

Security System

Technical Field

The present invention relates to a security system, and particularly but not exclusively to a system and method for monitoring a plurality of places.

Background

Home security is an extremely important need, both for individual house residence and business owners. They share a common interest to keep their respective places safe. Presently the security industry utilises many different products, including alarm systems and/or security cameras. Alarm systems are wired or rely on proprietary RF sensors at entry points such as doors and windows, and usually require professional installers.

Security cameras are not easy to install, and real-time streaming on multiple cameras is complex and expensive to manage. Moreover, the overwhelming wealth of data makes it difficult to accurately spot an intruder. There are also privacy issues associated with camera based security systems.

Wi-Fi, one of the most commonly used wireless network protocols, is typically associated with wireless internet access and local area networking of devices. The growth in number of Wi-Fi enabled networks around the world to comprise of tens of billions of connected devices has opened up a new range of possibilities for application of Wi-Fi technology other than providing wireless internet access and communication. One promising and tangible application of Wi-Fi signals is that of using it for motion sensing, which has practical applications including use in security systems.

Wi-Fi Sensing has been developed over recent years as an alternative way to monitor places. It has various advantages over other sensing solutions. In some forms, it does not need any extra hardware but can rely on existing Wi-Fi routers and Wi-Fi enabled devices in a place. For example, active radar systems require dedicated antennas and transceivers that are complex and costly, while Wi-Fi sensing uses existing devices like cell phones, PCs, and mesh Wi-Fi systems. A user need only to install the required software to transform their setup into a Wi-Fi sensing solution.

Wireless signals, for example Wi-Fi signals, can be used to sense an entity by monitoring changes in signal characteristics. The use of wireless signals in presence detection has the

advantage that no cameras need to be used, and therefore the privacy of those being sensed is maintained.

Wi-Fi signals penetrate through walls, enabling out of line-of-sight (LOS) operation, an important consideration for security monitoring applications.

Wi-Fi sensing is innately cost-effective due the near-ubiquitous nature of Wi-Fi. Wi-Fi is widespread, so the infrastructure is already in place. There is no need to build a new ecosystem because the IoT (Internet of Things) provides the perfect ecosystem for a sensing system.

Wi-Fi sensing has been found to be surprisingly accurate. Channel State Information (CSI) is collected from the packets and signals used for transmitting and receiving information from regular devices connected via a Wi-Fi network. This technology does not require any additional specialized signals, nor does it degrade network performance or the user experience when using Wi-Fi.

Wi-Fi sensing systems have been shown to be effective for the purposes of security. That is, they may provide sensed data relating to a place by means of which a user of a client device remote from that place may monitor sensed events at a user interface of his local device.

Summary

A mobile application has been developed to provide a user interface through which a user may set up, monitor and control Wi-Fi sensing systems. Users may set up a plurality of Wi-Fi sensing systems in a plurality of places, such as in their home, their place of work and their parents' house, for example. In this example, the user may have an account on the mobile application, the account associated with the three locations. The user may log in to a particular "location profile" associated with their account to view Wi-Fi sensing data associated with the selected location. If a user wishes to monitor Wi-Fi sensing data for a different location, the user must log out of the first location profile and select a different one.

This mobile application for monitoring data generated by Wi-Fi sensing systems requires that a user views data on a location-by-location basis. That is, only one place may be monitored at any given time by the user through the application. The inventors have recognised that this poses limitations when used for security purposes. The following describes a system and method for implementing a monitoring system which addresses these problems.

According to one aspect of the invention, there is provided a monitoring system for monitoring a plurality of places at separate geographical locations, the monitoring system comprising:

a computer device having a user interface configured to receive an identifier of a monitoring user;

a processor configured to process multiple streams of sensed data, each stream of sensed data comprising sensed data for a respective one of the plurality of places and indicative of one or more sensed event in the respective place, to generate display data for display at the user interface of the computer device, wherein the displayed data comprises a respective visual representation of a set of data for each of the plurality of places,

the processor configured to simultaneously render at the user interface at least two of the sets of data associated respectively with at least two of the plurality of places associated with the monitoring user.

In some embodiments, the computer device comprises a network interface configured to receive sensed data from each of the plurality of places, wherein the sensed data is derived from a Wi-Fi sensing system at the respective place. In such an embodiment, the sensed event may be indicative of motion and/or presence of a living being in the place.

In some embodiments, the living being is a person or animal.

In some embodiments, the network interface is configured to receive geolocation data of one or more person at each of one or more of the places. In such an embodiment, the processor may be configured to store the received geolocation data for each person and to record an indication of the most recent place where that person was located, based on the geolocation data.

In some embodiments, the processor is configured to render on the display a visual indication of the most recent place where one or more person was located in association with a graphical indicator of that person.

In some embodiments, the visual identifier comprises a graphical icon associated with that person.

In some embodiments, the user interface is configured to receive an authenticator associated with the monitoring user, and the processor is configured to authenticate the monitoring user based on the authenticator.

In some embodiments, the monitoring system comprises a computer server which is configured to provide a communication path which is configured to communicate with the computer device, the server being arranged to receive sensed data from each of the plurality of places and to transmit the sensed data to the computer device. In such an embodiment, the monitoring system may comprise computer memory which stores for each person of a plurality of people a set of one or more places associated with that person, whereby each person is authenticated as a monitoring user of each of the places associated with that person.

In some embodiments, the server comprises a computer memory which stores for each person of a plurality of people a set of one or more places associated with that person, whereby each person is authenticated as a monitoring user of each of the places associated with that person.

In some embodiments, the monitoring system comprises computer storage in which is stored a security contacts list comprising contact identifiers of a group of people with monitoring user access to the plurality of places, whereby each person on the security contacts list is authenticated as a monitoring user for the plurality of places.

In some embodiments, the processor is configured to render on the display an occupancy status associated with each of the places based on the sensed data.

In some embodiments, the processor is configured to render on the display an activity status for each of the places based on the sensed data.

