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A Safety Check-In Application for Location Recognition over Smartphones

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Abstract**—**This paper proposes a Safety Check_in application by using a location recognition algorithm for automatic check-in applications (LRACI), which is suited to be implemented within Smartphones and integrated in the Cloud represents a service for Cloud end users. The performance of which is independent of employed devices, uses both global and hybrid positioning systems (GPS/HPS) and in an opportunistic way, the presence of Internet access points (APs), through a new definition of Internet Touch Point (TP), which is proposed in this paper. This TP definition considers the order relation among the received signal strength (RSS) rather than the absolute values. This is one of the main contributions of the proposed application. The LRACI is designed to be employed where traditional methods, usually based only on GPS/HPS, fail, and it is aimed at finding user location, with room-level resolution, in order to estimate the total time spent in the location, called Permanence, instead of simple presence. The LRACI allows automatic check-in in a given location only if the users' Permanence is larger than a minimum amount of time, called Stay Length (SL), and it may be exploited in the Cloud. Using LRACI-based data collected by smartphones in the Cloud and made available in the Cloud itself, end users can be able to find the location of other users who are in danger in a more efficient way. The proposal will be practically implemented over Android operating system-based Smartphones as well as windows mobiles. In this sense, a preliminary study of its application in the Cloud, obtained through real time experiments, have been provided to highlight the advantages of the LRACI features.

Keywords- *Check-in applications, cloud computing, Internet TouchPoint , GPS/HPS receivers.*

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I. INTRODUCTION

The appearance of different technologies such as Internet, wireless networks, Global Positioning Systems (GPS) and, Geographical information systems (GIS), have introduced a new type of information technology called Location Based Service (LBS). LBS is an information service, accessible through mobile devices, such as Smartphones, which provides the identification of people and objects location. LBS applications may include parcel and vehicle tracking services and mobile commerce when taking the form of advertising directed at customers and based on their current location. One of the most popular LBS applications concerns Check-In, whose aim is allowing people to Check-In at specific locations such as pubs, supermarkets, and post offices. Two well-known Check-In applications are Foursquare [2] and Gowalla [3], which have spread rapidly. Using these applications, users can Check-In at a location, sharing information with other people, leaving comments and votes, retrieving suggestions and enjoying benefits dedicated to "regulars" that spend some time in the location. On the other hand, the increasing popularity of these applications has allowed revealing some of their weaknesses. For example, it is difficult to guarantee the owner of a pub (the location where to Check-In) that a customer has actually stayed in the location for a given amount of time. Some users could be tempted to Check-In when they simply pass near the location without really staying, just to obtain possible commercial benefits dedicated to accustomed people. To avoid this possibility Check-Ins should be validated by considering correct user location as well as minimum period of time spent by a user in a given location. This period is called Stay Length (SL) and it is usually set by a business owner. In practice, a Check-In request is considered valid only if the user permanence in the location (i.e., the overall time spent by that user in the location) is larger (or equal) than the SL.

This is the direction taken by the Location Recognition Algorithm for Automatic Check-In applications (LRACI) introduced in this paper. LRACI is implemented over Smartphones, is independent of the employed device, and uses GPS and HPS positioning information together with data received by Internet access points, when available, exploited through a new definition of Internet TouchPoint (TP), and uses the concept of Stay Length (SL) to validate Check-Ins.

The full and efficient utilization of LBS and of LRACI in particular, is strictly connected with the evolution of Cloud Computing. In detail: A) Smartphones, GPS/HPS, and Internet access points are part of the Cloud Platform and Infrastructure and are tools used by LBS applications: Platform and Infrastructure are Services for LBS applications and these matches PaaS and IaaS models. B) LRACI implementation, as said, is independent of the specific Smartphone technology: it is implemented in the Cloud, not within a part of it; so it is a Software Service for the Cloud following SaaS model. C) Location data (or, more specifically for this paper, Check-In data) represent a service for Cloud Users (as in DaaS model); this feature is characteristic for Cloud based LBS, and is a clear distinction factor with respect to traditional LBS. D) LRACI Location/Check-In data are shared among Cloud users and represent a resource pool to access.

