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Jonathan D. Hurwitz

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Determination of User Home Location for Emergency Services

ABSTRACT

This disclosure describes techniques to accurately determine a user's home location for use in voice over WiFi (VoWiFi) emergency calls. Per techniques of this disclosure, with user permission, a user's home location is determined on a user device based on location information and corresponding time signatures associated with the locations. Based on user location data, location clusters and sub-clusters are created. Based on the identified sub-clusters, a home cluster is identified and labeled as the user home location based on the location sub-cluster with time signatures representing the end of day and/or the location sub-cluster where the user has spent the longest stationary time. If the determined home location address is different from the current emergency address associated with the user, the user is prompted to update their emergency address to the newly determined home location address. The process is performed entirely on the user device.

KEYWORDS

- VoWiFi
- Voice over WiFi
- Emergency location
- Home address
- WiFi calling
- Emergency call
- Emergency service

BACKGROUND

Voice over Wi-Fi (VoWiFi), also referred to as Voice over Wireless LAN (VoLAN), or WiFi calling, uses a wireless broadband network instead of over a cellular network to route calls from mobile devices such as mobile phones, watches, etc. This technology provides service coverage where cellular coverage is weak but WiFi coverage is strong and enables users to still make and receive calls. For example, WiFi calling is especially useful for users in rural areas who have WiFi based network connectivity, but poor or no cellular service coverage. VoWiFi is also useful to users with cellular (e.g., 3G, 4G, LTE, etc.) dead zones in their homes (e.g., basements) and can effectively enable a ubiquitous calling experience for the user.

Emergency services are reachable when a user is connected over VoWiFi. Typically, when a user calls emergency services via their cellular network, e.g. an LTE network, the location of the cell tower that the user's device is connected to is relayed to the emergency service. Further, if the user's device is GPS-enabled, the user's location as determined by the GPS is also transmitted to emergency services to enable personnel to accurately locate the caller. However, the user may place the VoWiFi call from a location, e.g. a basement, in their home where the GPS is not available since the device cannot lock onto a GPS satellite. Additionally, the WiFi access point (AP) information may provide insufficient location information, thus limiting the ability of emergency services to locate the user.

Device manufacturers, operating systems, or other systems provide interfaces that prompt users, e.g., at a time of initial device and/or user account setup, for an emergency home location (emergency address) that can be transmitted to an emergency service provider in the event of an emergency call. However, users often fail to update the emergency address when they move. In a

situation where a user has moved to a new home and then calls emergency services, emergency responders may arrive at an incorrect location based on the previously set up home location.

DESCRIPTION

This disclosure describes techniques to accurately determine a user's home location for use in emergency location applications, particularly for VoWiFi based emergency calls. Per techniques of this disclosure, with user permission and express content, a user's home location is determined based on user location information and corresponding time signatures associated with the locations. The described techniques are implemented entirely on the user device. If the user home location is determined to be a location different from the current emergency home location associated with the user, the user is alerted to update their emergency home location to the newly determined home address.

Determination of the home location is based on the different primary locations where a user spends time and determining which of the different locations correspond to a user's likely home location. All obtained data is stored locally on the user device and determination of the user home location is made, with user permission and express consent, locally on a user's device. With user permission, the determination process is run as a background process on the user's device, e.g. a mobile phone, watch, etc. The user is provided with options to limit access to user data, or to turn off automatic determination of the user's home location.

Fig. 1: Providing an alert to update emergency home location

Fig. 1 depicts an example user interface that provides alert to the user to update their emergency home location address, per techniques of this disclosure. In this illustrative example, a first address ("1873 Mountain Drive, Livingstown, WI") is the emergency home location currently associated with the user.

Based on determination that the user's actual home location is different from the emergency home location, the user is prompted to update their emergency home location address. The newly determined home location address ("1721 Riverview Drive, Livingstown, WI") is provided to the user via a user interface to enable the user to easily update their emergency home location address by selecting the "Yes" button, or to reject the proposed new address by selecting the "No" button.

