applying point-in-polygon technique for the plurality of particular zones for identifying the zone from the plurality of zones associated with the identified cell.

[0017] In yet another non-limiting embodiment of the present disclosure, a zone violation detection system is disclosed. The zone violation detection system may comprise a memory and at least one processor communicatively coupled with the memory. The at least one processor may be configured to divide a geographical area into a plurality of zones, where each zone may have an associated list of devices which are permitted to enter inside the zone and divide the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells. The at least one processor may be further configured to determine a current location of a device traversing through the geographical area using one or more tracking devices installed within the geographical area, where at least one of the one or more tracking devices may communicate with the device. The at least one processor may be further configured to identify a cell, from the plurality of cells, corresponding to the determined current location of the device identify a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones. The at least one processor may be further configured to determine whether the device is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone; and provide an alert in response to determining that the device is not authorized to enter inside the identified zone.

[0018] In another non-limiting embodiment of the present disclosure, to determine a current location of a device, the at least one processor may be configured to receive a signal from each of the at least one tracking device, where the signal may indicate received signal strength indicator (RSSI) measurement data; and determine cartesian coordinates (X, Y) associated with the device based on the received RSSI measurement data, where the cartesian coordinates may indicate the current location of the device traversing through the geographical area.

[0019] In another non-limiting embodiment of the present disclosure, each cell may be a square of side L and may have a unique identity (cell_id). Further, to identify a cell, from the plurality of cells, corresponding to the determined current location of the device, the at least one processor may be configured to apply modulo operation on the determined cartesian coordinates (X, Y) associated with the device by:

$$Mx = X \% L,$$

$$My = Y \% L;$$

calculate a cell_id based on the determined cartesian coordinates (X, Y) associated with the device by:

$$cell\_id = 10 * ([X-Mx]/L) + ([Y-My]/L); \text{ and}$$

identify the cell from the plurality of cells based on the calculated cell_id.

[0020] In another non-limiting embodiment of the present disclosure, to identify a zone associated with the identified cell, the at least one processor may be configured to when the identified cell is completely inside a particular zone and is associated only with the particular zone, identify the particular zone as the zone associated with the identified cell; and when the identified cell is associated with a plurality of particular zones, apply point-in-polygon technique for the plurality of particular zones for identifying the zone from the plurality of zones associated with the identified cell.

[0021] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF DRAWINGS

[0022] Further aspects and advantages of the present disclosure will be readily understood from the following detailed description with reference to the accompanying drawings. Reference numerals have been used to refer to identical or functionally similar elements. The figures together with a detailed description below, are incorporated in and form part of the specification, and serve to further illustrate the embodiments and explain various principles and advantages, in accordance with the present disclosure wherein:

[0023] **Figure 1** shows an exemplary communication environment **100** for tracking location of an object within a geographical area for zone violation detection, in accordance with some embodiments of the present disclosure.

[0024] **Figure 2** shows a detailed block diagram **200** of the communication environment **100** illustrated in **Figure 1**, in accordance with some embodiments of the present disclosure.

[0025] **Figure 3** shows a simplified exemplary view of the communication environment **100** for tracking location of an object within a geographical area for zone violation detection, in accordance with some embodiments of the present disclosure.

[0026] **Figure 4** shows a detailed block diagram **400** of a computing system **110**, in accordance with some embodiments of the present disclosure.

[0027] **Figure 5** shows a flowchart illustrating a method **500** for zone violation detection, in accordance with some embodiments of the present disclosure.

[0028] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of the illustrative systems embodying the principles of the present disclosure. Similarly, it will be appreciated that any flowcharts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable mediu

[0029] m and executed by a computer or processor, whether or not such computer or processor is explicitly shown.

DETAILED DESCRIPTION

[0030] In the present document, the word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment or implementation of the present disclosure described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[0031] While the disclosure is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will be described in detail below. It should be understood, however, that it is not intended to limit the disclosure to the particular form disclosed, but on the contrary, the disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and the scope of the disclosure.

[0032] The terms "comprise(s)", "comprising", "include(s)", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a setup, device, apparatus, system, or method that comprises a list of components or steps does not include only those components or steps but may include other components or steps not expressly listed or inherent to such setup or device or apparatus or system or method. In other words, one or more elements in a device or system or apparatus proceeded by "comprises… a" does not, without more constraints, preclude the existence of other elements or additional elements in the system.

[0033] The terms like "at least one" and "one or more" may be used interchangeably throughout the description. The terms like "a plurality of" and "multiple" may be used interchangeably throughout the description.

[0034] In the following detailed description of the embodiments of the disclosure, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration of specific embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the scope of the present disclosure. The following description is, therefore, not to be taken in a limiting sense. In the following description, well known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

[0035] To determine whether an object has violated a particular zone of a geographical area, it is essential to first determine a current zone associated with a current location of the object. Conventionally, point-in-polygon (PIP) techniques are used to determine a zone associated with the current location of the object.

[0036] For a given object location, a PIP technique checks whether the given object location lies inside a polygon zone or outside a polygon zone. For checking this, many PIP based techniques have been introduced. A commonly used PIP technique (called 'ray casting technique') comprises following steps.

(1) Drawing a horizontal line to the right of the object location and extending it to the infinity.

(2) For each polygon zone, count the number of times the line intersects with edges of the polygon zone.

(3) A point is inside the polygon zone if either count of intersections is odd, or point lies on an edge of polygon zone. If none of the conditions is true, then point lies outside of the polygon zone.

[0037] Thus, for a single object location, the PIP technique performs check for all polygon regions. Hence, if the number of polygon regions and the number of objects to be located are large in number then for each object, the PIP technique would perform check on all polygon zones. This will consume huge amount of time and resources. Moreover, the computational complexity will also increase. Thus, using the PIP technique, it is challenging to efficiently determine a zone corresponding to a current location of an object.

[0038] The present disclosure overcome these and other problems by dividing the geographical area into a plurality of cells, and then determining a current cell and a current zone corresponding to a current location of the object using pre-stored data.

[0039] Referring now to **Figure 1**, which illustrates an exemplary communication environment **100** for tracking location of an object within a geographical area **120** for zone violation detection, in accordance with one embodiment of the present disclosure. The geographical area **120** may represent any premise of a corporate office, an IT park, a manufacturing plant, factory, home, military area, but not limited thereto. The object may be a living being (e.g., human or animal) or a non-living being (e.g., an electronics equipment, machine part etc.).

[0040] The communication environment **100** may comprise a computing system **110** (also referred as "a zone violation detection system" or "location tracking system") which may be in communication with one or more tracking device **150-1, 150-2, 150-3** (collectively referred as **150**) via a network **140**. The one or more tracking devices **150** may be installed inside the geographical area **120** at regular spacing and may be in communication with one or more user devices **130-1, 130-2** (collectively referred as **130**). Each tracking device **150** may cover a certain area depending on the technology used. It may be understood to a person skilled in art that the present disclosure is not limited to the communication environment **100** illustrated in

Figure 1 and may be implemented in various other communication environments as well, other than the one shown in Figure 1.

[0041] In one non-limiting embodiment of the present disclosure, the computing system **110** may be located within the geographical area **120** or may be located at a remote location. In another embodiment, the functionality of the computing system **110** may be implemented on a remote cloud server. In general, a computing system **110** is a set of integrated devices that input, output, process, and store data and information.

[0042] A tracking device **150** of the one or more tracking device **150** may be a wired device or a wireless device capable of communicating with the computing system **110** and with the one or more devices **130**. In a preferred embodiment, the tracking device **150** is a wireless location tracking gateway. The tracking device **150** receives signals from the one or more devices **130** and transmits the received signals to the computing system **110** for further processing to determine whether an object has violated a zone or not.