II. PROBLEM STATEMENT

To develop a safety Check-In application for location recognition by using GPS or without GPS, that helps to find out the location of users who are in uncertain dangers and allows sending emergency message or call to the preloaded users and even to the nearby users based on range selection.

III. Related Work

Now Now days many indoor and outdoor location recognition methods have been developed. Infrared, ultrasonic, GSM, Wi-Fi and RFID are commonly used technologies for indoor environments while, in case of outdoor scenarios, GPS and Cell Tower Localization are the most employed [4], [5].

A. *Global Positioning System (GPS)*

GPS is the most popular and widely used positioning system, which is maintained by the United States government and provides location information obtained by signals sent from a group of satellites. GPS can provide users' locations very accurately but, its signals are often blocked and absorbed by walls or other obstacles [7]. Therefore GPS is not suitable for indoor environments. Rosum's TV-GPS is an enhanced positioning technique, which works both indoor and outdoor. It uses the Time Difference Of Arrival (TDOA) approach applied to TV signals to estimate the position. As said in [8], it needs additional hardware for television transmitter towers to achieve precise time synchronization. The achieved positioning error is in the range 3.2–23.3 [m]. Another interesting localization approach is Japan's Indoor Messaging System (IMES), which is an important part of the regional Quasi-Zenith Satellite System (QZSS) project. It uses GPS signals and provides precise positioning because it employs terrestrial transmitter equipments and beacons to assist the whole localization process [9].

B. *WiFi Positioning System (WPS)*

Wi-Fi FingerPrint (FP)-based location recognition methodologies, originally designed and employed for indoor positioning purposes by using Wi-Fi positioning system and Bluetooth [7] are a very interesting approach also for outdoor positioning. There are many scientific papers in the literature aimed at recognizing locations by using Wi-Fi FPs that can be either built manually by trained experts and so available in advance, or, more practically, built automatically. [10] proposes a crowdsourcing radiomap building method for location recognition in urban environment, whose main idea is based on the fact that it is not always feasible to manually build a collection of Wi-Fi FPs (i.e., a radiomap) for each location/Point Of Interest (POI), especially in large-scale urban environments. In order to solve this problem, [10] proposes an algorithm in which the users of Wi-Fi enabled mobile devices contribute to build the FP in a collective and automatic way. Among FP-based approaches, a well-known platform is LifeMap. It is based on the autonomous construction of a personalized POI map, which provides location information for advanced mobile services. The key concept is to use an accelerometer to track user locations and to identify the POIs. The solution incrementally builds user's POIs through a personalized radiomap generated from the properties of Wi-Fi APs (e.g., from the RSS).

C. *Hybrid Positioning System(HPS)*

The need of localization techniques that provide good user position without requiring extra-hardware and high costs, and so that can be efficiently implemented over Smartphones, is satisfied by methods (called Hybrid Positioning Systems—HPS) that jointly use GPS, Wi-Fi Access Points, Bluetooth devices and Cell Towers signal strengths. An example of HPS is the Intel's Place Lab [4] method, which employs radio beacons (802.11 APs, GSM, and Bluetooth) that already exist in the environment and have unique or semi-unique IDs such as, for example, MAC addresses. Mobile devices compute their own location by detecting one or more IDs, to look up the associated beacons' positions in a locally cached map, and estimating their own position with respect to the beacons' positions [4]. Always within the family of HPSs, another method, applied by Skyhook, is the X Positioning System (XPS) [9]. In order to improve the localization accuracy, XPS detects Wi-Fi APs through a scanning algorithm, uses GPS positioning information about Wi-Fi APs to (reverse) triangulate the position of detected APs, and stores the position in a reference database. The precision of Wi-Fi APs positions is affected by the scanning scheme employed by the mobile device, which can have an error larger than 10 [m].