According to another aspect of the invention, there is provided a method of monitoring a plurality of places at separate graphical locations, each place having a Wi-Fi sensing system installed at the place, the method comprising:

- receiving at a user interface of a computer device an identifier of a monitoring user associated with the plurality of places;

- authenticating the identifier of the monitoring user;

- responsive to authentication of the monitoring user, generating display data for display to the monitoring user, the display data generated from multiple streams of sensed data, each stream comprising sensed data from the Wi-Fi sensing system from each respective place and indicative of a sensed event in the place; and

- simultaneously rendering on a display at least two sets of display data associated with at least two of the plurality of places associated with the monitoring user, where

each set of display data is rendered using a visual representation for each of the plurality of places.

In some embodiments, each visual representation is visually distinct for each place. **[e.g. by colours]**. In such an embodiment, the method may further comprise receiving a user selection of one of the visual representations and, responsive to the user selection of that visual representation displaying one or more of occupancy status and activity status based on the sensed data.

The system and methods described herein enable a home security social network platform. The system and methods are particularly useful for individual house residences and small business owners.

Existing home security social networks provide each person with a list of contact identifiers for that person, who are known and/or trusted by that person. Nowadays, people readily share their data, location, connections etc. The systems and methods described herein enable a social network of an individual person to be leveraged to provide additional assistance in monitoring a place.

Brief Description of Drawings

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made by way of example to the accompanying drawings in which:

Figure 1 shows a user interface configured to provide to a user visual representations of multiple Wi-Fi sensing systems in multiple locations.

Figure 2 shows a user interface through which visual representations of a particular Wi-Fi sensing system in a particular location are provided.

Figure 3 shows another example of the user interface shown in Figure 2, wherein the user interface is provided for a different location.

Figure 4 shows two exemplary user interfaces configured to provide a setup phase for a location in which a Wi-Fi sensing system is installed.

Figure 5 shows an exemplary overall environment in which multiple client devices and multiple Wi-Fi sensing systems are in communication with a server.

Figure 6 shows an exemplary data structure comprising data for a plurality of users.

Figure 7 shows an exemplary data structure comprising data for a plurality of locations.

Figure 8 shows an exemplary Wi-Fi sensing mesh network in a home.

Figure 9 shows a flowchart which demonstrates the authentication, login and security monitoring features of the user interfaces described herein.

Figure 10 is a schematic diagram of a client device on which the user interface features described herein may be implemented.

Detailed Description

The following description relates to a monitoring system which uses a security tool configured to provide a series of user interfaces which generate visual representations of Wi-Fi sensing data to a user in real-time. Herein the word ‘place’ is used to denote a monitored location, such as a home, office etc. A user may have a plurality of places relevant to him, each relevant place having a Wi-Fi sensing system installed therein. Note that the Internet of Things (a network of interconnected devices, including every-day devices like smartphones, smart TVs and smart watches in a particular place) provides a digital ecosystem capable of supporting a Wi-Fi sensing system. The user may log in to a personal profile on a mobile application or web interface of a user device, whereafter a plurality of visual representations corresponding to that user’s plurality of relevant places may be rendered on the user interface. That is, the user may simultaneously monitor Wi-Fi sensing data for the plurality of relevant places without having to log in to a different user interface that is specific to a particular place each time he wants to monitor a different place. Multiple users may be linked, for example by having one or more place that are mutually relevant. However, each user only sees visual representations corresponding to places relevant to them. Each visual representation in the user interface that comprises the plurality of relevant places may be selectable to view a more detailed report of the Wi-Fi sensing data and systems corresponding to the selected place, as is described in more detail with respect to Figures 1–3.

Figure 1 shows an exemplary user device 100 displaying a user interface 102, the user interface 102 configured to provide visual representations of analysis performed by one or more Wi-Fi sensing system in one or more location to a user operating the user interface 102 in real-time. That is, a user may install one or more Wi-Fi sensing system in one or more location or place.

The Wi-Fi sensing systems generate sensed data for processing at the user device. The Wi-Fi sensing systems may be controlled via a mobile application or web interface of the user device.

For the purposes of the following description, the term “operating user” refers to a user for whom the user interface is provided, and the term “other user” refers to a user with whom the operating user is linked. Note that the term “operating user” does not imply a level of authority or increased control of the system compared with other users; the term is merely used in description of Figures 1–3 to distinguish the user for whom the user interface is generated from other users with whom the operating user is connected. That is, other users may themselves be considered operating users of the user interface 102 when the user interface is rendered on their own device and is configured to provide analysis relevant to those other users. Note also that the user interface 102 is configured for each user based on locations relevant to them (or in which they have installed Wi-Fi sensing systems). The term “instance” of a user interface refers to a particular version of the user interface configured for a particular user.

The user interface 102 may be configured to provide, to the operating user, visual representations of Wi-Fi sensing data for multiple places relevant to the operating user. For example, the operating user may have a Wi-Fi sensing system installed at more than one relevant place, such as, by way of example, their home, their place of work and/or the home of a friend or relative. User interface 102 may allow the operating user to monitor activity within the places relevant to them by viewing visual representations of Wi-Fi sensed data generated for each of the places.

In the present description, the term ‘place’ is used interchangeable with ‘location’ to mean an environment monitored by a Wi-Fi sensing system. In the example of Figure 1, user interface 102 includes three location cards 104a, 104b and 104c, each location card 104 associated with a particular location relevant to the operating user and comprising an overview activity graph 110, which provides a simplified visual representation of Wi-Fi sensed data for its associated particular location. Each location card 104 further includes a location graphic 106 and an alert status icon 108. Provision of a plurality of location cards 104, each providing visualisations of Wi-Fi sensing data in real-time, enables a user to quickly determine the state of a plurality of locations simultaneously and to quickly identify anomalous patterns.

In the example of Figure 1, location card 104a corresponds to a first location, identified by a unique identifier rendered on the display e.g. “Santa Monica”, which may be the family home of the operating user. Location card 104a further includes a location graphic 106, which may

indicate the type of location associated with the location card, e.g. house, office, apartment etc. Location card 104a includes a location graphic 106 which resembles a home. Location graphics 106 may be selected by a curator or moderator user in a setup phase of the user interface 102, following installation of one or more Wi-Fi sensing system; moderator users are described later herein.