[0043] A device **130** may be any wired or wireless device capable of communicating with the one or more tracking devices **150** using one or more wired or wireless technologies. The wired or wireless technology may comprise Bluetooth, vision cameras, infrared ray (IR), ultrasonic wave, Wireless Local Area Network (WLAN), and radio frequency identification (RFID) etc. However, vision cameras and IR systems require a great deal of maintenance, repair costs, and high-cost system hardware. Ultrasonic wave systems are sensitive to temperature and Wi-Fi consumes a large amount of electric power. Additionally, RFID recognizes radio frequencies only at a short distance.

[0044] Bluetooth low energy (BLE) is a low energy implementation of Bluetooth. BLE may be adopted as a near-field location-based technology that uses radio signals. BLE-based device does not depend on an external power supply unit and can be sustained for a few months or years with a small battery. Therefore, BLE based beacon technology is a preferred choice for situations where battery life is preferred over high data transfer speeds. The device **130** may be called a BLE beacon device which transmits a universally unique identifier to the tracking devices **150**. The device **130** may be any communication device which may act as a beacon device such as, but not limited to, a wireless tag, a smartphone, a smart-watch, a fitness band, a BLE beacon tag etc.

[0045] In one non-limiting embodiment of the present disclosure, the device **130** may broadcast signals on regular intervals that can be detected by other BLE-enabled devices (such as the tracking devices **150**). The strength of the broadcasted signals may be indicated by Received Signal Strength Indicator (RSSI) measurements. RSSI is the strength of the beacon's signal as seen on the tracking devices **150**. The RSSI measurements may be used to calculate approximate distance between the tracking devices **150** and the device **130** using an expected value of RSSI.

[0046] In one non-limiting embodiment of the present disclosure, the tracking devices **150** may transmit the RSSI measurements and other data received from the device **130** to the computing system **110**. The computing system **110** may then analyze the data received from various tracking devices **150** and use conventionally known techniques such as, but not limited to, triangulation and trilateration techniques to determine location coordinates (X, Y) of the device **130**. Usually, a suitable location such as a corner of the geographical area **120** may be selected as an origin point or a reference point **R** for an indoor local coordinate reference system.

[0047] In general, the triangulation is a method for calculating a position and relies on a known distance between two measuring tracking devices and measured angles from those two tracking devices to an object. This works using the angle-side-angle triangle congruency theorem to find the location of an object. On the other hand, the trilateration uses known distance from at least three fixed points in 2D space or four fixed points in 3D space (as if on the surface of the Earth) to calculate the position of an object. Trilateration works by finding the intersection of a series of circles.

[0048] In one non-limiting embodiment of the present disclosure, the entire geographical area **120** may be divided into a plurality of zones **Z1-Z5**. For example, the geographical area **120** of **Figure 1** may be considered as a floor layout of a corporate office and may be divided into five zones namely, a CEO's cabin **Z1**, a conference room **Z2**, a recreation/gaming room **Z3**, employee workplace **Z4**, and open area **Z5**. Each zone may have an associated list of objects that are permitted to enter inside the zone. The computing system **110** may track real-time movements of objects within the geographical area and may raise an alert when an unauthorized object who is not authorized to enter inside a particular zone enters inside the particular zone.

[0049] Referring now to **Figure 2**, which illustrates a block diagram **200** of the communication environment **100** shown in **Figure 1**. According to an embodiment of the present disclosure, the computing system **110** may comprise at least one processor **210** and a memory **220**. The computing system **110** may be in communication with one or more tracking devices **150** via a network **140-2**. The tracking devices **150** may be in communication with one or more devices **130** via a network **140-1**.

[0050] The memory **220** may comprise various types of data and information. For example, the memory **220** may comprise association information of a plurality of cells and a plurality of zones, and a list of permitted devices for each zone, etc. The memory **220** may further store one or more instructions executable by the at least one processor **210**. The memory **220** may be communicatively coupled to the at least one processor **210**. The memory **220** may include a Random-Access Memory (RAM) unit and/or a non-volatile memory unit such as a Read Only Memory (ROM), optical disc drive, magnetic disc drive, flash memory, Electrically Erasable Read Only Memory (EEPROM), a memory space on a server or cloud and so forth.

[0051] The at least one processor **210** may include, but not restricted to, a general-purpose processor, a Field Programmable Gate Array (FPGA), an Application Specific Integrated Circuit (ASIC), a Digital Signal Processor (DSP), microprocessors, microcomputers, micro-controllers, central processing units, state machines, logic circuitries, and/or any devices that manipulate signals based on operational instructions. The at least one processor **210** may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0052] The network **140-1** may comprise Bluetooth, vision cameras, infrared ray (IR), ultrasonic wave, Wireless Local Area Network (WLAN), and radio frequency identification (RFID) etc. The network **140-2** may comprise a data network such as, but not restricted to, the Internet, Local Area Network (LAN), Wide Area Network (WAN), Metropolitan Area Network (MAN), etc. In certain embodiments, the network may include a wireless network, such as, but not restricted to, a cellular network and may employ various technologies including Enhanced Data rates for Global Evolution (EDGE), General Packet Radio Service (GPRS), Global System for Mobile Communications (GSM), Internet protocol Multimedia Subsystem (IMS), Universal Mobile Telecommunications System (UMTS) etc. In one embodiment, the networks **140-1, 140-2** may include or otherwise cover networks or subnetworks, each of which may include, for example, a wired or wireless data pathway.

[0053] In the forthcoming paragraphs, the present disclosure is explained by means of **Figure 3** in conjunction with **Figures 1** and **2** (discussed above).

[0054] Referring now to **Figure 3**, which illustrates a simplified floor layout of the geographical area **120** of **Figure 1**. In one embodiment, the floor layout of the geographical area **120** may be provided to the computing system **110** by a system administrator. In another embodiment, physical measurements or architectural diagrams of the geographical area **120** may be provided to the computing system **110** and the computing system **110** may automatically generate the floor layout based on the physical measurements or the architectural diagrams. In yet another embodiment, the administrator may draw the layout map on the computing system **110** using on one or more tools.

[0055] Once the floor layout of the geographical area **120** is generated, the at least one processor **210** may be configured to draw various polygon demarcating zones on the floor layout (i.e., the at least one processor **210** may divide the entire geographical area into a plurality of polygon zones). In an exemplary aspect, the geographical area **120** may be considered as a floor layout of a corporate office of an organization and the different zones may be named as a CEO's cabin **Z1**, a conference room **Z2**, a recreation/gaming room **Z3**, employee workplace **Z4**, and open area **Z5**. Now specific employees of the organization may be allowed to enter in specific zones while in some zones everyone may be allowed. For example, in gaming room **Z3** and in open area **Z5**, everyone may be allowed while only senior employees may be allowed to enter the CEO's cabin **Z1**. Similarly, if there is a zone comprising a data server (not shown) having confidential information stored therein, then only authorized computer operators may be allowed to enter.

[0056] In one non-limiting embodiment of the present disclosure, the one or more devices **130** may be assigned/given/attached to respective objects/employees such that each employee is assigned only a single device which he/she is to carry while traversing through the geographical area **120** (i.e., the office premise). Each device of the one or more devices **130** may be identified with a unique identifier associated with the device. Each zone of the plurality of zones may have a list of authorized devices that are permitted to enter inside that zone. These lists may be created and stored in the memory **220** at the configuration time. Thus, only the employees who are associated with the authorized devices can enter inside respective zones. In one non-limiting embodiment, the lists maybe updated based on approval from higher authorities.