The common point, among many of the techniques mentioned above is the employment of the absolute values of the measured RSS. FPs are built by measuring the RSS, sensed during a first step, called training phase. RSS absolute values are employed also in the recognition phase. This action, independently of the robustness of the employed method, presents some drawbacks. Measured RSS absolute values: a) are sensitive to multipath fading, to device orientation, and to other important factors; b) are strongly dependent on the employed device (i.e., two different Smartphones, in the same position with the same orientation, often provide different RSS measures). These drawbacks have an impact not only on the performance, but, the latter in particular, on the practical applicability of the location recognition solutions as SaaS in the Cloud, and on the Cloud Computing deployment model, mentioned in the Introduction.

The proposed system introduces a new Location Recognition Algorithm for Check-In applications, where the recognition action is based on: i) exploitation of GPS-HPS information opportunely filtered and weighted (Error Correction Filter with Internet stability condition); ii) new automatic, opportunistic and device-independent TP building and matching method.

IV. Proposed Methodology

A. *LRACI Working Principle and Flowchart*

LRACI employs positioning information, collected by Smartphones Operating System(s), acquired from GPS/HPS, and a new definition of TP detailed below. LRACI is based on a sliding time window of T seconds during which positioning data (latitude and longitude) and Internet scans, used to define the TP, are acquired simultaneously [1]. They represent the available information elements of the window. Z^{ζ} elements are stored in the generic ζ -th window. The number of stored elements can be different for each window because positioning data and Internet scans are provided by the Smartphone OS at irregular time intervals independent of time window T.

LRACI defines a generic location l, l € [1,L] , by three different features: i) the coordinates of the location centre represented by $C^l = [C^l_{lat}, C^l_{lon}]$ where C^l_{lat} indicates the latitude and C^l_{lon} is the longitude; ii) the radius R^l expressed in [m]; iii) the Internet TP of the location indicated through F^l. C^l and R^l completely identify the location from the geometrical viewpoint as a simple circle and are supposed known a priori, stored in a reference Database (DB) that is always accessible and available directly on the Smartphone when needed. TouchPoint F^l is not always available within the DB because either it cannot be computed because no Internet signals cover the location or because it is under computation locally to a

Smartphone (through the algorithm explained later in the paper) and not yet uploaded in the DB.

Fig. 1 represents the LRACI flowchart. For each generic ζ -th time window of T seconds, a location may be recognized by using dedicated procedures (detailed below), whose employment depends on the availability of the F^l of a given location within the reference DB. In particular, if F^l is not available in the DB, the location recognition and consequent Check-In is mainly based on GPS/HPS data. The acquired Internet signals, scanned during T are employed, if a Smartphone checks-in, to compute a TP that will be uploaded in the DB. It means that for successive recognition/Check-In in that location F^l will be available in the DB. If the TP is available the location recognition is based on it. The two procedures are called Unavailable TP and Available TP, respectively.

It is worth noting that, even if F^l is available, a TP is locally computed by a Smartphone to recognize the location and, after the Check-In, to upgrade the stored TP in the reference DB. In practice, LRACI offers a continuous and opportunistic learning process of the locations' TP.

