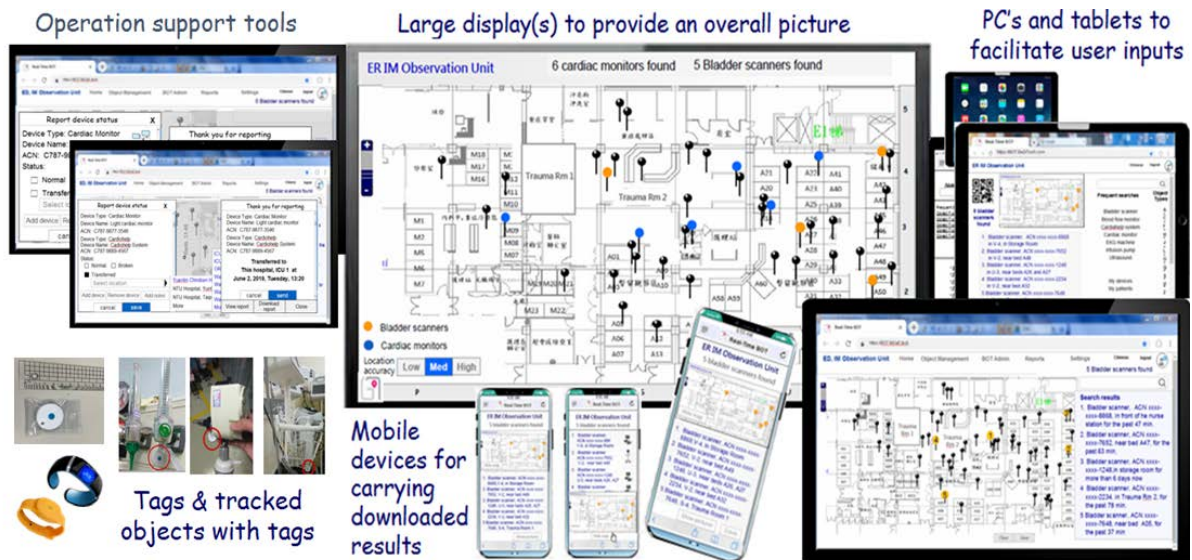


# Real-Time BiDaE Object Tracker at a Glance

For smart care providing institutions ♦



- Equipment search
- Device status report
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- Usage data collection
- Patient monitoring
- Shift change report
- Geo-fencing
- Contact tracing

June 2023

♦ Send request for "BiDaE Object Tracker for industrial organizations" to [sales@bidae.tech](mailto:sales@bidae.tech)

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# BiDaE Object Tracker at A Glance

June 2023

## 1. Overview

BiDaE Object Tracker (or BOT for short) is a system of software tools. Its primary purpose is to help you locate objects: The term *object* refers to a medical device or equipment, a patient/resident, a contractor, a customer representative, and so on, whatever you may need to locate during the course of your work. BOT also has tools that can help your organization to follow best practices in patient care and equipment management. They do so by helping you find devices, monitor patients and record notes on them, request repair service and record loans of devices, generate shift change records, prevent theft or unintentional removal of objects, and so on. This note presents an overview of these capabilities.

### 1.1 Location Beacons and Tags

From system structure point of view, you can think of BOT as an intelligent database on the platform **BiDaE indoor Positioning System (BPS)** deployed in the space covered by the BOT. You access the data and tools provided by BOT via its browser-based graphical user interface (GUI). The data stored in the database are collected collaboratively by Bluetooth low energy tags and Lbeacons (Location beacon). They are components of BPS.



**Tags** are battery powered transmitters. Each tag has a UUID (Universally Unique ID). It broadcasts periodically packets containing its own ID and thus advertizes to Bluetooth receivers nearby its own presence. BOT uses tags to make objects to be located visible: You make an object visible by having a tag attached to (or worn by) the object and storing in the server an association of the tag ID with the object ID/name. Thus, the system can use the location of the associated tag as the location of the object.

BOT uses two types of tags: simple tags or sensor tags. Simple tags do nothing other than broadcasting their ID's. *Sensor tags* contains sensors. In addition to its ID, each sensor tag also broadcasts readings of its sensors on a regular basis. A common type of sensor tags are smart watches and bracelets. They contain sensors that read the wearer's vital signs, including temperature, blood pressures, heart rate and blood oxygen level. Some sensor tags contain accelerometer that can detect small movements of the wearer. Hereafter, this note refers to both simple and sensor tags simply as tags except when it is necessary to be specific.

**Location beacons**, called *Lbeacons* for short, are Bluetooth Low-Energy (BLE) transceivers installed throughout the area where objects are to be located and tracked. Because they are often placed out of sight, you may not notice their presence, while you see tags everywhere. In addition to being connected to the server, each Lbeacon:

- Is powered by AC or POE (Power over Ethernet);
- Is located at a known location;
- Has a coverage area a few meters in radius shaped by a directional antenna;
- Stores and broadcasts its own ID or 3D coordinates continuously; and
- Scans its coverage area continuously for Bluetooth devices.

Whenever a Lbeacon hears a tag, it sends to the server the ID of the tag and the time interval during which the tag is heard along with its own ID. Based on the data from all Lbeacons installed in the area covered by BOT, the server determines at any time the location of every tag and the time interval during which the tag has been at the location. Every Lbeacon also forwards to the server time stamped readings from every sensor tag. This data enables BOT to support the vital sign and movement monitors to be described later.

## 1.2 Location Accuracy

BOT specifies the vertical location of every object by the floor on which the object is located. This information is never erroneous.

The system is often required to bring you to within sight of sought-after objects. To meet this requirement, Lbeacons are configured to achieve 3-5 meters or 5-10 meters accuracy. This is often referred to as *bed/desk-level* or *room-level* accuracy, respectively. This configuration is typically used for areas such as emergency department and patient wards in hospitals.

Your BOT may be configured to provide *zone-level* accuracy (i.e., a lower location accuracy of 10-20 meters or more) in some areas. This configuration is usually used when the goal is to determine whether the sought-after object is in the building, or on which floor, in which patient ward or which part of a ward. Because fewer Lbeacons are needed to cover areas requiring zone level accuracy, the cost of BOT is reduced accordingly.

## 1.3 Role-Based Access Control (RBAC)

BOT uses the well known the role-based access control (RBAC) mechanism for protection of sensitive data while ensuring that you and your colleagues can access data and perform

actions needed to do your job. According to Wikipedia on RBAC<sup>1</sup>, roles are created for various job functions within your organization. Permissions to access objects (i.e., to view certain data and perform certain operations) are assigned to specific roles. So, as a part of configuring your BOT before it starts to serve you, BiDaE engineers works with your IT staff to specify your RBAC model, i.e., define all the roles and assign permissions to access objects to individual roles. Hereafter, your IT staff will keep the model up to date.

For the most part, this note is for users in the *care provider* role. It is the role assumed by doctors, nurses, and their support staff: If you are a care provider in a patient ward, BOT lets you search and locate patients and medical devices within the ward. In contrast, a user who maintains the BOT has the *system administrator* role. Such a user can see the location and the battery consumption of every tag, but may not see the ID of object attached to the tag.

The note will also mention *charge\_nurse* and *BOT admin* roles. Charge\_nurse role is for the care provider who is in charge of the department during the current shift. Your department may want to set up an account for the user in this role. By logging in BOT using this account, the charge nurse gains during the shift the privileges/permissions needed to meet the responsibilities of overseeing all operations of the department. The privileges/permissions available to the charge\_nurse are restricted to the department, however. For example, your charge nurse can create and delete BOT accounts of users in your department but not in other departments. In contract, the privileges of a user in the BOT admin role are not restricted to individual departments. For this reason, the head nurse of your ward/department may want to have both the BOT admin role and the care provider/charge\_nurse role.