Location card 104a further includes an alert status icon 108a, which indicates an alert status for the corresponding place. That is, an alert status icon for a particular place may indicate the ways in which the associated Wi-Fi sensing system reacts to sensed activity in that place, for example by sending notifications to client devices and/or triggering deterrent action, such as an alarm.

User interface 102 further includes location cards 104b and 104c, which are respectively associated with an apartment and a place of work. Each of location cards 104b and 104c includes an overview activity graph 110 and an alert status icon 108, each activity graph 110 providing a visual representation of Wi-Fi sensing data for a corresponding location.

Each location card comprises an alert status icon 108. For example, location card 104a comprises alert status icon 108a, and location card 104c comprises alert status icon 108b. A particular alert status icon 108 may be associated with one or more user preference pertaining to alerts in the corresponding location. For example, a user may choose to have relaxed alert preferences in one place, but more active alert preferences in another place. A particular alert status icon 108 may be selected from a plurality of alert status icons 108 by a curator or moderator user in a setup phase of a location card 104, each alert status icon 108 in the plurality thereof being visually distinct, for example by colour, texture and/or shape.

In the example of Figure 1, the alert status icon 108a is rendered as a circle on the location card 104a. Note that the alert status icon 108a may also include a visual indicator such as a colour (e.g. green). The alert status icon 108a indicates that alerts are not active in the corresponding location. That is, a green circle alert status icon may indicate a “relaxed mode”, wherein activity is monitored and recorded, but alerts are not activated, and notifications of activity are not sent to client devices.

Alert status icon 108b is rendered as a triangle on the location card 104b. Note that the alert status icon 108b may also include a visual indicator such as a colour (e.g. red). The alert status icon 108b indicates a high level of alert in the corresponding location. That is, a red triangle alert status icon 108 may indicate an “alert mode”, wherein activity is monitored and recorded,

notifications are sent to relevant client devices, and deterrent actions such as sirens and calls to services such as the police may be triggered upon identification of worrying activity in the corresponding location.

It will be appreciated that the alert preferences associated with the alert status icons 108a and 108b are described by way of example, and other preferences may be implemented. For example, one or more intermediate alert status icon, with alert preferences between the extremes of the relaxed mode and alert mode described above, may be assignable. By way of example, the Wi-Fi sensing system of a particular location may be configured in an “aware mode”, wherein notifications of detected presence are sent to client devices, but deterrent actions are not implemented. The exemplary “aware mode” may be associated with a particular alert status icon 108, for example an orange triangle.

Note also that each location card may comprise a visual representation which has a visual indicator 122, which may be rendered on the user interface 102 as a colour or texture, and which enables the operating user to more easily distinguish between different location cards 104. The visual indicator 122 of a particular location card 104 may also be used to associate a particular user with the particular location, as described later herein.

Each location card 104 may be a selectable user interface feature which, when selected, causes a location-specific interface to be rendered, the location-specific interface providing a more detailed and more interactive means of monitoring Wi-Fi sensed data for the location corresponding to the selected location card 104. Location-specific interfaces are described later with reference to Figures 2 and 3.

The user interface 102 further comprises an add place button 124. The add place button is a selectable user interface feature which, when selected, allows a user to set up a new location card 104 corresponding to a new location in which a Wi-Fi sensing system is installed. The setup phase for a new location is illustrated in Figure 4, as described later herein.

An operating user may be linked with one or more other user, for example, family members, friends, or housemates etc., forming a cluster of users. Members of a cluster may have one or more location in common. Therefore, each instance of the user interface 102, corresponding to each user in a cluster, may show one or more common location card 104. Note, however, that a particular location may be common to some or all users in a cluster, or may be specific to a particular user; that is, a cluster of users may not necessarily have all locations in common.

It will be appreciated that a user may be part of more than one cluster. For example, a user may be part of a first cluster with their spouse and children, and also part of a second cluster with their brother and parents. The users in the first cluster may not have access to Wi-Fi sensed data pertaining to users in the second cluster, or the locations relevant to the users in the second cluster.

The user interface 102 of Figure 1 comprises three user cards, 112a, 112b and 112c, each user card 112 corresponding to a user within a cluster, of which the operating user in Figure 1 is a member. A user card 112 may also be generated for the operating user of the instance of the user interface 102; that is, users may see a user card representing themselves. In the example of Figure 1, the user card 112a, corresponding to user “Peter”, comprises a profile image 114, a whereabouts indicator 116a, and a moderator key 118. The profile image may be a photograph or other image provided by the user, or may be a graphical object selected by the user from a plurality of pre-designed graphical objects. For example, the profile image corresponding to user Peter is a lightbulb graphic.

User card 112a comprises a whereabouts indicator 116a, the whereabouts indicator including the visual indicator 122 associated with the location at which the associated user (Peter) was last detected by a Wi-Fi sensing system. The whereabouts indicator 116a may further comprise text indicating a time at which the user was last seen, or a length of time since the user was detected at a particular location. Note that the visual indicator 122 associated with a location at which a particular user is most recently detected may also be incorporated into the profile image 114 of that particular user. In the example of Figure 1, visual indicators 122 are displayed in the background of the profile image 114 for each user. Note that detection of a particular user by the Wi-Fi sensing system may be done using a GPS tracking system of a mobile user device, the GPS system being coupled to the application that is configured to provide the user interface 102.

User card 112a further comprises a curator key 118, which indicates that the user represented by user card 112a (Peter) is a curator or administrator for the user cluster. That is, the moderator key 118 may indicate to other users that Peter has administrative control over the associated Wi-Fi sensing systems, and that Peter may decide to whom each location is accessible in each user’s instance of the user interface 102. The user interface 102 comprises two further user cards, 112b and 112c, corresponding to users “Claire” and Julie” respectively. Note that Claire

and Julie may have reduced administrative control over the Wi-Fi sensing systems compared to Peter.