[0057] For the exemplary embodiment of **Figure 3**, suppose there are a total of 10 employees having corresponding devices **103-1, …, 103-10** and each employee may be authorized to access one or more zones. Each zone may have a corresponding list of devices that may be allowed to enter insider the zone. **Table 1** shows exemplary list(s) in accordance with the exemplary embodiment of Figure 3.

Zone	**List of permitted devices**
Z1 (CEO's cabin)	103-1, 103-5
Z2 (Conference room)	103-1, 103-5, 103-8, 103-10
Z3 (Gaming zone)	103-1, 103-2, 130-3, 130-4, 130-5, 130-6, 130-7, 130-8, 130-9, 130-10

Z4 (Employee workplaces)	103-1, 103-4, 130-5, 130-6, 130-7, 130-8, 130-9, 130-10
Z5 (Open area)	103-1, 103-2, 130-3, 130-4, 130-5, 130-6, 130-7, 130-8, 130-9, 130-10

Table 1

[0058] In one non-limiting embodiment of the present disclosure, the at least one processor **210** may be configured to divide the entire geographical area into a plurality of small cells superimposed on the floor layout of the geographical area **120**. The plurality of cells may collectively form a grid. In one embodiment, each cell may be a square of side length **L**. The at least one processor **210** may be configured to adjust the outer boundaries of the floor layout (if required) to fit inside the grid. In one non-limiting embodiment, the side of a cell may be equal to the minimum accuracy of a tracking device **130**. In another non-limiting embodiment, the side of the cell may be chosen based on a total area of the geographical area (e.g., if area is large, the side may be taken as large) provided that the side of the cell does not go beyond a predefined length.

[0059] In one non-limiting embodiment of the present disclosure, the plurality of cells is superimposed on the floor layout in such a way that each zone of the plurality of zones is associated with a plurality of cells or a cell is associated with one or more zones of the plurality of zones. If a zone is associated with a cell, it means that either the cell is completely inside the zone and not touching any zone boundary, or the cell is touching the boundary of the zone, or some area of the cell is inside the zone and remaining area is outside the zone. It may be noted here that one cell may be associated with more than one zones. This association information (i.e., a zone and its associated cell identifiers) may be stored in the memory **220**. For the exemplary embodiment of **Figure 3**, the association information has been shown in **Table 2**. It may be noted that for the sake of simplicity and explanation, only a few entries have been shown in **Table 2**. However, in actual scenario, Table 2 may comprise entries corresponding to each and every cell.

Cell identifiers (Cell_id)	**Associated Zone(s)**
00, 01, 02, 10, 11, 12, 20, 21, 22, 30, 31, 32	Z1
05, 06, 07, 08, 09, 15, 16, 17, 18, 19	Z2
03, 04, 13, 14, 23, 24, 33, 34	Z1 and Z2
25	Z2 and Z5

42	Z1 and Z3
43	Z1, Z3, and Z5
55	Z5
64	Z3 and Z5
85	Z4 and Z5

Table 2

[0060] Thus, it is clear from Table 2 that some cells are associated with only a single zone (e.g., 02, 12, 16, 61 etc.) while some cells are associated with more than one zones (e.g., 25, 42, 43). The association information may be stored in the memory **220** at the configuration time. The information from Tables 1 and 2 may then be used by the at least one processor **210** during run time (i.e., during real time location tracking of an object), as described below.

[0061] When the computing system **110** is ready and all configuration data has been stored in the memory **220**, the at least one processor **210** may be configured to track real time location of a device **130**. As described earlier, each object may have its own associated unique device. Thus, the meaning of phrase “tracking location of a device **130**” is same as “tracking location of an object”.

[0062] In one non-limiting embodiment of the present disclosure, when the computing system **110** is operational, the at least one processor **210** may be configured to determine a current location of a device **130** traversing through the geographical area **120** using the one or more tracking devices **150**. As described earlier, the device **130** may broadcast signals on regular intervals that can be detected by at least one tracking device of the one or more tracking devices **150**. The strength of the broadcasted signals may be indicated by RSSI measurement data. Each of the at least one tracking device **150** of the one or more tracking devices may then transmit signals comprising the RSSI measurement data and other data received from the device **130** to the at least one processor **210** which may determine the cartesian coordinates (X, Y) of the device **130** with respect to a reference point using at least the received RSSI measurements. The cartesian coordinates (X, Y) are indicative of the current location of the device **130** within the geographical area **120**. After determining the current location of the device **130**, the at least one processor **210** may identify a cell and then a zone corresponding to the determined location of the device **130**, as detailed below.

[0063] In one non-limiting embodiment of the present disclosure, the at least one processor **210** may be configured to identify a cell from the plurality of cells corresponding to the determined current location of the device **130**. The cell identification process takes a constant time (also named as O(1) time) by doing following calculations.The at least one processor **210** may first applying modulo operations on the determined X and Y coordinates by dividing the X and Y coordinates with the length of cell (L) and calculate remainder (Mx and My).

$$Mx= X \% L, \text{ and} \tag{1}$$

$$My= Y \% L \tag{2}$$

The length of cell (L) is a whole number greater than or equal to 1. The at least one processor **210** may then calculate cell coordinates (Ax, Ay) based on the calculated remainders.

$$Ax= X-Mx; \text{ and} \tag{3}$$

$$Ay=Y-My \tag{4}$$

The at least one processor **210** may then calculate a cell identifier (cell_id) based on the calculated cell coordinates by:

$$cell\_id =10* ([Ax]/L) + ([Ay]/L) \tag{5}$$

In one non-limiting embodiment, the cell_id may be directly calculated from the device coordinates by:

$$cell\_id =10* ([X-Mx]/L) + ([Y-My]/L) \tag{6}$$

In an alternative embodiment, the at least one processor **210** may calculate the cell_id using only the device coordinates (X, Y) by:

$$cell\_id = (\text{Quotient of } [X/L])*10 + (\text{Quotient of } [Y/L]) \tag{7}$$

[0064] The at least one processor **210** may then identify a particular cell corresponding to the calculated cell_id as the cell corresponding to the determined current location of the device **130**. For example, if the at least one processor **210** determines the cell_id as 11 then the cell corresponding to this cell_id is C_{11} in **Figure 3**. Similarly, if the at least one processor **210** determines the cell_id as 25 then the cell corresponding to this cell_id is C_{25} in **Figure 3**.

[0065] In one non-limiting embodiment, the at least one processor **210**, after identifying the cell corresponding to the determined current location of the device **130**, may identify one or more zones associated with the identified cell using the association information stored in memory **220** (i.e., using Table 2). For example, the at least one processor **210** may determining using Table 2 that the only a single zone Z1 is associated with the cell C_{11} and two zones Z2 and Z5 are associated with the cell C_{25}.

[0066] The at least one processor **210** may then identify a zone corresponding to the current location of the device **130** (i.e., the zone in which the device **130** is currently located) from the one or more zones using the association information and/or using PIP technique. For example, the at least one processor **210** may determine using PIP technique that out of Z2 and Z5, the device is located only inside zone Z2. It may be worth noting here that the PIP check is performed only for zones which are associated with the identified cell (i.e., zones Z2 and Z5) and not for all zones.

[0067] In one non-limiting embodiment, when the association information indicates that the identified cell is associated only with a single zone (i.e., the identified cell is completely inside the single zone), the at least one processor **210** may identify the single zone as the zone corresponding to the current location of the device **130**. For example, for cell C_{11} there is only a single zone Z1 which corresponds to the current location of the device **130**.