## 1.4 Graphical User Interface (GUI)

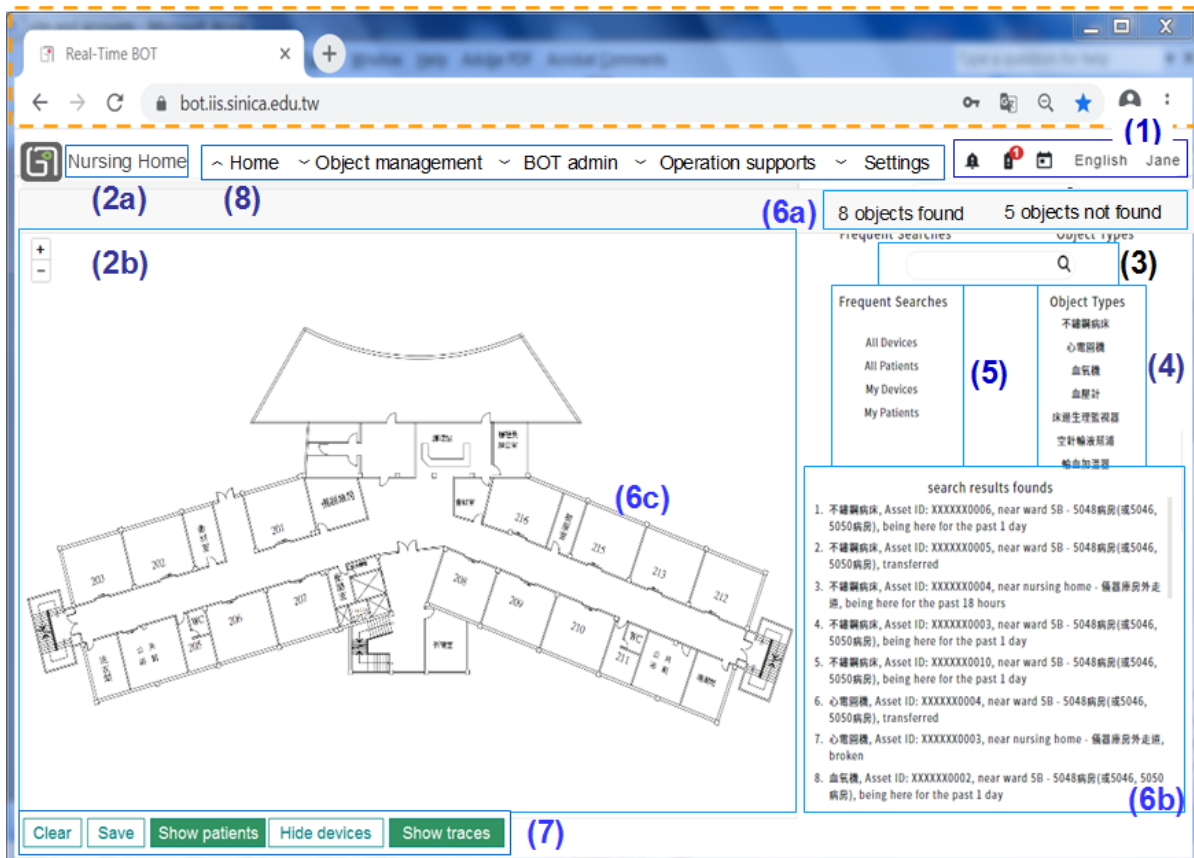
You use BOT via its browser-based graphical user interface (GUI): You can launch a session from your browser on a PC, laptop, tablet or smart phone. When the GUI opens, it presents to you the Home page, which may look like the picture shown on the next page. The picture, like those in figures to be presented hereafter, shows the appearance of the GUI on a PC monitor or a laptop. Except for differences due to differences in screen sizes and aspect ratios and in ways you interact with the interface (e.g., by sliding and tapping with your finger on tablets), the GUI on tablets is essentially the same. GUI on smart phones offers only a subset of the functions, on the other hand.

The area on the top enclosed by the orange dashed box contains your browser's toolbars and address bars. In the example here, the BOT GUI was launched from Google Chrome. So inside the orange box are the combined toolbars and address bars of Chrome. Clearly, the appearance here would be different if your browser is Microsoft IE or Microsoft Edge, the other browsers supported by the current version of BOT.

The area below browser's toolbars and address bars contains components of BOT GUI: They are listed on the next page and are described in the remainder of this section:

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<sup>1</sup> Role-based access control, [https://en.wikipedia.org/wiki/Role-based\\_access\\_control](https://en.wikipedia.org/wiki/Role-based_access_control), last retrieved Nov. 2021



- (1) Language selection, Login and Notification
- (2) Covered area: (2a) and (2b)
- (3) Search box
- (4) Object-type list
- (5) Frequent searches
- (6) Search results: (6a), (6b) and (6c)
- (7) Action buttons
- (8) Tabbed menus

## 2. Language Selection, Login and Notification (1)

BOT supports multiple languages. Before logging in, you can select your preferred language using the drop-down list on the BOT start up page. The GUI also provides the list for language selection. It is in the box marked (1) at the top left corner of the screen.

Again, BOT uses role-based rule to control users' accesses. So, you must have a BOT account associated with your current role. Moreover, you must log in BOT to start using what BOT offers you and log out when you are done. You can find the shortcut to login at the right of the language selection list. During the session while you remain logged in, the system is configured according to your role and personalized according to your preferences.

BOT supports multi-device usage: You can log in on multiple devices simultaneously. This feature enables you and your colleagues with the same role to share one account and use BOT concurrently for sake of convenience. To illustrate, suppose your department has a `charge_nurse` account. The care provider who is in charge of the department during the current shift uses this account. If and when the charge nurse must have a substitute (e.g., for a couple of hours during a meeting away from the department), both the charge nurse and the substitute can access the `charge_nurse` account. This allows the substitute to respond to events (e.g., vital sign alerts) that must be handled locally at the department with the benefit of the oversight of the charge nurse remotely via a smart phone or tablet.

BOT provides a variety of monitoring services, including patient location and movement monitors, geo-fence alarms, personal emergency alerts, patient vital sign monitor, and patient safety notifications. Such services call your attention to alerts via alert/notification indicators. They are located in (1) at the top-left corner of the screen, to the left of the language selection list. Tags runs on battery. Whenever a tag is low on battery, BOT sends a low (tag) battery notification to you also in this way. When you place the cursor on an indicator, BOT presents to you descriptions of alarms/notifications that have been delivered via the indicator but have not yet been cleared by you.

### 3. Covered Area (2)

While you are logged in, the upper left corner of the screen marked by (2a) shows the name of the covered area of the current session. Here, the term *covered area* refers to the *ward or department or unit* in which you assume your current role and is used interchangeably with *ward/department/unit*. The map displayed in the left half of the screen marked by (2b) is the floor plan or a part of the floor plan of the department. Furthermore, by default, the scope of searches you will perform is confined to the objects owned, used by and cared for by the department. As an example, in the figure presented earlier, the covered area shown on the screen is nursing home. This means that the logged in user Jane is currently working in that department/ward with duties and responsibilities defined by her role there. So, All Patients means all the patients in the home; My Patients means the Jane's nursing home patients. Similarly, “Heartbeat monitors” means all devices of heartbeat monitor type owned by and used within the home. If the floor plan displayed in area (2b) is only a part of nursing home, a dropdown list would be available using which you can change the part displayed.

A user may work in multiple departments/wards. Take as an example a clinical nurse specialized in critical care for elderly. The nurse sometimes works in the nursing home and sometimes in an intensive care unit (ICU). The need of such a user is met by providing the user with an account associated with multiple departments. By choosing the department after logging in, the user specifies the correct role at the time. So in case of this example, the nurse specialist may use a mobile device to access BOT. During work, the nurse may move from nursing home to ICU and vice versa and can change role by selecting the department/covered area upon arrival to the department using the short dropdown list at 2(a), allowing the user to choose easily between nursing home and ICU.