Other user types may also exist. For example, there may be users who are known and identifiable by the Wi-Fi sensing systems, but who do not have access to an instance of the application. These users are referred to herein as “steward” users, and may include peoples such as, for example, babysitters, gardeners, cleaners, neighbours, carers or any other person who is linked with the users in a non-personal way. Similarly, toddlers, young children and pets may be identifiable entities that are sensed by the Wi-Fi sensing systems, but these entities do not have access to the user interfaces described herein.

It will be appreciated that a particular person may be a different type of user in different clusters. For example, a user may be a curator within their family cluster, they may then be a standard user in a different cluster (extended family, for example) and may also be a steward user in a different cluster.

In the example of Figure 1, the user interface 102 has recently been loaded. Upon opening the user interface, an overview notification 120 may be rendered on the surface of the user interface 102 as a pop-up alert or banner. The overview notification 120 comprises text which may confirm that no noteworthy activity has been detected, or may identify one or more of the multiple locations relevant to Claire at which anomalous, unexpected, worrying or otherwise noteworthy activity has occurred. In the example of Figure 1, the overview notification reads, “Hi Claire, everything is fine at all the places”. Note that the overview notification is addressed to Claire, who is the operating user of the instance of the user interface 102 shown in Figure 1.

Figure 2 shows an exemplary location-specific interface 202 rendered on the same user device 100 as in Figure 1, the location-specific interface 202 presented upon selection of the location card 104b shown in Figure 1, which corresponds to the location labelled “Brentwood”. The location-specific interface 202 comprises a plurality of user profile images in a region denoted 222. The profile images associated with a particular user may be displayed in the region 222 of the location-specific interface 202 when that user is present at the location.

The location specific interface 202 comprises an activity card 204, the activity card 204 further comprising a detailed chart 206 and a corresponding timeframe selector 208. The detailed chart 206 is a visual representation of activity data generated by a Wi-Fi sensing system, and includes data in a timeframe determined by the timeframe selector 208. Timeframe selector 208 comprises a plurality of selectable features configured to modify the detailed chart 206 by

changing the timeframe within which activity data is presented. For example, the timeframe selector 208 comprises selectable features labelled: “4H”, “1D”, “1W”, “1M”, “1Y” and “all” which, when selected, respectively modify the detailed chart 206 such that it provides activity data from the past four hours, one day, one week, one month, one year, or for as long as the data has been recorded. An alert status icon 108 is also rendered on the location-specific interface 202, indicating the alert preferences for the Brentwood location.

The location-specific interface 202 further includes a plurality of room cards 210, each room card 210 corresponding to a room of the selected location, in which one or more Wi-Fi sensing device has been installed. It will be appreciated that a general location-specific interface may comprise one or more room card, depending on the number of rooms monitored by a Wi-Fi sensing system. Each room card 210 may comprise a sound level indicator 214, which indicates the volume level of alarms and sirens in the associated room in the event that an alarm is triggered. In the example of Figure 2, the living room, bathroom and bedroom are in a silent mode, as indicated by the cross through the sound level indicator 214. The sound level indicator 214 corresponding to the kitchen includes two “bars”, indicating a loud alarm is to be sounded in the kitchen if an alert is triggered. Note that a sound level indicator 214 may be configurable to other volume levels, such as one bar (indicating moderate alarm volume) or three bars (very loud alarm volume). The state of a sound level indicator 214, and therefore an associated user preference of alarm volume, may be configurable by the curator or moderating user.

Each room card 210 may further comprise one or more device panel 216, each device panel 216 representing a Wi-Fi sensing device physically located in the corresponding room. In the example of Figure 2, the room card 210 labelled “Kitchen” comprises two device panels 216, indicating that the kitchen in the “Brentwood” location comprises two Wi-Fi sensing devices. In another example, the room labelled “Bedroom” comprises one device panel 216, indicating that one Wi-Fi sensing device is physically located in the bedroom of the Brentwood location.

Each device panel may further include a device-specific alarm indicator 218. A device-specific alarm indicator 218 may include a colour, texture, shape or other visual property which indicates the state of the associated device. A subset of the one or more devices in a particular room may be configured to sound an alarm. Similarly, a subset of the one or more devices in a particular room may be configured to not sound an alarm. The device-specific alarm indicator 218 indicates whether or not the associated device is configured to sound an alarm when an alert is triggered.

It will be appreciated that the sound level indicator 214 of a particular room may determine the alarm volume of the devices in that room that are configured to sound an alarm. This holds for rooms which are configured in silent mode; that is, if a room is in silent mode, no alarm is sounded, even by devices with a device-specific alarm indicator 218 state which indicates an alarm is to be sounded when an alert is triggered.

The location-specific interface 202 may arrange the room cards 210 in zones. For example, each room card 210 may be associated with a particular zone and rendered on the user interface 202 alongside other room cards which share the same zone. In the example of Figure 2, there are two zones: “Ground Floor” and “2nd Floor”. Zones may be created by a user in a setup phase, and rooms may subsequently be assigned to a particular zone upon creation of a new room within the application. It will be appreciated that a single room may constitute a zone if there is a standalone Wi-Fi sensing system therein.

Devices that are part of the same zone may be able to act as beacons and/or listen to other Wi-Fi sensing devices in that zone. If a device in a particular zone is unable to communicate effectively with other devices in that zone, the application may suggest that a separate zone be created. It will be appreciated that such suggestions may only be made to a curator user.

The location-specific interface of Figure 2 further comprises a “return” icon 220 which, when selected, may cause the user interface 102 of Figure 1 to be rendered on the user device 100.

Exemplary features of Wi-Fi sensing systems include but are not limited to: security, automation (e.g. lighting and heating), energy saving and wellness monitoring. Such features may be provided on a granular basis through the application. That is, security, automation and monitoring systems may be enabled on a zonal or room-by-room basis. For example, a lighting automation function may be permanently enabled in a basement zone, but not in an upstairs zone. Similarly, an alarm system for a garage room may remain enabled though an alarm system rest of the downstairs zone is not enabled, even if one or more person is in the building.