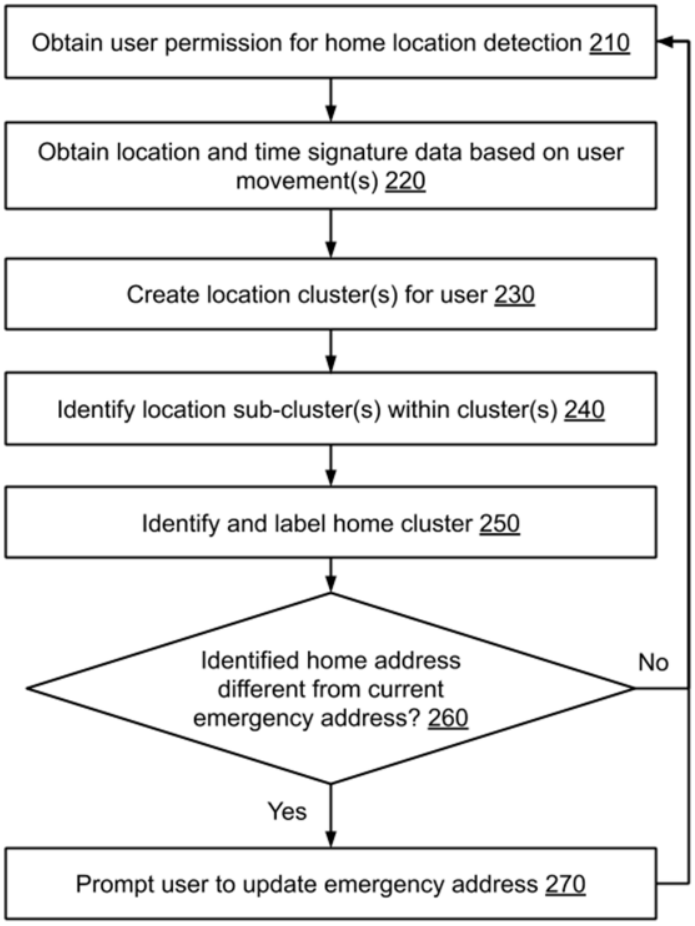

Fig. 2: Location and time signature data are utilized to update a user home location

Fig. 2 depicts an example method to determine and update a user's emergency location address, per techniques of this disclosure. User permission to implement home location determination is obtained (210) to perform home location detection via a user device. If the user denies permission, the rest of the steps are not performed. If permitted, subsequent steps are performed using only such user data for which the user has provided consent.

User location data and time signature data associated with the user locations are obtained from the user device (220), as the user goes about their routine activities. The obtained data is stored locally on the user's device; no data is sent to a server or shared with service provider(s)

or other applications. The time signature data for each location is utilized to weight the corresponding location data and to provide an indication of the time spent by the user at each location. With user permission, user movements are detected based on Inertial Measurement Unit (IMU) data from the user device and/or based on changes observed in user location data. GPS data, WiFi packet data, and/or Bluetooth Low Energy (BLE) packet data associated with the user locations can be obtained and utilized for this purpose.

Based on the obtained user location data, location clusters are created (230) for the user. To account for potential errors in the GPS data, a threshold tolerance radius is used to cluster a set of points within the tolerance radius as a single location. Techniques such as k-means clustering and/or density-based spatial clustering of applications with noise (DBSCAN) can be utilized to create the clusters. The elbow method is utilized to identify an optimum number of location clusters to be created. Per the elbow method, the number of clusters to be created is sequentially increased until the point at which there is marginal decrease in information gain encoded by the clusters.

Typically, places that are visited routinely by a user, e.g. home, workplace, gym, etc. are represented in relatively dense clusters with a large number of data points. Sub-clusters are created (240) from the identified larger clusters to further narrow down the likely user home location. Sub-clusters are created by applying the elbow method and clustering techniques to the larger clusters.

Based on the identified sub-clusters, a home cluster is identified and labeled (250) as the user's home location based on the location sub-cluster with time signatures representing the end of day and/or the location sub-cluster where the user has spent the longest static (stationary) time. This is based on the intuition that the location of a user at the end of the day is likely the

user home location and the long static time is representative of a user's sleep time. The time period for identifying the home cluster is selected to be sufficiently long to accommodate irregular sleep schedules, etc.

If the determined home location address is different from the current emergency address associated with the user (260), the user is prompted to update their emergency address to the newly determined home location address (270).

In some implementations, labeling of the clusters is based on additional information as permitted by the user. For example, a user's typical charging and inactivity schedule can be utilized to infer a likely user home location. As an example, if a wearable device such as a smartwatch is charged daily (and is stationary) from 11pm-7am and indicates user movement during the rest of the day, the location where the watch is being charged is a likely home location.

If the user permits, other devices associated with the user can be used to infer a likely home location. For example, if the user device utilized to implement the home location determination is also associated/connected with a second user device, e.g. a smart speaker or other smart appliance, a WiFi router (e.g., bearing the user's name such as "Jemima's home" or "Jemima's bedroom") when the user device is located at a certain location, that location can also be determined as a likely home location for the user. Further, a geographical information system or a digital map application can be utilized to infer if a determined user location lies in a residential zone.

Determination of the user home location is performed periodically using the user device at a predetermined frequency to reevaluate the clusters to determine if a user's home location has changed. For example, if a cluster different from the current home location cluster becomes a

high density cluster and corresponds to the last location for the day frequently, the user may be prompted to update their emergency address.

The described techniques are implemented entirely on a user device and with specific user permission. As described earlier, all location and time related data is obtained with specific user permission and is used specifically for the purpose of determining the home location. The obtained data is stored and processed locally on the user's device, and is not sent to a server or other device. All data associated with user location determination is purged from the device when the user turns off the user location determination feature.

Further to the descriptions above, a user is provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., information about a user's location, charging schedules, movements, activities, or a user's preferences), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user. Thus, the user has control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques to accurately determine a user's home location for use in voice over WiFi (VoWiFi) emergency calls. Per techniques of this disclosure, with user permission, a user's home location is determined on a user device based on location information and corresponding time signatures associated with the locations. Based on user location data, location clusters and sub-clusters are created. Based on the identified sub-clusters, a home cluster

is identified and labeled as the user home location based on the location sub-cluster with time signatures representing the end of day and/or the location sub-cluster where the user has spent the longest stationary time. If the determined home location address is different from the current emergency address associated with the user, the user is prompted to update their emergency address to the newly determined home location address. The process is performed entirely on the user device.

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