## 4. Search Types and Support

Search is a core capability provided by every BOT. Specifically, the system supports two types of searches: location search and object search. You do a *location search* when you want to locate some objects (e.g., a blood-flow monitor and patient Clark Kent): You do so by providing BOT with their names, IDs, type names, tag ID or/and other attributes as search terms. In response, BOT will return to you their locations. Sometime, you may want to know the names/IDs of objects of some type(s) at a known location (e.g., residents in Exercise Room and devices in Room 448). To get this information, you do an *object search* by providing BOT with a search term that specifies the names of the object types and location of interest (e.g., Residents in Exercise Room and 3-in-1 Monitor in Rm-448). In response, BOT will return to you a list containing the names and IDs of the objects of the specified type found at the specified location.

You can start a search in one of three ways: type search term(s) in the search box, click/touch an object type in the object type list, or click/touch an entry in the frequent searches list. Your covered area may have aliases for official names of some object types, patients and locations. You can use them in place of official names.

This note focuses mainly on location search since by far it is more frequently used and returns more complex data. You can find details on object search together with supports for it in the **BOT Getting Started Guide (BOT GSG for short)** [1].

### 4.1 Search Box (3)

BOT search box behaves pretty much like search boxes of your browser and favorite search engine. Specifically, its features include auto-complete and search term suggestions.

### 4.2 Object Types (4)

Often, you need to locate one of a type of object, not anyone in particular. For example, suppose that you need a heartbeat monitor and any heartbeat monitor in working condition will do. In this situation, the most convenient way for you is to have BOT find all the heartbeat monitors owned by your department and return to you their locations. You can then choose one from them to meet your need. The list Object Types is provided for this purpose.

Object Types displayed by the GUI in the figure presented earlier contains the names of all types of objects belonging to your department/ward. Such a list is called a *flat list*. By clicking on the type name of objects you are looking for, you will find locations of all objects of the type. In other words, a flat list lets you launch a search for all objects of a selected type with one click. For this reason, the current version of BOT supports flat list.

However, when the number of object types is big, a flat list becomes too long to be used conveniently. *Indexed object type list* is an alternative: With this alternative, you are first presented with a list of alphabets. A click or touch of a letter causes the list of object type names starting from the letter to appear. You then select a type name from the expanded list. BOT provides this option as an add on.



### 4.3 Frequent Searches (5)

Frequent searches list contains several names/aliases/ID of object types and objects you have searched recently. When you want to search for any of them again, all you have to do is click the entry kept here. Both the maximum number of items in the list and the order by which they are sorted are setting parameters. You can set them according to your preference.

Frequent Searches always includes All Devices. This list contains the types of all devices of your covered area. In response to a click on this entry, BOT will search for all the devices and return their locations. If patients are monitored, All Patients contains the names/IDs of all patients being cared for within the covered area. It is also included in Frequent Searches.

*Named lists* containing types/names/IDs of specific objects provide you with a convenient way to name the objects which you may want to search repeatedly. There are two types of such lists. Your head/charge nurse can create *user-defined named lists* for use by you and your colleagues in you covered area. You can find how such named lists of objects and locations are defined and generated and ways you can use them in **BOT GSG**.

The remainder of this note will focus mainly on two special named lists: My Devices and My Patients. They are named lists generated by BOT for you. To explain what they are, note that during the current shift, you may be responsible for keeping track of a subset of devices of your covered area. Your My Devices list is set up to contain the names/IDs of these devices. Similarly, if your ward uses BOT to locate and monitor patients, your My Patients list provides the names and/or ID's of patients cared by you during the current shift. These lists enable you to locate all your devices (and patients) with one click at the start and end of your shift and in the course of your work during the shift. My Devices and My Patients are included in Frequent Searches by default.

## 5. Search Results

BOT presents the results of each search in three ways: They are a summary to give you an overview, lists detailing the locations of objects found and information about objects not found and location pins on the map showing visually the locations of the objects found.

### 5.1 Search Result Summary (6a)

When a search completes, a summary of the results appears just above the search box. The summary consists of two text strings. One string states the number of objects found (e.g., "5 bladder scanners found"). The other string states the number of objects not found (e.g., "3 bladder scanners not found").

Both text strings function as request buttons. A click on either one will cause a detailed list describing objects found or objects not found to be displayed below Frequent Searches.

### 5.2 Result Lists (6b)

Details on search results are presented in two lists: Objects Found and Objects Not Found. The former is displayed by default immediately after the search result summary appears. You

can have the latter displayed in place of the former by clicking the text string Objects Not Found in the result summary and have the former displayed again in place of the latter by clicking the text string Objects Found.

Each entry in Objects Found contains some or all of the following information on an object:

- By default, name/alias of the object;
- Optionally according to user's setting, any or all of name/alias of the object type, and/or ID or Asset ID/ACN (Asset Control Number) of the object;
- A brief description of the current location of the object; and
- Length of time in minutes or days the object has been at the location.

Below are examples of typical entries:

Cardiac monitor-3, near bed No.26, for the past 18 minutes

Bladder scanner-2, ACN ...0168, at left of nurse station, for more than 2 days

CPM-1 device, ID ... 052, in Room 5048, for the past 28 minutes

Thomas Wong, Resident, ID...052, in Recreation Room, for the past 20 minutes

Mr. Good Buddy, in front of nurse station, for the past ten minutes

Each entry on an object in the Objects Not Found list also contains the same information item(s) as in entries of Objects Found. Instead of the current location, the entry includes the location and the time at which the object was last seen and the status of the device (e.g., the device was reported broken or was borrowed by another department) if any is on record.

### 5.3 Location Pins (6c)

BOT uses pushpin-like location pins to tell you on the map of the covered area where the searched and found objects are. The table on the next page lists examples. As you can see, pins with heads of different shapes and colors intend to convey information about the objects other than their locations. In particular, you can tell from the head of a location pin whether the object it represents is a medical device, or a piece of equipment (e.g., a bed or a wheelchair), or a person; if it is equipment, whether it is ready for use; and if it is a person, whether the person is in need of immediate attention.

By the way, the reason for using pushpins rather than the more commonly used location markers (e.g., teardrop or circle shaped markers) arises from the need for BOT to display locations of numerous objects clustered together. As illustrated by clusters of black pins in the upper left corner of the table, you can determine easily the number of devices in a cluster by counting the tails of the pins.

### 5.4 Additional Information

The results mentioned above are displayed automatically when your search concludes. In addition, you can get further information and choose information displayed on the screen when you take the following actions:

Black pins are used to mark locations of medical devices when there is no need to know their types and IDs.

Grey pins mark locations of devices that were reported broken or await transfer but are still in the covered area.

Pins with square heads mark locations of hospital equipments, such as beds and wheel chairs. Items marked by white pins are ready for use. Objects marked by pins with patterned heads must be cleaned.

*Note: Playing the cursor on an entry in Objects Found list causes a orange disk to appear around the location pin representing the entry on the map as an estimate of location error.*

These pins mark the locations of persons, including patients/residents, visitors and contract workers, when there is no need to know who they are.

Pins with numbered and colored heads mark the locations of individual objects. Pins of the same color mark the locations of objects found in the same search: In case of devices, they are usually of the same type. The number on the pin representing an object is the same as the number of the entry on the object in the Objects Found list.

From left to right, these pins mark the locations of persons who have triggered, respectively, an emergent alarm, vital sign alert, geo-fence alarm, geo-fence alarm, vital sign alert and patient safety notification, respectively

From left to right, these pins represent a device on which the panic button was pushed, a device that has triggered a geo-fence alarm, and a device that was reported broken or transferred/loaned at a geo-fence, respectively.