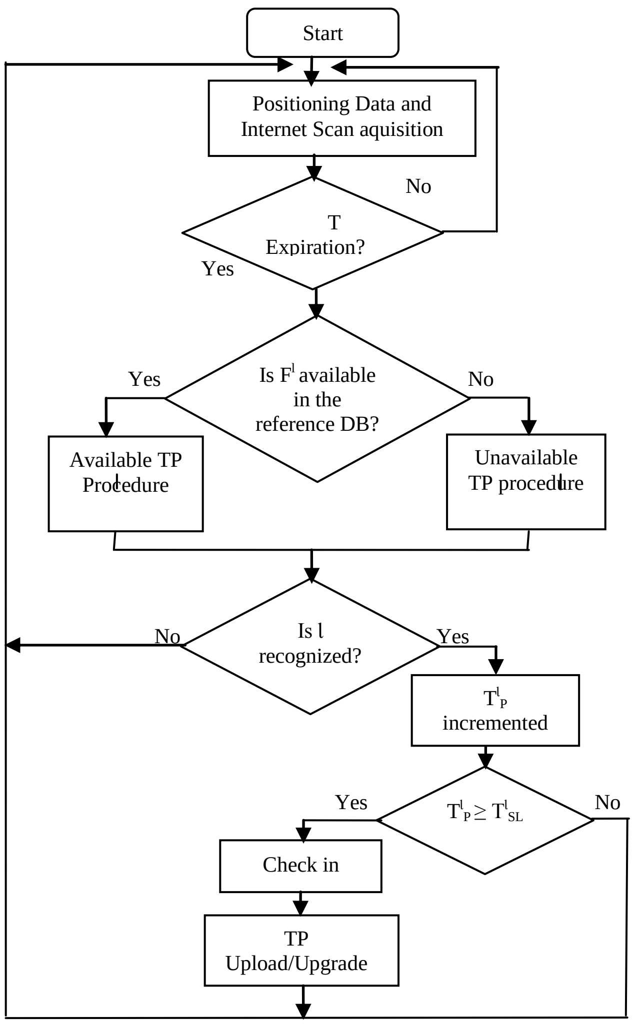

Figure 1: LRACI Flowchart

B. *Internet Scan Definition*

LRACI uses a method where a Smartphone cyclically radio scans the surroundings of a location for Internet signals. Three features for each detected AP are acquired during each scan: *i)* APs *MAC addresses*, *ii)* Service Set Identifier *SSID* and *iii)* measured Received Signal Strength (*RSS*) in [dBm]. A matrix $\hat{S}^k$ is computed for each generic *k*-th Internet scan:

$$\hat{S}^k = \begin{pmatrix} \hat{s}^k_{11} & \dots & \hat{s}^k_{m1} & \dots & \hat{s}^k_{M1} \\ \vdots & & \vdots & & \vdots \\ \hat{s}^k_{1\acute{n}} & \dots & \hat{s}^k_{m\acute{n}} & \dots & \hat{s}^k_{M\acute{n}} \\ \vdots & & \vdots & & \vdots \\ \hat{s}^k_{1N} & \dots & \hat{s}^k_{mN} & \dots & \hat{s}^k_{MN} \end{pmatrix}$$

m € [1,*M*] identifies the features (concerning this paper *m*=1 is the *MAC address*, *m*=2 the *SSID* and *m*=3 is the *RSS*) and ń € [1,*n*] identifies the sensed AP during scan k € [1, *K*]. *K* is the total number of scans performed. The total number N of sensed APs N obviously varies and can change for different scans.

C. *GPS/HPS Positioning and Error Correction Filter (ECF)*

In order to improve the possible position error of the HPS and to obtain a more robust position data, this paper proposes a correction filtering approach that exploits the time-based sliding window. The main idea is to store the positioning information, composed of latitude and longitude, within a filter during a temporal window of *T* seconds. This is compatible with Check-In applications. In practice, data (i.e., the elements in the window) is collected until the difference between the acquisition time of the last and the first element is longer than the window size *T*. When the filter is completely filled, the weighted mean position $P = [P_{lat}, P_{lon}]$ obtained from all acquired data, is computed by using the following equation:

$$P_{lat} = \frac{\sum_{z=1}^{Z^{\zeta}} w^z \acute{P}^z_{lat}}{\sum_{z=1}^{Z^{\zeta}} w^z}; \quad P_{lat} = \frac{\sum_{z=1}^{Z^{\zeta}} w^z \acute{P}^z_{lon}}{\sum_{z=1}^{Z^{\zeta}} w^z} \tag{1}$$

Where, Z^{ζ} is the number of positioning data stored during the ζ -th time window, $\acute{P}^z_{lat}$ and $\acute{P}^z_{lon}$ represent the latitude and longitude of the *z* -th generic position, respectively, and ω^z is a weight assigned to each data. Practical experiences allow concluding that the following values can be employed: $\omega^z = 0.8$ if the positioning data is provided by GPS, $\omega^z = 0.2$ if the positioning is obtained from HPS. The process is repeated by sliding the time window *T* of one element. In practice, the first element of the windows is removed and new positioning data can enter; when the window is filled again, equations in (1) are applied. The filtered positioning data $P=[P_{lat}, P_{lon}]$ are used to recognize a location if the TP of that location is not available.