[0068] In another non-limiting embodiment, when the association information indicates that the identified cell is associated with more than one particular zone (i.e., the identified cell is either colinear with at least one zone boundary, or the identified cell is being intersected by one or more zones), the at least one processor **210** may identify a particular zone from the more than one particular zone by applying point-in-polygon technique only for the more than one particular zone but not for all zones in the geographical area. The identified particular zone is the zone corresponding to the current location of the device **130**. For example, for cell C_{25} there are two zones Z2 and Z5 but after applying PIP technique, only for zones Z2 and Z5, the at least one processor **210** may determine that the device **130** is located inside zone Z2. This way a single zone corresponding to the current location of the device **130** is determined. After determining the zone corresponding to the current location of the device **130**, the at least one processor **210** may determine whether the device **130** is authorized to enter inside the identified single zone or not.

[0069] In one non-limiting embodiment of the present disclosure, the at least one processor **210** may use pre-stored information (i.e., Table 1) to determine whether the device **130** is authorized to enter inside the identified single zone. For example, the at least one processor **210** may check the list of devices which are authorized to enter inside the identified single zone and if the device **130** is not present in the list of devices, the at least one processor **210** may determine that the device **130** is not authorized to enter inside the identified single zone. Thus, the at least one processor **210** may provide an alert to indicate that the device **130** is not authorized to enter inside the identified single zone. The alert may be provided on the device **130** or on a device of a system administrator.

[0070] In one non-limiting embodiment of the present disclosure, the alert may be provided in the form of an alarm. For example, at least one processor **210** may raise an alarm when the device **130** enters in an unauthorized zone. In another non-limiting embodiment, the alert may be in the form of a voice or text message delivered to a user of the device **130** or delivered on the device of the system administrator.

[0071] In one non-limiting embodiment of the present disclosure, the zone violation information for each object may be stored in the memory **220** for future use. In one non-limiting embodiment, when the number of zone violations of a particular object exceeds a threshold limit, the at least one processor **220** may instruct the system administrator to take appropriate action against the particular object who is frequently violating the zones.

[0072] The at least one processor **210** may continuously track the real time locations of all objects inside the geographical area **120** and whenever any object violates a zone, the at least one processor **210** may raise an alert.

[0073] The exemplary embodiment for detecting zone violation as illustrated in **Figure 3** is now explained with the help of few examples. As described earlier, at the configuration time, the at least one processor **210** may store the association information shown in Table 2 (i.e., information indicating an association of the each of the plurality of zones Z1-Z5 with the one or more cells) and the lists of devices (i.e., the devices that are allowed to enter inside a zone) shown in Table 1. In the illustrated example, the length of each square cell is considered as 10 inches.

<u>Example-1</u>

[0074] Consider a first example, where the at least one processor **210** is tracking movement of a first device **130-1**. The first device **130-1** may be associated with a first object. The at least one processor **210** may determine the coordinates (X1, Y1) corresponding to a current location of the first device **130-1** using RSSI measurement data. Consider that the at least one processor **210** determines the coordinates corresponding to the current location of the first device **130-1** as (17, 16).

i.e.,

$$X1=17$$

$$Y1= 16$$

Now, the at least one processor **210** may use any of the equations (5)-(7) for determining a cell_id corresponding to the current location of the first device **130-1**, as described below:

Applying modulo operation using equations (1) and (2),

$$Mx=17\%10; My= 16\%10;$$

$$\text{i.e., } Mx=7 \text{ and } My=6.$$

The cell coordinates may be calculated using equations (3) and (4) as:

$$Ax=17-7; \text{ and } Ay= 16-6;$$

$$\text{i.e., } Ax=10; \text{ and } Ay=10.$$

The cell_id may then be calculated using equation (5) as:

$$Cell\_id= 10*(10/10)+10/10$$

$$Cell\_id=11$$

Thus, the cell corresponding to the current location of the first device **130-1** is C_{11}.

[0075] The at least one processor **210** may then determine one or more zones associated with cell C_{11} using the association information stored in Table 2. Using Table 2, the at least one processor **210** may determine that the cell C_{11} is associated with a single zone i.e., zone **Z1**. It means that the zone corresponding to the current location of the first device **130-1** is zone Z1 (or that the first device **130-1** is currently located inside zone Z1). The at least one processor **210** may then check whether the first device **130-1** is authorized to enter inside the zone Z1 or not using the information present in Table 1. Using Table 1, the at least one processor **210** may determine that the first device **130-1** is authorized to enter into zone Z1 and thus there is no need to take any action.

<u>Example-2</u>

[0076] Consider a second example, where the at least one processor **210** is tracking movement of a second device **130-2**. The second device **130-2** may be associated with a second object. The at least one processor **210** may determine the coordinates (X2, Y2) corresponding to a current location of the second device **130-2** using RSSI measurement data. Consider that the at least one processor **210** determines the coordinates corresponding to the current location of the second device **130-2** as (26, 53). i.e.,

$$X1=26$$

$$Y1= 53$$

Now, the at least one processor **210** may use any of the equations (5)-(7) for determining a cell_id corresponding to the current location of the second device **130-2**, as described below: Applying modulo operation using equations (1) and (2), Mx=26%10; My= 53%10;

i.e., Mx=6 and My=3.

The cell coordinates may be calculated using equations (3) and (4) as:

Ax=26-6; and Ay= 53-3;

i.e., Ax=20; and Ay=50.

The cell_id may then be calculated using equation (5) as:

Cell_id= 10*(20/10)+50/10

Cell_id=25

Thus, the cell corresponding to the current location of the second device **130-2** is C_{25}.

[0077] The at least one processor **210** may then determine one or more zones associated with cell C_{25} using the association information stored in Table 2. Using Table 2, the at least one processor **210** may determine that the cell C_{25} is associated with two zone i.e., zone **Z2** and zone **Z5**. However, practically any device cannot be in two zones at a time. Thus, the at least one processor determines a single zone, from the two zones Z2 and Z5, corresponding to the current location of the second device **130-2**.

[0078] To determine the single zone corresponding to the current location of the second device **130-2**, the at least one processor **210** applies point-in-polygon technique on the zones Z2 and Z5. Starting from the current location of the second device **130-2**, the at least one processor **210** may draw a straight line through the geographical area **120** towards one side. The at least one processor **210** may determine that the straight line intersects zone Z2 at one instance and intersects zone Z5 at two instances. Now the count of intersections is odd for zone Z2 and even for zone Z5, it means that the current location of the second device **130-2** is inside zone Z2 (or that the second device **130-2** is currently located inside zone Z2).

[0079] The at least one processor **210** may then check whether the second device **130-2** is authorized to enter inside the zone Z2 or not using the information present in Table 1. Using Table 1, the at least one processor **210** may determine that the second device **130-2** is not allowed to enter into zone Z2. Upon determining that the second device **130-2** is not allowed to enter into zone Z2 (i.e., zone violation detected), the at least one processor **210** may take necessary action such as raising an alert.

[0080] Using similar techniques, the at least one processor **210** may track real time locations of all devices **130** which are inside the geographical area **120**.

[0081] It may be worth noting here that the present technique of determining a zone corresponding to a current location of an object do not rely on time consuming PIP techniques when a single zone is associated with the current location of the object. Also, even when more than one zone is associated with the current location of the object, the present technique uses PIP techniques only for the associated more than one zones and not for all zones within the geographical area **120**. For example, in example 2 (described above), PIP check was performed only for the associated zones (i.e., Z2 and Z5) and not on all zones Z1-Z5.