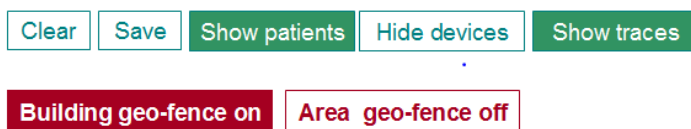
These pins mark the locations of objects attached to tags that are low on battery.

- Click the objects not found text string in result summary -- The list of detailed information on objects not found will be displayed in place of the Objects Found list. Click the objects found text string in result summary causes to the lists to be swapped.
- Pull down Details at the right of result summary -- You will get a list detailing the numbers of objects of individual types found and not found by the most recent searches.
- Place the cursor on a location pin or a cluster of pins -- A callout containing the names and locations of the objects represented by the pins touched by the cursor will be displayed while the cursor remains there. If the pins represent persons wearing sensor tags, their latest vital sign readings are also displayed.
- Place the cursor at a place where there is no pins. -- A callout containing the name of the nearest location will be displayed. This is a way for you to find location names.
- Select an object by placing the cursor on its entry in the Objects Found list: -- A yellow disk will appear on the map at the location of the selected object to indicate location error. This is also a way to locate quickly the pin representing the object on the map.
- Click a location pin or an entry in one of detailed search result lists: -- You do so when you want to report/change device status or take patient notes. BOT interprets your action as the selection of the object represented by the pin or described by the entry. In response, BOT opens the Report Device Status popover window or the Patient Notes and Alert/Notification Setup window depending whether the selected object is a device or a patient. This is also a way to get detailed information on the selected entry, including the type name and ID/Asset ID/ACN of the entry, as they are displayed in the window.

- Click action buttons below the map -- You will see location pins representing devices or patients appear and disappear in response to your clicking of the show/hide buttons. You can clear search results from the screen by clicking the Clear button and request the results of the latest search to be saved in a PDF file by clicking Save button.
- Click + sign in zoom control at the top-left corner of the map and drag and move the map. Thus, you can bring an enlarged part of the map of interest to the center of the screen.
- A dropdown list is provided in the upper left corner of the screen where the floor plan of the covered area is displayed when the covered area has multiple floor plans. You can select the floor plan to be display using the list.

## 6. Action Buttons

Under the map, there are usually buttons such as the ones shown below. There are three kinds of buttons: Show/Hide, Clear/Save and On/Off buttons.



Show/Hide buttons are toggle switches. You can use them to select the information displayed on the screen. Their labels indicate the action which you can request: For example, if your ward uses BOT to locate patients, a large number of person pins marking their locations on the map may obscure search results on medical devices you are looking for to take care of your patients. A click on Hide Patients causes all person pins to be hidden. Then, the label of the button changes to Show Patients. Thus the button becomes ready for you to request the reappearance of all the person pins. You can set up your preferences to have selected information items hidden or shown on GUI by default [1]. You always can use these buttons to override the default settings.

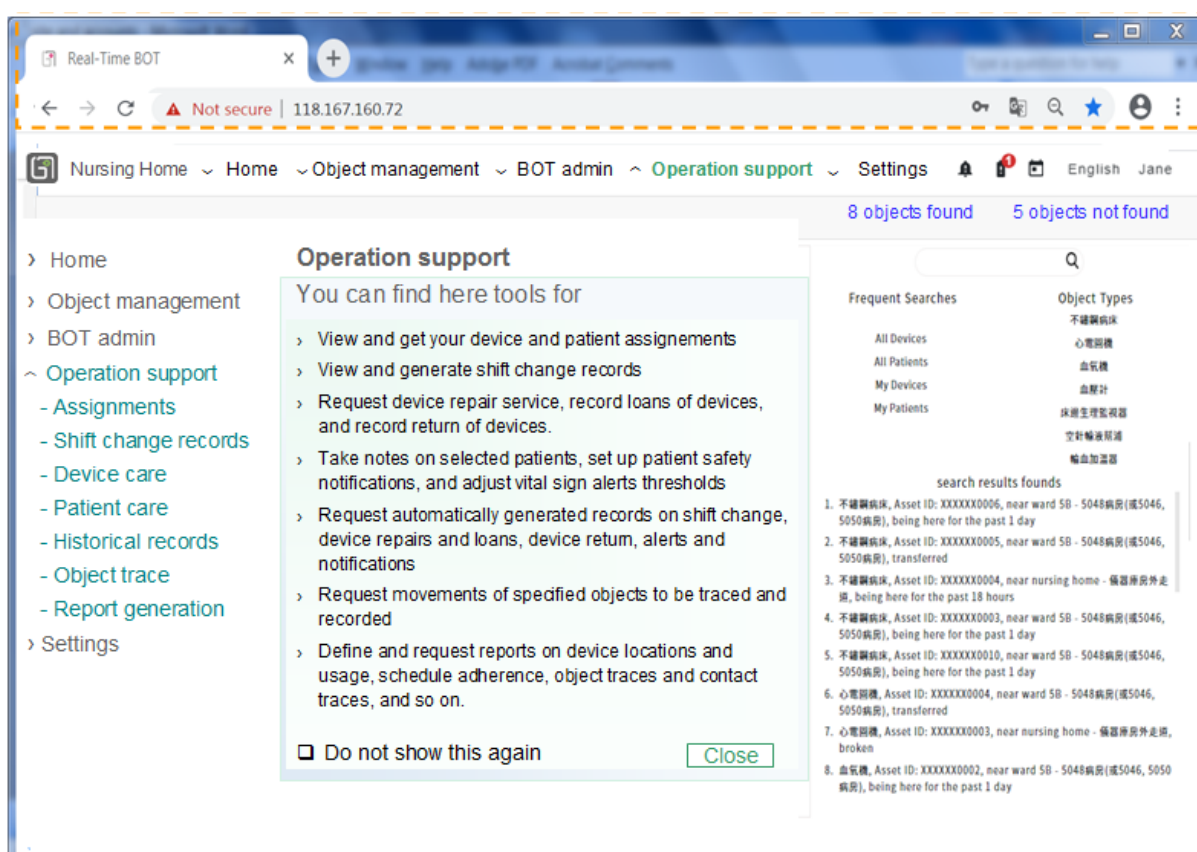
Clear and Save buttons are also common. Their meanings and functions depend on where the buttons are. Take as an example the Clear and Save buttons below the map. At the start of the day, you can click the Clear button to clear the search results left on the screen, and at the end of the day, you can click Save to have the search results on the screen saved in a PDF file. Clear and Save also appear in popover windows which pop up for you to change status of a device, enter notes on a patient, and so on. You click Save to save what you have entered in the window in a PDF file and click Clear to have the form in the window cleared.

This note will present a brief overview on the kinds of monitors for different purposes provided by BOT. All monitors deliver alerts/notifications in specified ways when conditions monitored by them occur. Every alert/notification is cleared/reset manually via a Clear Alert button that appears on the screen when the alert is delivered. When you click the button, a popover window will popup and you will be prompt to enter a note in the window on whether and how the alert has been handled. BOT saves the note as a part of the record on the alert when you click Submit in the window.

If your covered area uses one or more of geo-fence and movement/location monitors, the on-off buttons under the map are used to control their states: The label of such a button indicates the state of the monitor controlled by the button. For example, in the figure on the last page, there are two on-off buttons. They indicate that one geo-fence is on and the other one is off. You can turn each monitor on and off from the GUI using the on-off buttons if you have the authorization to do so, overriding the on/off times specified in Settings.