D. *Work Principle*

In In practice, during the ζ–th window of T [s], both positioning data and Internet scans are acquired simultaneously. So, operatively, the total number of K scans is equal to the number Z^{ζ} of the positioning data. Among the locations considered in the decision process, whose definitions

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(i.e., centre, radius and, if available on the reference DB, TP) are known a priori.

During a (sliding) window of T [s], a S^k matrix is obtained. Given the TP (F^l) of a generic location l available in the reference DB, the set of Common Access Points (CAPs), in terms of APs' *MAC Address*, between the sets $col_l\ S^k$ and F^l, is a set represented by their intersection. Expressed as:

$$\Pi^{lk} = \{ F^l \cap col_l\ S^k \} \qquad (2)$$

Whose t-th element is π_t^{lk} and its cardinality is $card(\Pi^{lk})$.

Thus, for each k-th scan and l-th location ,whose TP is available, a match score value is ξ^{lk} computed by using the following equation:

$$\xi^{lk} = \sum_{t=1}^{card(\pi)} \hat{W}^k \left(\Omega(col_l S^k, \pi_t^{lk}),\ \Omega(F^l, \pi_t^{lk}) \right) \qquad (3)$$

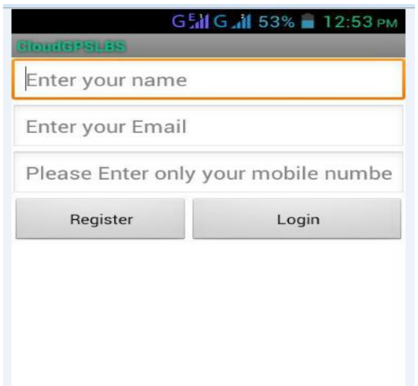
Where functions $\Omega(.,.)$ and $\hat{W}^k(.,.)$ are defined as in [1]. Considering (3), the value of the match score is directly proportional to the number of CAPs. This is coherent with the fact that the more APs are in common among scans, the higher the matching value is. Considering that a time window of T [s] contains Z^ζ scans, when the window finishes and the location recognition process ends, the considered overall match score value, for a given location l, is:

$$\xi^l = \frac{1}{Z^\zeta} \sum_{k=1}^{Z^\zeta} \xi^{lk}, \forall k \in [1, Z^\zeta] \qquad (4)$$

In order to decide in which location the Smartphone is located, the location(s) with match score(s) above a given threshold γ_ξ is selected. This approach, on one hand, avoids considering locations with very low match score values but, in the same time, implies the possible physical overlapping of locations. If γ_ξ is too low then the procedure cannot distinguish the location(s) where the Smartphone is among all the considered ones. On the contrary a too high γ_ξ often does not allow recognizing any location. Practical experiments have shown that $\gamma_\xi = 0.1$ is a good trade-off.

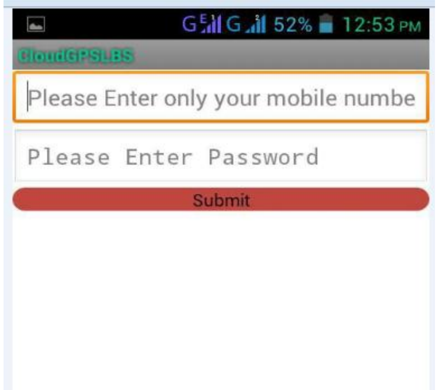
V. RESULTS AND DISCUSSION

1) User Registration Window:



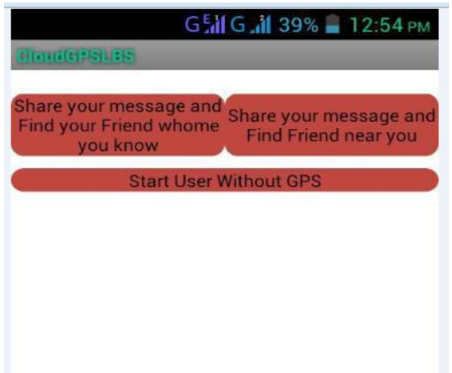
This window shows If the user is using the app for the first time the user should get registered for the platform with an user name, email-id and phone number.