Wellness monitoring systems may be used to monitor people who are vulnerable. In one example, an alert may be sent to one or more relevant user device if a particular user (a grandparent, for example) spends an unusually long time in the bathroom. In another example, pets may be monitored.

Figure 3 shows the user device 100 of Figures 1 and 2, now displaying a different location-specific interface 302. In the example of Figure 3, location-specific interface 302 is presented

upon selection of the location card 104c shown in Figure 1, which corresponds to the location labelled “Century Boulevard”; this location is a place of work. The location specific interface 302 comprises an activity card 304, the activity card 304 further comprising a detailed chart 306 and a corresponding timeframe selector 308. Similar to the example of Figure 2, The detailed chart 306 of Figure 3 is a visual representation of activity data generated by a Wi-Fi sensing system that is physically located in the Century Boulevard location, and includes data in a timeframe determined by the timeframe selector 308.

The location-specific interface 302 includes a room card 310 corresponding to an office room, the room card 316 comprising two device panels 316, each device panel representing a Wi-Fi sensing device that is physically located within the office room of the Century Boulevard location. Note that the office room card 310 comprises a sound level indicator 214, which includes two bars. This indicates that triggered alarms are configured at a loud setting. However, in the example of Figure 3, the alert status icon 108 is set to relaxed mode, and both devices in the office room are set to silent. It will be appreciated therefore that alarms are not sounded when an alert is triggered in the example of Figure 3.

The location-specific interface 302 further comprises a camera card 320, the camera card 320 configured to provide a real-time video or image feed 312 of the associated location to the user. The video or image feed 312 may be CCTV video or iteratively updated images of the selected location. In some embodiments, the video or image feed 312 may be a selectable feature of the location-specific interface 302 which, when selected, opens a full-screen viewing mode on the user device 300. In such an embodiment, video or image data may be stored at a plurality of quality levels (e.g. frame rates and/or resolutions), wherein reduced quality video or imagery, requiring less bandwidth, is automatically presented alongside other features of the location-specific interface through the feed 312 of the camera card 320. A higher quality version of the video or image content may then be accessible upon selection of the video or image feed 312.

Figure 4 shows a computing device 400 displaying a series of user interfaces configured to assign graphical indicators to a newly created or edited location. Figure 4 shows a first user interface 402a, wherein a particular place type may be selected from a plurality of place types. Each place type may be represented as a selectable user interface feature which can be selected to assign a corresponding place type. Each place type 404 may further be associated with a particular place icon, which may be a graphical representation of the associated place type. In the example of Figure 4, the place types labelled: house, apartment and shopping, are

respectively associated with graphically rendered images of a house, an apartment and a shop. It will be appreciated that the first user interface 402a of Figure 4 may be rendered on the display of the computing device 400 upon selection of the add place button 124, as shown in the user interface 102 of Figure 1. The first user interface 402a further includes a “back” button 406 which, upon selection, may return the user to the user interface through which they accessed the first user interface 402a, such as the user interface 102 of Figure 1.

The first user interface 402a includes a first “next” button 408a, which is a selectable user interface feature which, when selected, causes a second user interface 402b to be rendered on the display of the computing device 400, the second user interface 402b being generated based on the place type 404 selected on the first user interface 402a. It will be appreciated that in some embodiments, the first next button 408a may only become selectable upon selection of a particular place type 404. In other embodiments, a default place type may be pre-selected upon rendering of the first user interface 402a, and selection of the first next button 408a may simply render the second user interface 402b corresponding to the default pre-selected place type.

The second user interface 402b is configured to allow a user to select a further visual indicator to be assigned to the newly created or edited location. In the example of Figure 4, the second user interface 402b allows a user to select a colour 410. A visual indicator selected in the second user interface 402b may subsequently be assigned to a location card 104 displayed in the user interface 102 of Figure 1, the location card 104 corresponding to the newly created or edited location. Note that the second user interface 402 also includes a back button 406 which, when selected, may cause the first user interface 402a to be rendered, allowing a user to, for example, select a different place type 404. The second user interface 402b further includes a second next button 408b which, when selected, may cause a third user interface to be rendered on the display of the computing device 400, the third user interface allowing further aspects of the new or edited location to be assigned. For example, an example of third user interface may be a user interface configured to allow a curator user to grant access to other users to see the Wi-Fi sensed data pertaining to the associated location. In other embodiments, selection of the second next button 408b may cause the user interface 102 of Figure 1 to be loaded on the computing device 400, the user interface 102 of Figure 1 including a location card 104 corresponding to the newly created or edited location, including visual indications as assigned in the first and second 402a, 402b user interfaces of Figure 4.

The application configured to provide the user interfaces described herein may further allow configuration of automation, energy saving, security and other features which a Wi-Fi sensing network is capable of providing. For example, on a zonal or room-by-room basis, a user may configure energy saving and comfort preferences for heating, ventilation and air conditioning (HVAC) systems, configure soft security settings such as lighting settings (such as timer systems), and control other automated systems such as, for example, automatic closing of blinds and/or curtains. In some embodiments, recognition by the Wi-Fi sensing systems of the behavioural patterns of inhabitant users may be used to automatically configure preferences of the above Wi-Fi sensing features.

Figure 5 portrays a highly schematic diagram of an overall environment in which one or more client device communicates with one or more Wi-Fi sensing system in one or more place or location via a server 503. Figure 5 shows three places: Place 1 501a, Place 2 502b and Place 3 501c, each place 501 in the diagram representing a real location which comprises a Wi-Fi sensing system. The diagram of Figure 5 also shows a first user 505a and a second user 505b, each user 505 associated with a respective first client device 507a and second client device 507b. That is, each user 505 may have an account which they log in to on a client device to access relevant Wi-Fi sensed data 509 through the user interfaces described herein. In the example of Figure 5, the first user device 507a is a smartphone device and the second user device 507b is a tablet device. It will be appreciated, however, that other computing devices may be used. Each user device 507 is in communication with the server 503 to facilitate implementation of the user interfaces described herein.