## 7. Tabbed menus

At the top of the screen is a row of tabs. They are named Object management, BOT admin, Operation support, and Settings. Each tab provides you with a convenient way to access/invoke several related or similar tools/functions. To illustrate, the figure below shows what the GUI displays in response to your click of Operation support: You have on the left of the screen the list of submenus of Operation Support for your selection in midst of other available menus. The menu list will stay on the screen until you choose Home again. This subsection will describe each of the submenus briefly, as well as the submenus made available by clicking other menu tabs.



Note that the search elements and result lists are at where they are on the Home page. Hence, you can start new searches and access/select individual objects in search result lists whenever you need to do so. Also, the popover in the middle of the screen presents an overview of the capabilities offered by Operation support to acquaint you with them. Similar overviews of tools/functions offered by other menus will be presented whenever you click any of named tabs on the top of the screen until you tell BOT not to display the overview again.

Before moving on to describe them, we note that the majority of the functions under Operation support are accessible by all care providers, and the charge nurse or head can access all the functions. In contrast, functions under other menus are available to users in the BOT Admin role. Either none or only a subset of the functions under them are accessible by care providers, including charge nurses and heads. Also, note that many BOT functions/tools produce as results data, reports and records. BOT keeps these results on a temporary basis. It assumes that by agreement with your organization, these results will be transferred to your organization's information system(s) after a specified length of time (e.g., 3 or 6 months). BOT provides API's using which your organization's system(s) can call to transfer the data. Regardless, BOT purges the results after keeping them for the specified length of time.

## 7.1 Operation Support

As the figure on the last page shows, Operation support has several submenus. They contains short-cuts/commands for accessing the tools designed to support your daily work. You are likely to use them often and will surely become familiar with them in no time.

- *Assignments*: More specifically, you have here device assignments and patient/resident assignments. Earlier, [Section 1.4.3](#) stated that My Devices (and My Patients) in Frequent Searches enable you to search with one click all devices (and all patients) under your care during the current shift. The underlying use scenario assumed by BOT is that at the start of the current shift, each care provider on service selects one or more device assignments from available ones kept under this submenu. *Device assignments* are disjoint subsets of devices of your covered area generated by your charge nurse or head. By selecting an assignment, you pledge to be responsible for the devices in the subset. After you made your selection, your My Devices is linked to the assignment(s) selected by you. During the shift, some devices may be removed from and some devices may be added to your assignment(s). When this occurs, BOT notifies you of the change via notification indicator at the upper right corner of the screen. Your My device list is updated when you click on it after the notification, in essence acknowledging your acceptance of the change. Similarly, patient assignments are disjoint subsets of all patients. Your My Patients is linked to the patient assignment(s) which you selected from available patient assignments. When new patients are added to and discharged patients are removed from your patient assignment(s), you will be notified. Your My Patients is updated when you click on it to acknowledge your awareness of the change.
- *Shift change records*: That is to view existing records or generate new records. At the start or/and end of your shift, you and the colleague on the previous or next shift can account for all devices assigned to you based on the results of the latest search of My devices: After you have verified that all devices are at locations stated in the search result lists, you can have the lists saved in a PDF file as a part of your shift change record.

Similarly, if your covered area also uses BOT to track patients, your records on your patients contain notes you took on them during the shift. BOT can generate as a part of your shift change record a PDF file containing the records, together with patients' current locations and, if patients wear smart watches, their current vital sign readings.

- *Device care*: The functions provided here aim to help you and your colleagues follow the best practices in managing devices owned by your department. In response to your selection of this submenu, BOT will open a small popover window containing a form. You can use the form to make request for, or generate a report on, one or more devices. You select each device by clicking the entry on the device in the Objects Found list or Objects Not Found list. For each selected device, BOT automatically fill in the form the name and ACN/ID of the device. You can also cause the popover window to open and the form in the window filled by clicking the entry of an object in a search result list.

The form provides you with four report/request choices: They are:

- (i) Request repair service for the selected device(s),
- (ii) Report the loan of the device(s) to an other department or organization,
- (iii) Report the return of one or more repaired or loaned devices, and
- (iv) Reserve the use of a selected device.

If your selection is (i), or (ii), or (iii), a record in PDF format is generated when you submit the form. The record contains the specifics of the request/report and your name together with the time and date of the report's submission. The status of a device requiring repair or having been or to be on loan is said to be *abnormal*, meaning that it is not available for use. When it is still under the coverage of BOT, the location pin representing an abnormal device has a grey head. The submission of a report on its return from loan or after it is repaired will restore its status to *normal*.

- *Patient care*: Your choice of this submenu opens a popover window for taking notes on a patient, or setting up an alert or notification for the patient. The patient's ID or name or alias can be entered directly into the form in the window. When search results on patients are available, you can also open this window and specify the patient by clicking on the patient's location pin on the map or entry in one of the search result lists. In response, BOT automatically fills in the ID and name of the patient in the form. If you choose to write a note on the patient in the space provided by the window, BOT will save the note in a PDF file when you are done along with notes on the patient you have written previously during the current shift. The file can be download and used as a part of your shift change record on the patient.

The popover window also provides you with the means to set up safety notifications and customize vital sign alert deliveries for individual patients: Your covered area may use BOT vital sign monitor to keep close watch of patients wearing smart watches and have the monitor alert you when some vital sign (e.g., heart rate) of a patient is found to be out of the normal range (e.g., (60, 120) beats per minute) specified for all monitored patients. Often, there is a need to adjust the ranges for individual patients in order to minimize false alarms: For example, an athlete patient's heart rate can safely go as low as 50 bpm and as high as 180 bpm. You can specify and set up for such a patient deviations from the common alert thresholds here. You can also specify conditions under which BOT will not deliver alerts for the patients.

This submenu is also where you can request that the location of a specified patient be monitored and a notification stating the reason for the alert be delivered upon the patient's arrival to any of the specified covered areas. The drop-down and selection lists provided within the popover window enable you to enter an appropriate notification message and specify the covered areas. This feature aims to enhance patient safety. It is an easy to use alternative to location/movement monitors which your covered area may use to monitor all patients or specific types of patients for various purposes.