[0082] Thus, the present disclosure provides optimal techniques for real time tracking of a large number of objects in a geographical area while checking against a large number of restricted zones. The present disclosure provides accurate, cost effective, time efficient, and resource efficient technique for zone violation detection.

[0083] Referring now to **Figure 4**, which shows a block diagram of the computing system **110**, in accordance with some embodiments of the present disclosure. In one non-limiting embodiment of the present disclosure, the computing system **110** may comprise various other hardware components such as various interfaces **402**, a memory **408**, and various units or means **414**. The units **414** may comprise a dividing unit **416**, a determining unit **418**, an identifying unit **420**, and an alerting unit **422**, and various other units **424**. In an embodiment, the units **416-424** may be dedicated hardware units capable of executing one or more instructions stored in the memory **408** for performing various operations of the computing system **110**. In another embodiment, the units **416-424** may be software modules stored in the memory **408** which may be executed by the at least one processor **210** for performing the operations of the computing system **110**.

[0084] The interfaces **402** may include a variety of software and hardware interfaces, for example, a web interface, a graphical user interface, an input device-output device (I/O) interface **406**, a network interface **404** and the like. The I/O interfaces **406** may allow the computing system **110** to interact with other computing systems/devices directly or through other devices. The network interface **404** may allow the computing system **110** to interact with one or more devices either directly or via the network **140**.

[0085] The memory **408** may comprise the association information indicating an association of the plurality of zones and the plurality of cells. The memory **408** may further comprise a plurality of lists corresponding to the plurality of zones, each list comprising identities of devices which are authorized to enter inside a particular zone. The memory **408** may further store one or more instructions executable by the at least processor **210**. The memory **408** may be same as the memory **220**.

[0086] Referring now to **Figures 5**, a flowchart is described illustrating exemplary zone violation detection method **500,** according to an embodiment of the present disclosure. The method **500** is merely provided for exemplary purposes, and embodiments are intended to include or otherwise cover any methods or procedures for zone violation detection.

[0087] The method **500** may include, at block **502**, dividing a geographical area into a plurality of zones, where each zone has an associated list of devices which are permitted to enter inside the zone. For example, the at least one processor **210** may be configured to divide the geographical area into the plurality of zones. The operations of block **502** may also be performed by the dividing unit **416** of **Figure 4**.

[0088] At block **504**, the method **500** may include dividing the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells. For example, the at least one processor **210** may be configured to divide the geographical area into the plurality of cells such that each zone of the plurality of zones is associated with one or more cells. The operations of block **504** may also be performed by the dividing unit **416** of **Figure 4**.

[0089] At block **506**, the method **500** may include determining a current location of a device traversing through the geographical area using one or more tracking devices installed within the geographical area **120**. The at least one of the one or more tracking devices **150** may communicate with the device **130**. For example, the at least one processor **210** may be configured to determine a current location of a device traversing through the geographical area using one or more tracking devices installed within the geographical area **120**. The operations of block **506** may also be performed by the determining unit **418** of **Figure 4**.

[0090] In one non-limiting embodiment of the present disclosure, the step **506** of determining a current location of a device **130** may comprise receiving a signal from each of the at least one tracking device **150**, where the signal indicates received signal strength indicator (RSSI) measurement data; and determining cartesian coordinates (X, Y) associated with the device **130** based on the received RSSI measurement data, where the cartesian coordinates indicate the current location of the device **130** traversing through the geographical area. For example, the at least one processor **210** may be configured to receive the signal from each of the at least one tracking device **150** and determine cartesian coordinates (X, Y) associated with the device **130** based on the received RSSI measurement data.

[0091] At block **508**, the method **500** may include identifying a cell, from the plurality of cells, corresponding to the determined current location of the device **130**. For example, the at least one processor **210** may be configured to identify a cell, from the plurality of cells, corresponding to the determined current location of the device **130**. The operations of block **508** may also be performed by the identifying unit **420** of **Figure 4**.

[0092] In one non-limiting embodiment of the present disclosure, each cell may be a square of side L and may have a unique identity (cell_id). The step **508** of identifying a cell from the plurality of cells may comprise calculating a cell_id using the equations **(1)-(7)** described in paragraph [0063] and identifying a particular cell corresponding to the calculated cell_id as the cell corresponding to the determined current location of the device **130**.

[0093] The method **500** may include, at block **510**, identifying a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones. For example, the at least one processor **210** may be configured to identify the zone associated with the identified cell based at least on pre-stored association information indicating the association of the plurality of cells with the plurality of zones. The operations of block **510** may also be performed by the identifying unit **420** of **Figure 4**.

[0094] In one non-limiting embodiment of the present disclosure, the step **510** of identifying a zone associated with the identified cell may comprise: when the identified cell is completely inside a particular zone and is associated only with the particular zone, identifying the particular zone as the zone associated with the identified cell; and when the identified cell is associated with a plurality of particular zones, applying point-in-polygon technique for the plurality of particular zones for identifying the zone from the plurality of zones associated with the identified cell.

[0095] At block **512**, the method **500** may include, determining whether the device **130** is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone. For example, the at least one processor **210** may be configured to determine whether the device **130** is authorized to enter inside the identified zone by checking the list of devices which are authorized to enter inside the identified zone. The operations of block **512** may also be performed by the determining unit **418** of **Figure 4**.

[0096] At block **514**, the method **500** may include, providing an alert in response to determining that the device **130** is not authorized to enter inside the identified zone. For example, the at least one processor **210** may be configured to provide the alert in response to determining that the device **130** is not authorized to enter inside the identified zone. The operations of block **514** may also be performed by the alerting unit **422** of **Figure 4**.

[0097] The above method **500** may be described in the general context of computer executable instructions. Generally, computer executable instructions can include routines, programs, objects, components, data structures, procedures, modules, and functions, which perform specific functions or implement specific abstract data types.

[0098] The order in which the various operations of the method are described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Additionally, individual blocks may be deleted from the methods without departing from the spirit and scope of the subject matter described herein. Furthermore, the methods can be implemented in any suitable hardware, software, firmware, or combination thereof.

[0099] The various operations of method described above may be performed by any suitable means capable of performing the corresponding functions. The means may include various hardware and/or software component(s) and/or module(s), including, but not limited to the processors **210** of **Figure 2** and the various units **414** of **Figure 4**. Generally, where there are operations illustrated in Figures, those operations may have corresponding counterpart means-plus-function components.

[0100] It may be noted here that the subject matter of some or all embodiments described with reference to **Figures 1-4** may be relevant for the methods and the same is not repeated for the sake of brevity. It may be noted that in the present disclosure the geographical area is an indoor area. However, the present disclosure is not limited thereto and can be extended to outdoor geographical areas as well.

[0101] Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the present disclosure. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages consistent with the embodiments described herein. The term “computer-readable medium” should be understood to include tangible items and exclude carrier waves and transient signals, i.e., non-transitory. Examples include Random Access Memory (RAM), Read-Only Memory (ROM), volatile memory, nonvolatile memory, hard drives, Compact Disc (CD) ROMs, Digital Video Disc (DVDs), flash drives, disks, and any other known physical storage media.

[0102] Certain aspects may comprise a computer program product for performing the operations presented herein. For example, such a computer program product may comprise a computer readable media having instructions stored (and/or encoded) thereon, the instructions being executable by one or more processors to perform the operations described herein. For certain aspects, the computer program product may include packaging material.