The Wi-Fi sensing systems located at each of Places 1, 2 and 3 (501a, 501b and 501c respectively) may transmit Wi-Fi sensed data 509 to the server 503. The server 503 may include a server memory component 515 that holds data structures 513 comprising, for example, user data, location data and relevant permissions for each user. Descriptions of exemplary data structures that may be stored in the server memory 515 are provided with respect to Figures 6 and 7. It will be appreciated, however, that in some embodiments the data structures 513 may be stored in a device memory component 1010, as described with reference to Figure 10.

Wi-Fi sensing data 509 for each place, used to generate the user interfaces described herein, may be communicated to one or more client device 507 based on the user permissions held in the data structures 513. For example, the user permissions held in the data structures 513 may identify that the first user 505a has access to Places 1, 2 and 3 (501a, 501b and 501c

respectively). That is, for the first user 505a, Places 1, 2 and 3 may be considered the “relevant” places for which visual representations of Wi-Fi sensed data are rendered on the user interfaces of Figures 1–3. As a result, the user interfaces generated on the first client device 507a may provide Wi-Fi sensed data 509 pertaining to all of Places 1, 2 and 3 (501a, 501b and 501c respectively), as represented by table T1. In this example, the first user 505a may be a curator or moderator, as described previously herein. In another example, the user permissions held in the data structures 513 may identify that the second user 505b has access only to Place 3 501c. As a result, the user interfaces generated on the second client device 507b may provide Wi-Fi sensed data 509 pertaining only to Place 3 501c, as represented by table T2.

In the example of Figure 1, the place at which each user was last seen is identified through the user interface; this feature may be implemented as shown in the exemplary network of Figure 5. Each client device 507 may provide GPS data 511 to the server 503. Location data stored in the data structures 513 at the server 503 may include coordinate data pertaining to each place 501. The server may use the GPS data 511 provided by each client device 507 to identify when each user arrives at or leaves a particular place 501. For example, when the server 503 identifies, based on Wi-Fi sensed data provided by a particular client device 507, that the corresponding user 505 has arrived at a particular place, the server 503 may provide the GPS data to the Wi-Fi sensed system of the particular place. The Wi-Fi sensing system may therefore associate presence, motion or other activity within the particular place with the particular user 505.

In some embodiments, processing operations which are performed on the Wi-Fi sensed data 509 to enable generation of the relevant user interfaces may be performed at the server 503, the server 503 providing the processed Wi-Fi sensed data 509 to the relevant client devices 075 based on the permissions stored in the data structures 513. In other embodiments, the same processing operations may be performed on the Wi-Fi sensed data 509 by the Wi-Fi sensing system of a particular place 501. In such an embodiment, processed Wi-Fi sensing data may arrive at the server 503, the server 503 distributing the Wi-Fi sensing data 509 according to the user permissions stored in the data structures.

It will be appreciated that Figure 5 shows an exemplary overall environment or network. In some embodiments, the network may include more or fewer users and or places.

The following describes several exemplary data structures, such as those described with reference to Figure 5. Figure 6 shows an exemplary user data structure 601 which comprises

data pertaining to each user in a cluster. The user data structure 601 comprises a plurality of User IDs 603, each user ID 603 corresponding to a user name 605, a user type 607 and a hobby icon identifier 609. Each user ID 603 may be a unique string assigned to a particular user account and used to provide the correct Wi-Fi sensed data and user interface features to each user. Each user name 605 may be a name or nickname associated with a particular identifier ID which is provided by the user upon creation of their account, and which is unique to that user. A user may be able to change their name 605, for example in a settings section of an app. The user data structure 601 may be updated each time a name 605 changes. The user data structure also includes a user type indicator 607. The user type indicator may determine a level of administrative authority within the cluster of users. For example, the user “Peter” has a user type indicator 607 set at a value of “1”. This may indicate that Peter is a curator for the cluster of users. The users “Claire” and “Julie” are associated with a user type indicator 607 value of “2”, which may indicate that Claire and Julie are normal users. It will be appreciated that though not shown in the exemplary data user structure 601 of Figure 6, more user type indicators may exist. For example, a user type indicator 607 value of “3” may indicate that the corresponding user is a steward user, as described earlier herein. Each user in the user data structure 601 is further associated with a hobby icon identifier 609, the hobby icon identifier determining which hobby icon to show on a user interface to represent the associated user. As described with respect to Figure 1, each user may select a hobby icon from a plurality of available hobby icons stored in memory. When a particular hobby icon is selected and assigned to a particular user, the hobby icon indicator 609 within the user data structure 601 is updated to correctly associate each user with their selected hobby icon.

Figure 7 shows several exemplary interconnected data structures 701, 713, 715 and 717, used to generate user interfaces and provide the user interfaces to the correct users. The exemplary data structures shown Figure 7, which comprise location data, may be used in conjunction with a data structure comprising user data, such as that of Figure 6, to generate and provide the user interface features described herein.

Figure 7 shows a location data structure 701 comprising data pertaining to a plurality of real-world places, each real-world place having a Wi-Fi sensing system installed therein. The location data structure 701 comprises a plurality of location identifiers (IDs) 703. Each location identifier 703 may be associated with a location name 705, which may be provided by a user upon creation or editing of the corresponding location. Each location ID 703 may be associated with one or more data sub-structures, each data sub-structure comprising further information

pertaining to its associated location. For example, each location ID 703 may be associated with a room sub-structure 707.

A room sub-structure 707 may comprise a row per room in the corresponding location, each row including a room ID, a room name and a zone ID. Note that the room sub-structure 707 may be updated to include a new row if a new room is added to the location, for example by a curator user. In the example of Figure 7, the room sub-structure 707 corresponding to the location “Brentwood” is shown. Referring back to Figure 2, wherein a user interface 202 corresponding to the Brentwood location is shown, each room card 210 in the user interface 202 is generated based on the rows in the room sub-structure 707 of Figure 7. For example, the sub-structure 707 comprises a room with room ID: “R0001”, named “Kitchen”, which is identified as having zone ID: “Z1”; the user interface 202 of Figure 2 includes a room card 210 which represents this row in the sub-structure 707. In this example, the zone ID “Z1” corresponds to the “Ground Floor” zone of the Brentwood location, as shown in Figure 2. Though not shown in the example of Figure 7, the name associated with each zone may also be included in the room sub-structure 707.