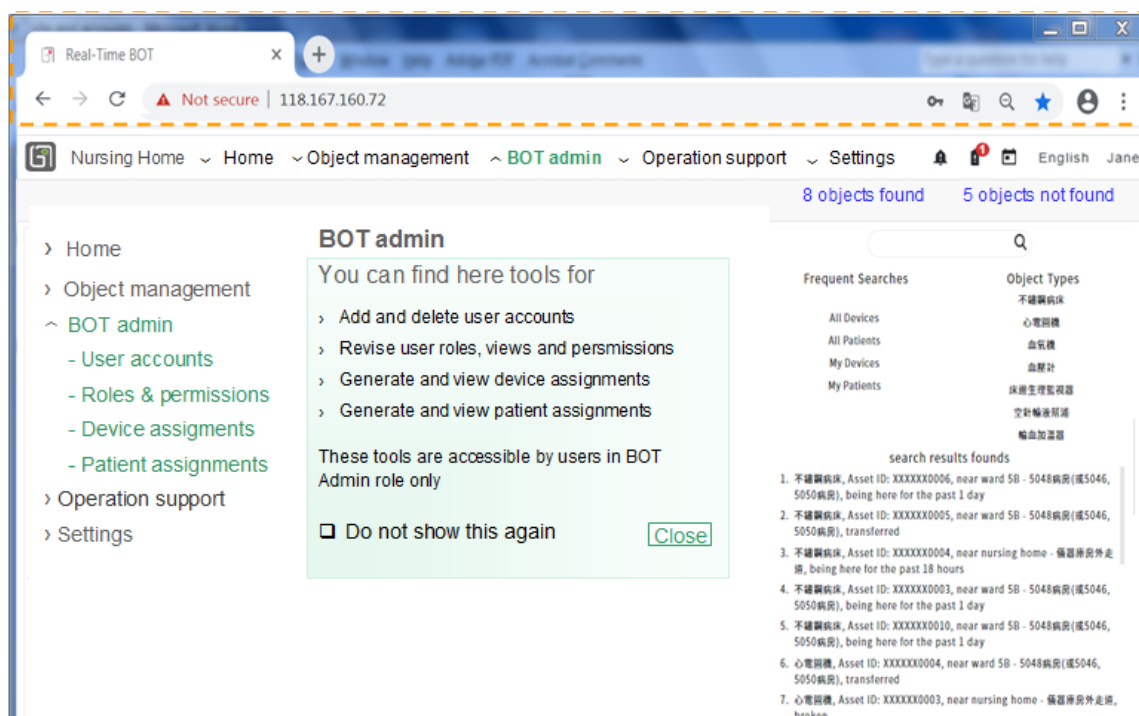
- *Historical Records*: As stated earlier, BOT stores locally data, reports and records generated by BOT functions/tools on behalf of your organization for a specified length of time. This submenu provides tools using which you can have locally stored shift change records, device status change records, patient notes, object traces, and alert/notification records displayed on the screen in PDF format and made ready for download. You can find sample reports and records in **BOT GSG**. The usual role-based access control applies here. So, if you are a care provider, you have access only to your own most recent one or two shift change records, and all device repair request records, device loan records and patient notes generated by you. A charge nurse can access all reports and records generated during the current shifts. The head of a department has access to stored records generated by all users of the department, as well as records on alerts and notifications triggered by objects of the department.
- *Object trace*: This submenu enables you to request the movement of one or more selected objects to be traced for the time interval specified by its start or end time and its duration. As a result, a track of the objects' locations in the specified time interval is displayed on the map and a record of their time stamped locations is stored.
- *Report generation*: Location data on objects collected and stored by BOT can provide information to meet diverse needs. For example, as a care provider in a nursing home, you may want to know the fractions of each day residents under your care spent in their own rooms, recreation areas, and other public areas. As a head, you may want to know whether night shift staff check on residents more or less according to the hourly rounding schedule. Your department or organization may need usage data on valuable medical devices, or all devices. Data on fraction and length of time each device of interest is in use are needed to support modern asset management strategies. This submenu is where you can find tools for extracting such information from stored data and generate reports to meet these needs. They complement submenu Historical Records. There, you can get records with fix contents and formats generated by you (e.g., shift change records and patient notes) or by BOT (e.g., vital sign alert and emergency alert records) displayed and downloaded. In contrast, tools here can process stored data and present the extracted information in forms according to your specification. You can find the types of reports provided by BOT and ways to customize individual reports, as well as details on available report components and illustrative sample reports, in **BOT GSG**.

## 7.2 BOT Administration

The figure on the next page shows the screenshot displayed in response to a click of the BOT Admin tab by a user in the BOT Admin role. The tools/functions provided by the menu are



listed. Some of them may be accessible and hence are also shown to the charge nurses/heads. In contrast, if according to the RBAC model adopted by your organization, users in the care provider role have no privilege to use these tools, then the tools and hence the entire menu are invisible to them.



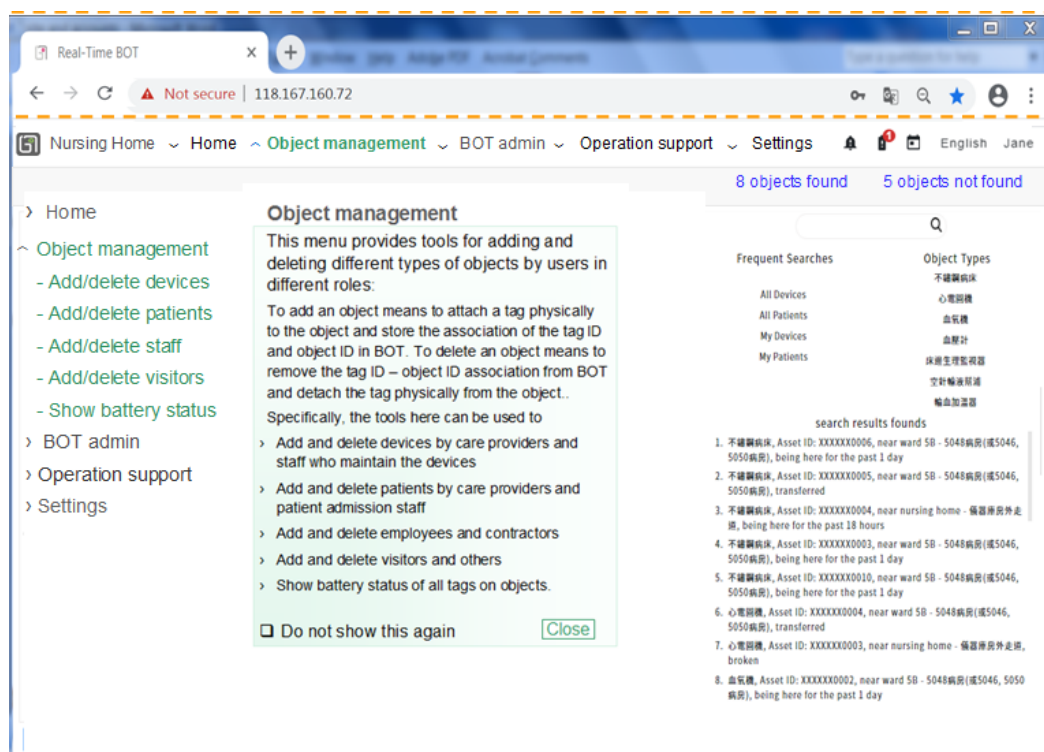
Note that the list of submenus does not include Site Configuration. The reason is that the submenu is accessible only to the few users in the super-BOT admin role. From earlier sections, you can see that BOT is designed to serve diverse organizations, including hospitals, elderly care facilities, and other types of health facilities and care facilities in general. Many of its features can be configured and customized according to the site configuration of the system to meet the needs and preferences of the organization served by the system. Site Configuration provides the tools for this purpose. These tools are not needed after the system is set up. Details on site configuration can be found in **BOT GSG**.

- *User accounts:* BOT Admin menu contains essential tools for managing users: Your BOT account was created by someone with authorization to do the task using the User accounts tool provided here. This someone may be your charge nurse or head if the role-based access control is set up to grant them the privilege to create/delete accounts of users in your department. A user in the BOT Admin role can create/delete accounts of users in all covered areas.
- *Roles and permissions:* Invariably over time, there will be need to revise the underlying role-based access control model, that is, revise the views of data and privileges to use tools for users with different roles, add or delete roles, and so on. Roles and permissions submenu provides supports for these tasks. This submenu is accessible to BOT administrators only.

- Device assignments:** Most likely, for each shift every day, your charge nurse or head assigns all patients in your covered area to nurses on service during the shift. This common practice has shown to improve quality of patient care and reduce nurses' workload and stress. A similar approach to device management can also help to reduce the time and effort spent on accounting for all devices during shift changes. Device assignments is a tool to support this practice. Your charge nurse or head can use it to partition all the devices of your department into a number of disjoint subsets. The subsets are called *device assignments*. Device assignments can also be imported via a file. Device assignments thus generated can be viewed by all care providers of your department and made available for selection by nurses on service under the Assignment submenu of Operation Supports.
- Patient assignments:** Similarly, *patient assignments* are disjoint subsets of all patients in your covered area. They may be generated on HIS (Hospital Information System). In that case, the assignments can be downloaded to BOT. This approach is infeasible when BOT is not allowed to access to HIS. For this reason, BOT provides the tools in this submenu. Similar to Device assignments, the tools here enable charge nurse or head to generate and revise patient assignments and make them available for selection by care providers of the covered area.