[0103] Various components, modules, or units are described in this disclosure to emphasize functional aspects of devices configured to perform the disclosed techniques, but do not necessarily require realization by different hardware units. Rather, as described above, various units may be combined in a hardware unit or provided by a collection of interoperative hardware units, including one or more processors as described above, in conjunction with suitable software and/or firmware.

[0104] The terms "including", "comprising", "having" and variations thereof mean "including but not limited to", unless expressly specified otherwise.

[0105] Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the invention be limited not by this detailed description, but rather by any claims that issue on an application based here on. Accordingly, the embodiments of the present invention are intended to be illustrative, but not limiting, of the scope of the invention, which is set forth in the appended claims

WE CLAIM:

1. A zone violation detection method (500), comprising:

dividing (502) a geographical area into a plurality of zones, wherein each zone has an associated list of devices which are permitted to enter inside the zone;

dividing (504) the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells;

determining (506) a current location of a device (130) traversing through the geographical area using one or more tracking devices (150) installed within the geographical area, wherein at least one of the one or more tracking devices (150) communicates with the device (130);

identifying (508) a cell, from the plurality of cells, corresponding to the determined current location of the device (130);

identifying (510) a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones;

determining (512) whether the device (130) is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone; and

providing (514) an alert in response to determining that the device (130) is not authorized to enter inside the identified zone.

2. The method as claimed in claim 1, wherein determining a current location of a device comprises:

receiving a signal from each of the at least one tracking device, wherein the signal indicates received signal strength indicator (RSSI) measurement data; and

determining cartesian coordinates (X, Y) associated with the device based on the received RSSI measurement data, wherein the cartesian coordinates indicate the current location of the device traversing through the geographical area.

3. The method as claimed in claim 2, wherein each cell is a square of side L and has a unique identity (cell_id), and wherein identifying a cell, from the plurality of cells, corresponding to the determined current location of the device comprises:

applying modulo operation on the determined cartesian coordinates (X, Y) associated with the device by:

$$Mx = X \% L,$$

$$My = Y \% L;$$

calculating a cell_id based on the determined cartesian coordinates (X, Y) associated with the device by:

cell_id =10* ([X-Mx]/L) + ([Y-My]/L); and

identifying the cell from the plurality of cells based on the calculated cell_id.

4. The method as claimed in claim 1, wherein identifying a zone associated with the identified cell comprises:

when the identified cell is completely inside a particular zone and is associated only with the particular zone, identifying the particular zone as the zone associated with the identified cell; and

when the identified cell is associated with a plurality of particular zones, applying point-in-polygon technique for the plurality of particular zones for identifying the zone from the plurality of zones associated with the identified cell.

5. A zone violation detection system (110), comprising:

a memory (220); and

at least one processor (210) communicatively coupled with the memory (220) and configured to:

divide a geographical area into a plurality of zones, wherein each zone has an associated list of devices which are permitted to enter inside the zone;

divide the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells;

determine a current location of a device (130) traversing through the geographical area using one or more tracking devices (150) installed within the geographical area, wherein at least one of the one or more tracking devices (150) communicates with the device (130);

identify a cell, from the plurality of cells, corresponding to the determined current location of the device (130);

identify a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones;

determine whether the device (130) is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone; and

provide an alert in response to determining that the device (130) is not authorized to enter inside the identified zone.

6. The zone violation detection system as claimed in claim 5, wherein to determine a current location of a device, the at least one processor is configured to:

receive a signal from each of the at least one tracking device, wherein the signal indicates received signal strength indicator (RSSI) measurement data; and

determine cartesian coordinates (X, Y) associated with the device based on the received RSSI measurement data, wherein the cartesian coordinates indicate the current location of the device traversing through the geographical area.

7. The zone violation detection system as claimed in claim 6, wherein each cell is a square of side L and has a unique identity (cell_id), and wherein to identify a cell, from the plurality of cells, corresponding to the determined current location of the device, the at least one processor is configured to:

apply modulo operation on the determined cartesian coordinates (X, Y) associated with the device by:

Mx= X % L,

My= Y % L;

calculate a cell_id based on the determined cartesian coordinates (X, Y) associated with the device by:

cell_id =10* ([X-Mx]/L) + ([Y-My]/L); and

identify the cell from the plurality of cells based on the calculated cell_id .

8. The zone violation detection system as claimed in claim 5, wherein to identify a zone associated with the identified cell, the at least one processor is configured to:

when the identified cell is completely inside a particular zone and is associated only with the particular zone, identify the particular zone as the zone associated with the identified cell; and

when the identified cell is associated with a plurality of particular zones, apply point-in-polygon technique for the plurality of particular zones for identifying the zone from the plurality of zones associated with the identified cell.

Dated this 24th day of June 2022

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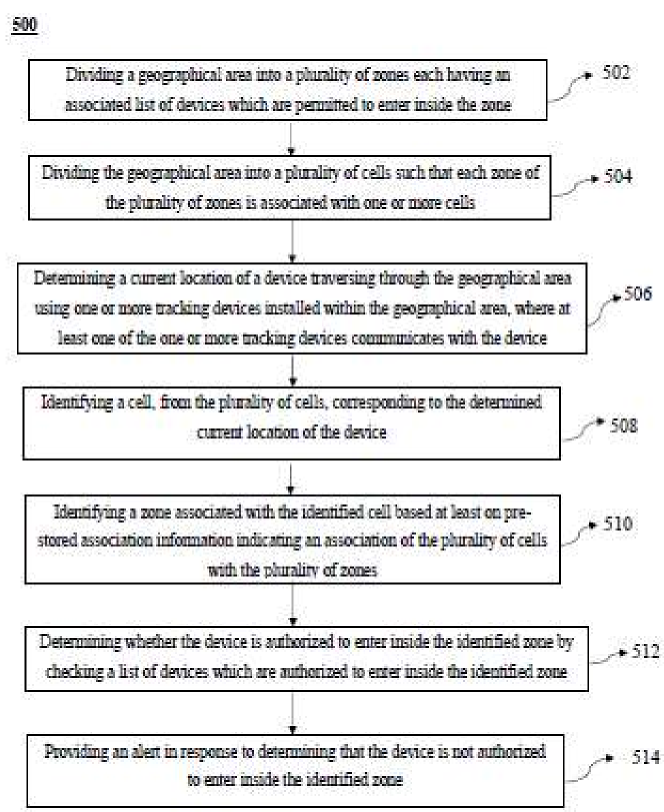
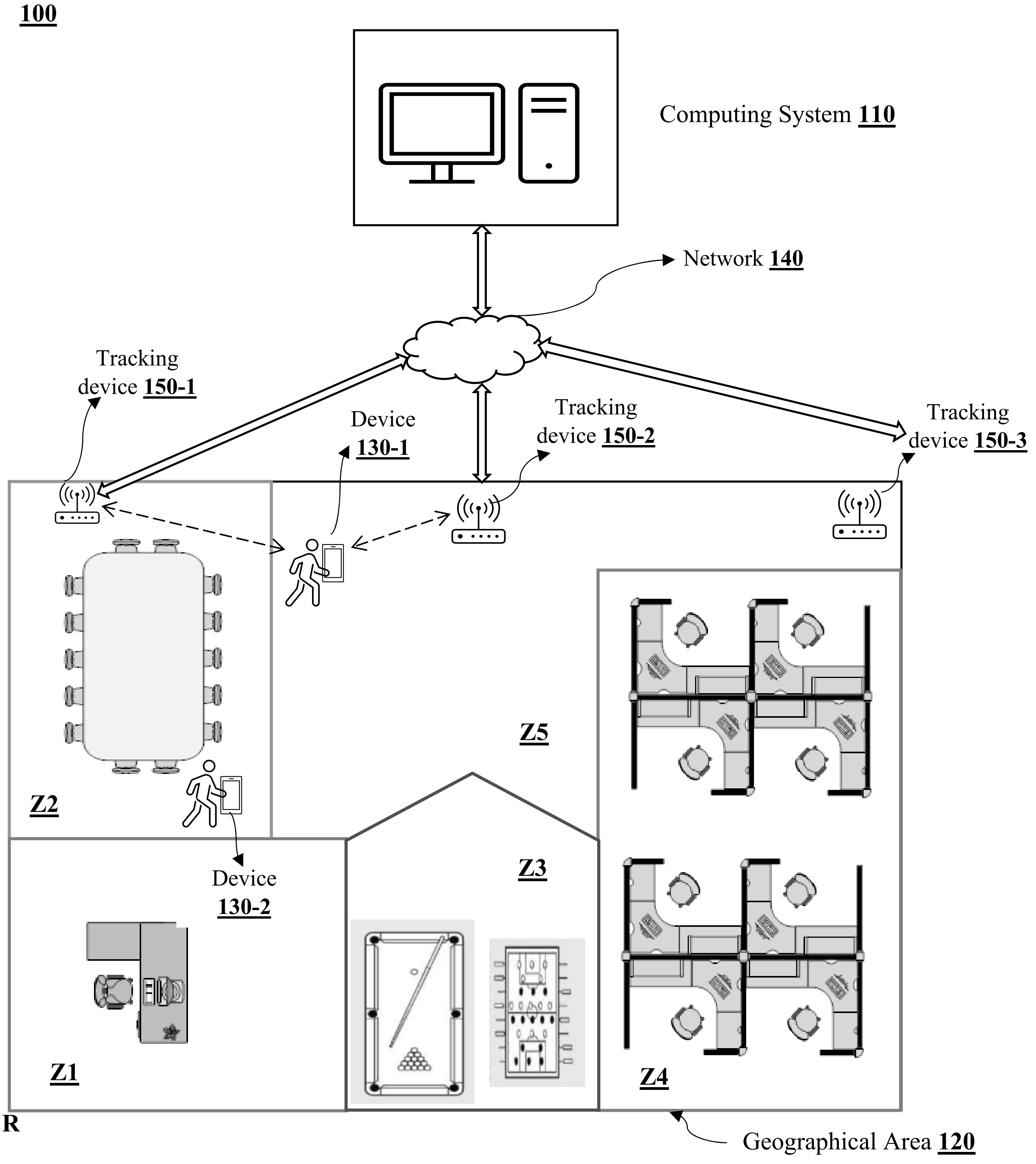
ABSTRACT