Note that the room sub-structure 707 may also include, for each room, data pertaining to an assigned sound level and a corresponding sound level indicator 214 to be rendered on a location-specific interface 202.

Each location ID 703 in the location data structure 701 may further be associated with a device sub-structure 709, the device sub-structure comprising a row per device that is installed in the corresponding location. Each row may include a device ID for the associated device and a room ID corresponding to the room in which the device is located. With reference to Figure 2, note that the device panels 216 for each room card 210 may be generated based on the room ID associated with each device in the device sub-structure 709. It will be appreciated that though not shown in Figure 7, the device sub-structure may also comprise data which determines an icon used to represent the device in each device panel 216 of Figure 2. The device sub-structure 709 may further include data which determines an alarm status for each device, and a corresponding device-specific alarm indicator 218. .

Each location ID 703 in the location data structure 701 may further be associated with a permitted users sub-structure 711, which comprises a column of user IDs corresponding to users who are permitted to view the Wi-Fi sensing data for the corresponding location. Note that in the example of Figure 7, users with user IDs U0001, U0002 and U0003 are found in the

permitted users sub-structure 711. Referring back to Figure 6, the above implies that the users: Peter, Claire and Julie are permitted to monitor Wi-Fi sensing data pertaining to the Brentwood location.

In some embodiments, the location data structure 701 may further include geographical data such as coordinates for each location ID 703, which may be used to identify instances when a user enters or leaves a particular place, as described with respect to Figure 5. The location data structure 701 may also include, for each location, data pertaining to an alert status and corresponding alert status icon 108.

Figure 8 shows a house with three rooms, each room housing at least one network device 802a–d. The house of Figure 8 is an example “place” or “location” of the present disclosure, where a place is a region being monitored by the sensing network. There are two network devices 802a, 802b in the living room, and one device 802c, 802d in each of the bedroom and study respectively.

The network shown in Figure 8 has a full network topology, where each device 802a–d is in direct communication with each of the other devices 802a–d. Additionally, each of the devices 802a–d acts as both a transmitter and a receiver, as shown by the bi-directional arrows.

That is, for example, the device 802c in the bedroom receives signals from the two devices 802a, 802b in the living room and the device 802d in the study. It also transmits signals to each of the devices 802a, 802b, 802d. By placing network devices around the house, a sensing network can be configured which transmits signals between devices 802a–d such that the signals can be used to sense most — if not all — of the house. Existing Wi-Fi sensing systems comprise devices which are dedicated beacons or receivers, limited to only one functionality. A novel Wi-Fi sensing system which uses dual-purpose beacon and receiver devices in a mesh network configuration is described in more detail in our sister application: **[PWF REF: 429513SG]** The present security system may be implemented with any suitable Wi-Fi sensing system.

Although the signals in Figure 8 are shown to be transmitted in a straight line between the transmitter and the receiver, at least part of each signal may be reflected off surfaces, including furniture and walls.

Figure 9 shows a flow chart which demonstrates an embodiment of the authentication, login and security monitoring features of the user interfaces described herein. In the example of

Figure 9, the user interface is loaded in an application running on a client device 507. Further, it should be noted that the exemplary operating user described in Figure 9 may form a cluster of other users, with whom the operating user is linked.

Figure 9 begins at a step S901, wherein the application is loaded on the client device 507. The user may be presented with a user interface configured to receive login details such as a username and password. At a step S903, the application receives user input of login details.

At a step S905, upon entry of valid login details, the client device 507 may access user data from memory. For example, the client device may access a data structure comprising user data, such as the exemplary user data structure 601 shown in Figure 6, which may be stored in a server memory component 515 and accessible via a network such as the internet. In other embodiments, the user data structure 601 may be stored in a client device memory 1010, as illustrated in Figure 10.

At a step S907, the client device 507 may access data pertaining to places that are relevant to the user. For example, the client device 507 may access a data structure comprising place data and user permissions for each place, such as the exemplary location data structure 701 shown in Figure 7, to identify which locations are relevant to the user, and therefore to identify the places for which Wi-Fi sensing data is to be retrieved. Again, the location data structure 701 may be stored in a server memory component 515 and accessible via a network such as the internet, or may be stored internally on the client device 507 in the client device memory 1010.

At a step S909, based on the user data and place data retrieved from the respective data structures, the client device 507 renders a plurality of location cards 104 on a display 1018, each location card 104 corresponding to a place comprising a Wi-Fi sensing System, and for which the user has permission to view visual representations of Wi-Fi sensed data.

At a step S911, the application may receive real-time updates of Wi-Fi sensing data for each of the places relevant to the user, monitoring trends and patterns in the data to identify potential security alerts. It will be appreciated that though Figure 9 is in context of security alerts, other alerts such as wellness monitoring alerts may be implemented in other embodiments.

At a step S913, the application determines whether or not the Wi-Fi sensed data for one or more place exhibits a pattern or other sign that a security alert should be triggered. If no alert is deemed to be triggered, the flow returns to step S911, where the Wi-Fi sensed data is monitored further. If, at step S913, an alert is triggered for a particular place, the flow continues

to a step S915, wherein the place data structure is accessed to determine one or more users to whom the alert should be sent. It will be appreciated that in some embodiments, all users to whom a particular place is relevant may receive alerts that are triggered in that particular place. In other embodiments, however, some but not all users to whom the place is relevant may be identified as a recipient of an alert for that place.

The flow ends at a step S917 wherein, if the operating user of Figure 9 is identified as a recipient user for the alert at step S915, a notification of the security alert may be transmitted to the device of the operating user. Note also that the same alert may be transmitted to the devices of one or more other identified recipient user. The alert notification is then rendered on the user interface on each recipient user's client device.

Note that alert notifications may not be sent only through the application. For example, the user data structure may comprise contact details such as an email address, mobile or other phone number etc., which may be accessed each time an alert is triggered. If an alert is triggered in a particular place, each user identified as an alert recipient for that particular place may be contacted using one or more of the contact details stored in the user data structure.