### 7.3 Object Management

Object management menu provides access to tools used by persons responsible for routine set up and maintenance tasks. The figure below shows the screenshot displayed in response to your click of Object management tab. Your BOT may be configured so that all the functions are visible to you as shown in the figure or only functions for users in your role are visible. Your organization can make this choice via BOT Settings accessible to BOT administrators



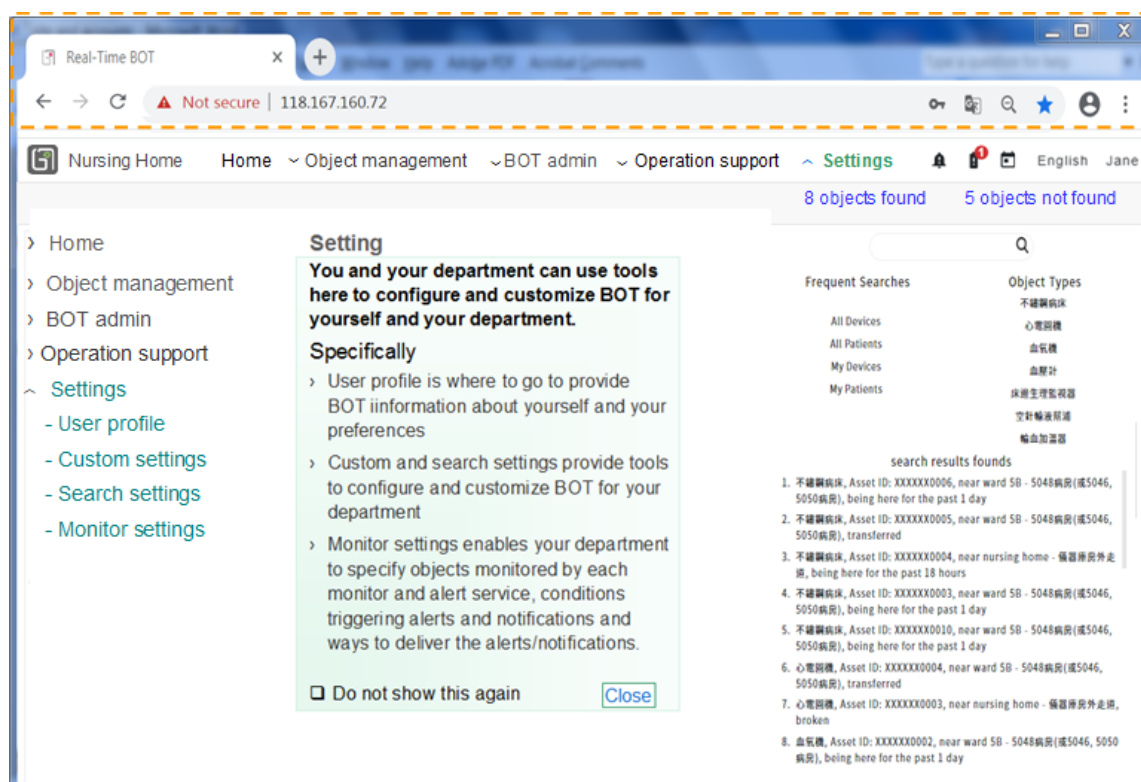
An often performed task is add and delete objects: To add an object means to attach a tag to the object, associate the tag ID with the name/ACN/ID of the object and store the association in BOT. Thus, the object is made visible to BOT. To delete an object means to detach the tag on the object physically from object and delete its tag ID-object name/ACN/ID association stored in BOT, thus making object invisible to BOT and the tag reusable. Adding and deleting different types of objects are subjected to different restrictions, including requiring different privileges. For this reason, this menu provides functions for adding and deleting different types of objects for use by different groups of users.

- *Add/delete devices*: Your RBAC model may allow devices belonging to a ward be added and deleted by care providers and support staff whose service area(s) includes the ward. A user in the BOT admin role can also add/delete these devices, as well as devices and hospital equipment (e.g., fire extinguishers and wheelchairs) of all areas. Some departments may choose to have tag batteries replaced as needed by care providers. This submenu is also where the tool for this purpose can be found.
- *Add/delete patients*: In wards that use BOT to locate and monitor patients, the add patients function enables nursing and support staff to add each newly admitted patient of the covered area by providing the patient with a tag (i.e., a wristband containing a simple tag or a wearable sensor tag) and associating the tag ID with the patient ID. When the patient is discharged, the stored tag ID-patient ID association is deleted and tag is either given to the patient or disinfected and made ready for use by another patient.
- *Add/delete staff*: As stated earlier, who can add and delete hospital staff and contractors are specified by configuration parameters of your organization and your department. For example, staff and contractors working in your ward and visitors to the ward can be added and deleted by your head and charge nurse.
- *Add/delete visitors*: When visitors to your organization are monitored by BOT, they are typically added by the security personnel at the entrances to your facility and deleted when they leave the facility.
- *Show battery status*: In response to your click of this submenu, a list of all objects in your covered area is displayed. Each entry contains a battery level indicator. Its being red tells you that the battery of the tag attached to the object needs to be replaced or recharged.

## 7.4 Settings

Similar to settings on your phone and tablet, Settings menu, illustrated by the figure on the next page, is where you can find your profile containing information about you and your preferences. User preference parameters offered by the current version of BOT are limited to the number of entries and sort order of your Frequent Searches list, information displayed or hidden on the screen and use of aliases versus official names. They are set to their default values when you log in the first time. If you wish to change some of the values after you try the default settings, you can find functions for this purpose under User profile. User profile is also where to go to change your password and add or remove your service areas. (Service areas are the departments where you work and the covered area used by BOT to determine

the scope of your searches and area where location data are displayed.) BOT supports several alert and notification services. Some notification may be delivered to you via short messages. You can provide information for such purposes in About you.



Settings is also where you can find customization settings and configuration parameters of your department. For example, your department may share among users easy to remember aliases for some device types and patients and named lists of objects, object types and locations. Custom settings and Search settings have tools which your head or charge nurse can use to create aliases and named lists. It is also where you and your colleagues can find definitions of aliases and named lists.

A ward may use one or more monitors to keep an eye on movements and well being of patients (e.g., they are to remain in their rooms at night and their vital sign readings are in normal ranges), enhance the safety of your patients and people around them, prevent unauthorized removal of devices from the area, enable you and your colleagues to call for immediate attention of security personal, etc. You can find definition of each monitor, the objects monitored by it, parameters specifying when the monitor is on and off, how alerts and alarms from the monitor are to be delivered and to whom, and so on in the Monitor settings submenu. The next section will provide further details.

## 8. Monitors and Alarms

Current version of BOT provides five types of monitor and alarm services. They are emergency alarms, vital sign monitor, patient safety notifications, geo-fences monitors and location/movement monitors.

## 8.1. Common Concepts and Features

The purposes of different monitor services and conditions triggering alarms from them differ significantly. Nevertheless, they all are means to call for immediate attention to monitored objects and have the following commonalities.

- *Alert delivery:* All monitor services can be configured to trigger alerts and notifications and deliver the alerts by one or more available means, including displays on GUI, alarm bells, flashing lights, and short messages to designated recipients. By default, alerts (and notifications) are delivered whenever they are triggered. In other words, alerts are delivered *unconditionally*.

BOT also supports *conditional alert delivery*. For many reasons, one may want to have alerts/notifications sent only under some specified condition(s). As an example, a nursing home may set up the vital sign monitor to trigger an alert whenever the heart rate of any resident falls below 50 beats per minute (BPM). When alert delivery is conditional, BOT delivers the alert via specified means only if the resident is not an athlete or if the resident is an athlete and the heart rate is less than 45 BPM. As another example, a location monitor used to monitor contractors is to trigger a notification to human resources (HR) when any contractor is away from the contractor's service area. The monitor can be set up to refrain from delivering the notification during the 20-minute break which contractor can take with permission from the HR. Conditional alert delivery is used to reduce false alarms (e.g., in case of the vital sign monitor) and to provide flexibility of location monitors and geo-fences (e.g., in case of the location monitor).