METHOD AND SYSTEM FOR DETECTING ZONE VIOLATION

The present disclosure describes a technique for zone violation detection in a geographical area (120). The technique of the present disclosure divides the geographical area (120) into a plurality of zones and a plurality of cells such that each zone is associated with at least one cell. The technique determines a current location of a device (130) traversing through the geographical area and identifies a cell corresponding to the determined current location of the device (130). The technique further identifies a zone associated with the identified cell based at least on pre-stored association information that indicates an association of the plurality of cells with the plurality of zones. The technique of the present disclosure further determines whether the device (130) is authorized to enter inside the identified zone by checking a pre-stored list of devices which are authorized to enter inside the identified zone.





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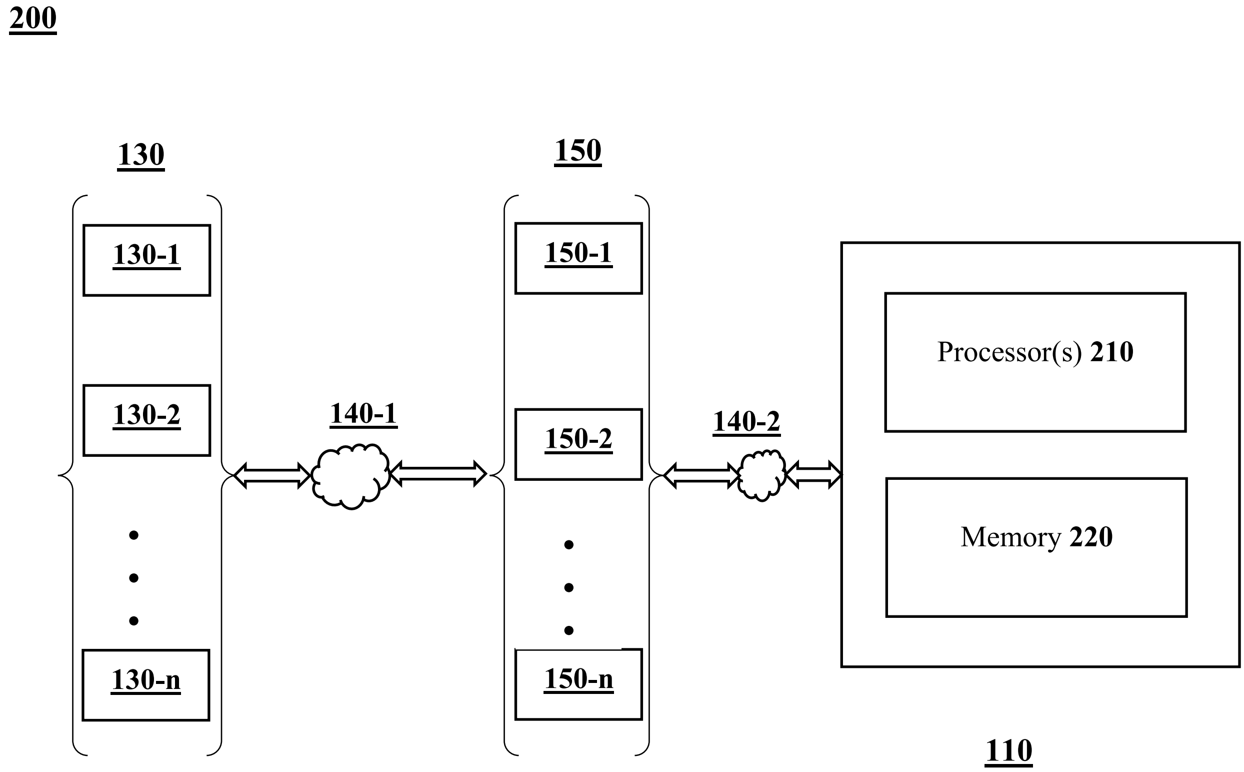