A schematic view of the client device 507 according to an embodiment is shown in Figure 10. The user device 507 has a controller 1022. The controller 1022 may have one or more processors 1004 and one or more memories 1010. For example, a computer code of executing the mesh configuration algorithm and/or the sensing mode engines on the user device 507 may be stored in the memory 1010. The configuration memory may also be stored at the memory 1010. The memory 1010 may also store the application which provides the user with capabilities for selecting devices and receiving visual representations of sensed data, sensing information and alerts, the application being implemented by the processor 1004.

The controller 1022 is also shown as having a graphics controller 1006 and a sound controller 1012. It should be appreciated that one or both of the graphics controller 1006 and sound controller 1012 may be provided by the one or more processors 1004. Other functional blocks may also be implemented by suitable circuitry or computer code executed by the one or more processor 1004.

The graphics controller 1006 is configured to provide a video output 1008. The sound controller 1012 is configured to provide an audio output 1014. The controller 1022 has a network interface

1016 allowing the device to be able to communicate with a network such as the Internet or other communication infrastructure.

The video output 1008 may be provided to a display 1018. The audio output 1014 may be provided to an audio device 1020 such as a speaker and/or earphones(s).

The device 507 may have an input device 1002. The input device 1002 can take any suitable format such as one or more of a keyboard, mouse, or touch screen. It should be appreciated that the display 1018 may in some embodiments also provide the input device 1002, for example, by way of an integrated touch screen.

The blocks of the controller 1022 are configured to communicate with each other via an interconnect such as a bus or any other suitable interconnect and/or by point-to-point communication.

It should be appreciated that, in some embodiments, the controller 1022 may be implemented by one or more circuits, at least in part.

It should be appreciated that embodiments may be deployed in different system architectures. For example, the sensing engines may be implemented as a computer program that is stored in the memory 1010 of the user device 507. In another system architecture, the configuration memory and/or the sensing mode engines are stored at the server 503, and implemented by a processor of the server 503. Sensing information is then provided by a network to the user device 507 for providing to the user via the user interface.

It will be appreciated that the above embodiments have been described only by way of example. Other variations and applications of the present invention will be apparent to the person skilled in the art in view of the teaching presented herein. The present invention is not limited by the described embodiments, but only by the accompanying claims.

Claims:

1. A monitoring system for monitoring a plurality of places at separate geographical locations, the monitoring system comprising:

a computer device having a user interface configured to receive an identifier of a monitoring user;

a processor configured to process multiple streams of sensed data, each stream of sensed data comprising sensed data for a respective one of the plurality of places and indicative of one or more sensed event in the respective place, to generate display data for display at the user interface of the computer device, wherein the displayed data comprises a respective visual representation of a set of data for each of the plurality of places,

the processor configured to simultaneously render at the user interface at least two of the sets of data associated respectively with at least two of the plurality of places associated with the monitoring user.

2. The monitoring system of claim 1 wherein the computer device comprises a network interface configured to receive sensed data from each of the plurality of places, wherein the sensed data is derived from a Wi-Fi sensing system at the respective place.

3. The monitoring system of claim 2 wherein the sensed event is indicative of motion and/or presence of a living being in the place.

4. The monitoring system of claim 3 wherein the living being is a person or animal.

5. The monitoring system of claim 2 wherein the network interface is configured to receive geolocation data of one or more person at each of one or more of the places.

6. The monitoring system of claim 5 wherein the processor is configured to store the received geolocation data for each person and to record an indication of the most recent place where that person was located, based on the geolocation data.

7. The monitoring system of claim 6 wherein the processor is configured to render on the display a visual indication of the most recent place where one or more person was located in association with a graphical indicator of that person.

8. The monitoring system of claim 7 wherein the visual identifier comprises a graphical icon associated with that person.

9. The monitoring system of claim 1 wherein the user interface is configured to receive an authenticator associated with the monitoring user, and the processor is configured to authenticate the monitoring user based on the authenticator.

10. The monitoring system of claim 1 comprising a computer server which is configured to provide a communication path which is configured to communicate with the computer device, the server being arranged to receive sensed data from each of the plurality of places and to transmit the sensed data to the computer device.

11. The monitoring system of claim 10 comprising computer memory which stores for each person of a plurality of people a set of one or more places associated with that person, whereby each person is authenticated as a monitoring user of each of the places associated with that person.

12. The monitoring system of claim 10 wherein the server comprises a computer memory which stores for each person of a plurality of people a set of one or more places associated with that person, whereby each person is authenticated as a monitoring user of each of the places associated with that person.

13. The monitoring system of claim 1 comprising computer storage in which is stored a security contacts list comprising contact identifiers of a group of people with monitoring user access to the plurality of places, whereby each person on the security contacts list is authenticated as a monitoring user for the plurality of places.

14. The monitoring system of claim 1 wherein the processor is configured to render on the display an occupancy status associated with each of the places based on the sensed data.

15. The monitoring system of claim 1 wherein the processor is configured to render on the display an activity status for each of the places based on the sensed data.

16. A method of monitoring a plurality of places at separate graphical locations, each place having a Wi-Fi sensing system installed at the place, the method comprising:

receiving at a user interface of a computer device an identifier of a monitoring user associated with the plurality of places;

authenticating the identifier of the monitoring user;

responsive to authentication of the monitoring user, generating display data for display to the monitoring user, the display data generated from multiple streams of sensed data, each stream comprising sensed data from the Wi-Fi sensing system from each respective place and indicative of a sensed event in the place; and

simultaneously rendering on a display at least two sets of display data associated with at least two of the plurality of places associated with the monitoring user, where each set of display data is rendered using a visual representation for each of the plurality of places.

17. The method of claim 16 wherein each visual representation is visually distinct for each place.

18. The method of claim 17 comprising receiving a user selection of one of the visual representations and, responsive to the user selection of that visual representation displaying one or more of occupancy status and activity status based on the sensed data.