- *Clearance/reset and recording:* Regardless of its type, every alert/alarm/notification occurrence is recorded by BOT. Every delivered alert is cleared/reset manually. The time of its clearance, along with notes on how the event triggering the alert was handled if any, is recorded. Undelivered alerts are cleared after a delay of a specified length.
- *Alert state:* An object is in the *alert state* when it has triggered an alert of a monitor service. It stays in the alert state until the alert is cleared or reset.
- *Home and current areas:* The term *home area* refers to the covered area (i.e., the department) to which the monitored object belongs. The *current area* of an object refers to the covered area containing the current location of the object.
- *Alert/notification recipients:* Regardless of the type of monitor service, an alert or notification triggered by the occurrence of an event involving an object is delivered in specified ways to notify users in the object's home area. In this way, users responsible for the object are made aware of the event occurrence. Alerts and notifications generated by geo-fence monitor and emergency alert services are also delivered to specified recipients in the current area of any object in the alert state if the current area is not object's home. The reasons for doing so include the need for appropriate action(s) to be taken in the immediate vicinity of the object in response to the occurrence of event.
- *Limitations and constraints:* As it will become evident, geo-fence and location monitors require well placed Lbeacons. In general, changes in monitored locations of location

monitors and boundaries of geo-fences may require changes in Lbeacon placements. If and when the need for such changes arises, your head will need to work with a system administrator to decide the best approaches to meeting your need and have the system administrator make the changes.

## 8.2 Emergency Alerts


Some tags used in BOT come with push buttons. Each advertisement packet from such a tag carries a flag to indicate whether the button on the tag has been pushed recently. BOT uses this feature to support location-based emergency alarm service.

The use scenario assumes that a person wearing a tag with a push button may call for immediate attention from care providers or/and security personal by pushing the button. When a person's button is pushed, the person enters the alert state; an emergency alarm is delivered unconditionally: The entry of the person in the Objects Found list of the person's home area is marked by "SOS". If the location pin representing the person is visible on the map, it is also thus marked. As mentioned above, other means for alarm delivery include visual and audio alarms, SMS to designated phone number(s), display of videos from nearby CCTV cameras, and so on.

By default, if a person in the alert state is away from home, then the emergency alarm is also delivered in similar ways to specified users in the person's current area. Your department can use tools provided in Monitor Settings to specify how and to whom emergency alarms set off by different types of persons and for different locations of the persons monitored by your department are delivered.

## 8.3 Vital Sign Monitor

As stated in [Section 1.1.1](#), sensor tags reads the vital signs of their wearers and send their readings to Lbeacons nearby on a regular basis. The vital sign monitoring service provided by BOT makes use of this capability. By having patients wear sensor tags, a ward can get from BOT up to date vital sign readings of each patient, in addition to the patient's location, at all time. By default, the readings are not displayed routinely. You can have get vital sign readings of any patient displayed when you place the cursor on a patient's location pin or entry in the Objects Found list.

Also, vital sign monitor can be set up to trigger an alert whenever some of the vital sign readings of a patient wearing a sensor tag fall inside the alert ranges specified by your head or charge nurse via Monitor Settings. Examples include when the body temperature of the wearer exceeds 37 degrees, or heart beat is lower than 50 or higher than 140 beats per minutes, or blood oxygen level falls below 95%. Alerts can be set up to be delivered unconditionally or conditionally. To deliver an alert, the location pin representing the person and the entry in Objects Found list describing the person are marked by the alert symbol . Your head/charge nurse and the care provider assigned to take care of the patient are notified if the service is set up to do so.

## 8.4 Patient Safety Notifications

Patient safety notification is a feature aiming to enhance safety of patients as well as people around them. Take as an example of its usage: When a patient with an infectious condition arrives at any of the departments where ultrasound, medical imaging, EKG, endoscopy, etc. are taken, a notification is triggered and delivered unconditionally by BOT to alert the technicians and support staffs there upon the arrival of the patient at the entrance. Thus the staff are enabled to take appropriate precaution prior to the first close contact with the patient. This and similar use scenarios make two assumptions. First, patients with conditions that warrant special attention are tracked by BOT. Second, the departments where notifications are to be delivered are guarded at entrances at least, if not fully covered, by BOT.

This feature can be used to supplement location/movement monitors to be described shortly. For example, patients suffering from contagious respiratory deceases should be isolated. So, the presence of such a patient outside the isolation area should trigger an alert. This alert indeed can be done for all patients with such condition using location/movement monitors. A care provider can easily set up and request a patient safety notification for this purpose for individual patients in covered areas where the more general movement/location monitors are not available.

## 8.5 Geo-fences

According to Wikipedia, a geo-fence is a virtual boundary of a real-world geographic area. It is used when there is a need to monitor some objects as they cross the geo-fence to enter or exit the area. Each crossing of the boundary by a monitored object triggers an alert in order to notify designated person(s). By default, every alert triggered by an object is delivered to the home area and the current area of the object.

BOT provides the geo-fencing capability. Typically, there is a geo-fence enclosing each covered area for the purpose of detecting unauthorized removal of devices from the area. A nursing home may also use one or more geo-fence to monitor patients/residents so that nursing staff can be notified when any of them leaves the home. In addition to its on-time and off-time, each geo-fence can be configured to deliver notifications in specified forms (e.g., via audio alarm and/or flashing lights, streaming of videos from nearby CCTV, and/or short message to designated receivers).

## 8.6 Location/Movement Monitors

Location monitors are typically used to keep close eyes on patients/residents at all time beyond what is possible with available manpower. Each monitor is defined in natural language a monitored condition. It is to trigger an alert when the monitored condition is violated. It is to deliver the alert, either always or only when a specified alert delivery condition is true.

There are two types: Movement monitors and location monitors. *Movement monitors* are concerned with movements or lack of movements of the monitored person. Examples of monitored condition include “The patient has been in bathroom for less than an hour” or “The

patient has moved in the past 5 minutes." A movement monitor can be set up to monitor such a condition and to trigger an alert when the condition is violated. Note that the former is feasible only if there is an Lbeacon in every bathroom, and the latter is feasible if every patient wears a sensor tag with an accelerator needed to sense movements of the wearer.

*Location monitors* are used to enforce location restrictions of monitored objects at specified locations. Each location monitor is specified by confined-to or disallowed locations during specified time intervals. An example of location restrictions is "No patient in hallways from 20:00 to 5:00" or more strictly, "Every patient in the patient's own room during bed time hours". The location monitor is to trigger an alert when such a restriction is violated.

Note that location monitors and geo-fences can be viewed as different ways to enforce location restrictions: Geo-fence is a good choice when the monitored area has a clear boundary. Location monitor is a better way to provide geo-fencing capability when the monitored area are not contiguous. Take as an example, during a virus outbreak, a nursing home surely wants to make sure all infectious residents stay in the isolation area(s). If each isolation area is a ward, a zone on a floor or an entire floor, geo-fences can be used conveniently to monitor the area. On the other hand, location monitor can provide monitoring and enforcement functions more conveniently for a fragmented isolation area containing rooms scattered in the building, especially if parts of the area may be added and removed according to the space need.

Similar to geo-fences, each movement monitor can be turned on and off by users who have permission to do so. It can be configured to deliver notifications in any of the supported ways, including audio alarm, flashing lights, and short message to designated receivers. Monitor Settings under Settings is also where specifications and configuration parameters regarding these aspects of each monitor can be set for each covered area.

## 9. References

[1] BiDaE Object Tracker, Getting Started Guide, available by request at sales@bidae.tech.