Figure 2

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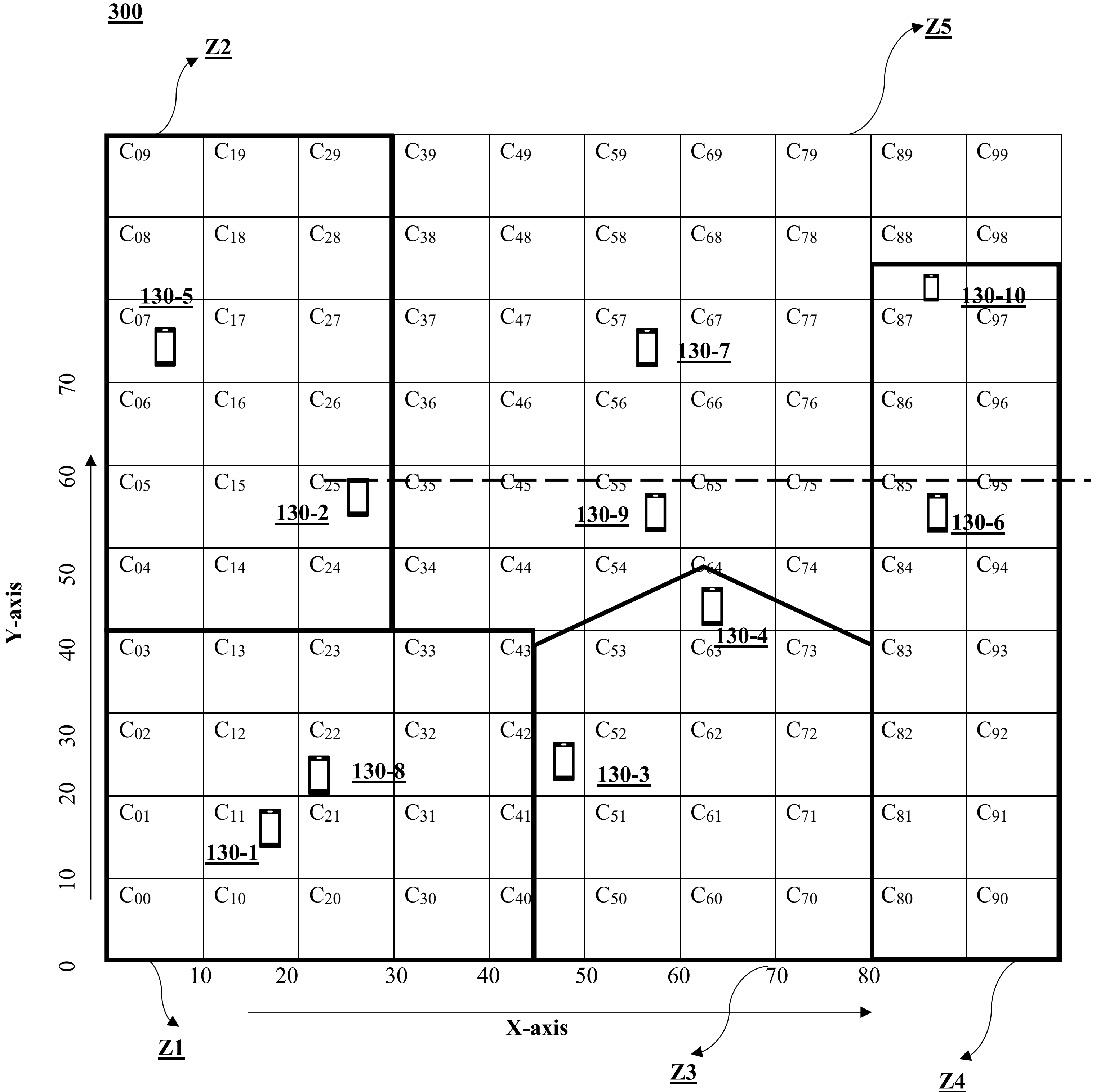

Figure 3

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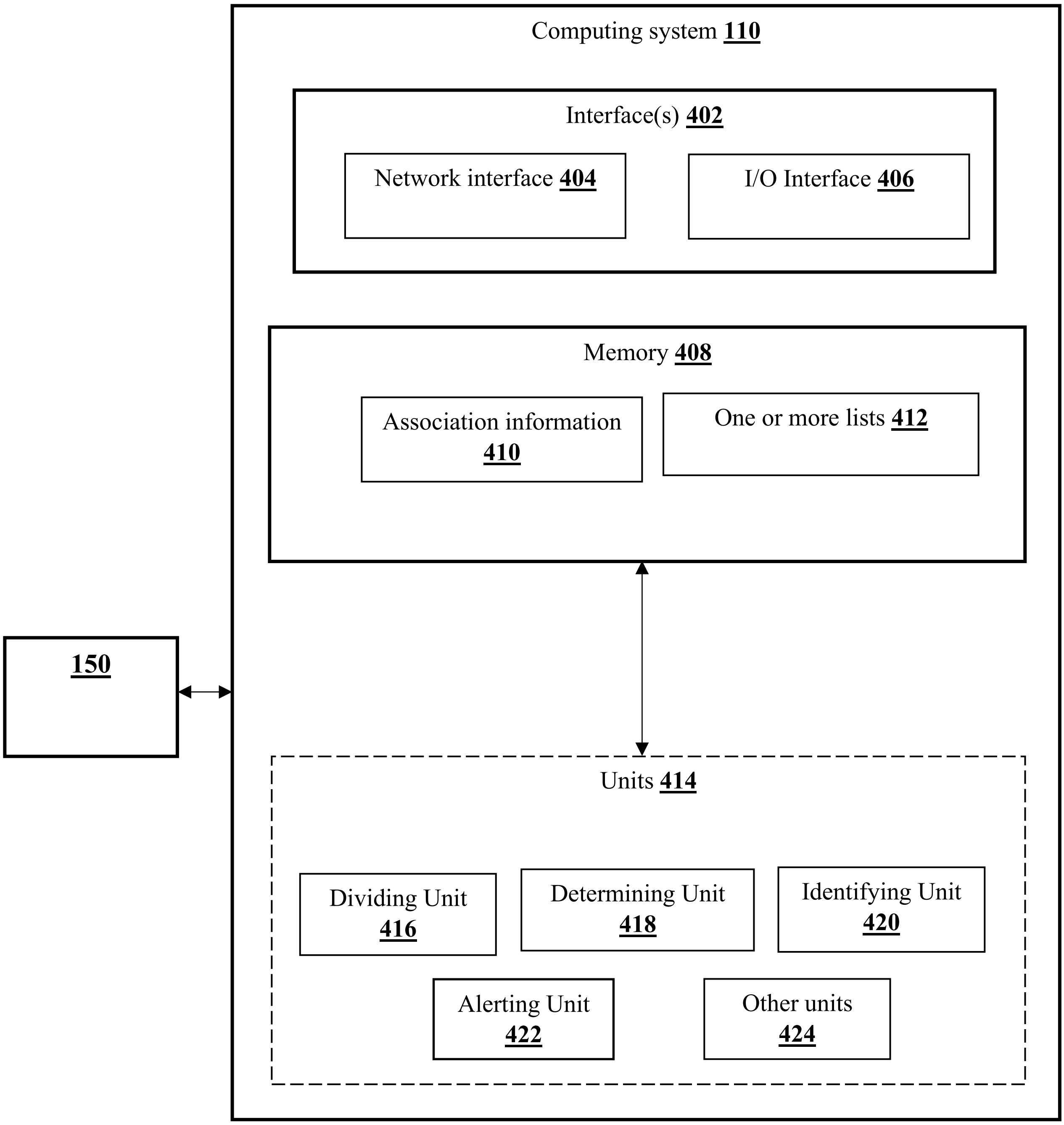

Figure 4

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500

Dividing a geographical area into a plurality of zones each having an associated list of devices which are permitted to enter inside the zone — 502

↓

Dividing the geographical area into a plurality of cells such that each zone of the plurality of zones is associated with one or more cells — 504

↓

Determining a current location of a device traversing through the geographical area using one or more tracking devices installed within the geographical area, where at least one of the one or more tracking devices communicates with the device — 506

↓

Identifying a cell, from the plurality of cells, corresponding to the determined current location of the device — 508

↓

Identifying a zone associated with the identified cell based at least on pre-stored association information indicating an association of the plurality of cells with the plurality of zones — 510

↓

Determining whether the device is authorized to enter inside the identified zone by checking a list of devices which are authorized to enter inside the identified zone — 512

↓

Providing an alert in response to determining that the device is not authorized to enter inside the identified zone — 514

Figure 5

-- Digitally Signed--
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