2) User Login Window:



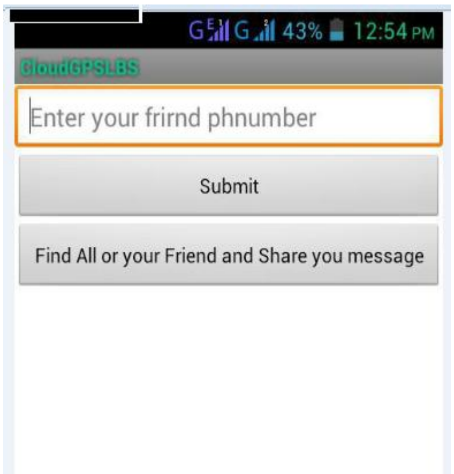
After successful Registration user can login by using phone number and password. If the credentials are True then user can access the application.

3) Find location using GPS or without GPS Window:



This window helps both GPS users aswell as without GPS users to find and share the message to other users.

4) Find Friends and Share Message Window:



This window helps to find the location of friends, who using this application by entering their phone number and also allows to find the users who are near based on range selection[m].

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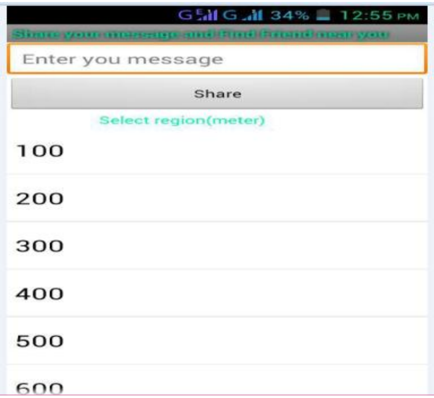
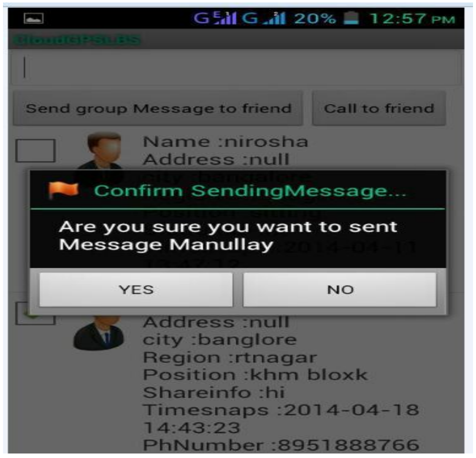
5) Location Recognition based on Range selection:



This window helps user to find the friends location even though they are not in their contact list, based on range[m] instead of finding only preloaded user location.

6) Manually Sending message window:



This window asks if the user wants to send message manually. If No default message containing status " I am in danger I need help please follow my location" along with location details will be sent to preloaded users as well as to the users who are near to that location, based on range [m].

VI. CONCLUSION

The paper introduces a Check-In Application using Location Recognition algorithm for Automatic Check-In applications called LRACI. It is implemented over Smartphones and integrated in the Cloud Computing platform so represents a service for Cloud end-users. The proposed Location Recognition approach is based on the joint exploitation of GPS positioning information, corrected by sliding window filtering (ECF), and of a novel Internet TouchPoint (TP) definition. The proposed TP definition is independent of the Received Signal Strengths (RSSs) measured absolute values as it considers only the order relation among them. As a result, the proposed method, tested through real experiments, in heterogeneous Smartphone platforms, which senses different AP RSS values from the same positions and orientations, without any impact on the location recognition accuracy which is about 90%.

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