Buddy-Finder: a Proposal for a Novel Entertainment Application for GSM

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***Abstract*—Since the first deployment of cellular phones, we have witnessed an almost global revolution in the development of wireless communication. This success has been evident for the GSM technology, whose popularity has exploded during the 1990s thanks to its affordable price, digital quality and a pervasive innovative application as SMS. However, the same positive conditions seems to lack in the next generations of wireless communication, as UMTS, thus slowing down their market penetration. Therefore, both mature and recent mobile technology could benefit from the introduction of a novel application able to shake the market. To this aim, mobile location could be used to facilitate the diffusion of many novel services for cellular systems. We present in this paper, an innovative location based application that involves only a minor impact on the current GSM architecture, while offering to customers an appealing means to obtain multimedia entertainment.**

Keywords-GSM, mobile service, entertainment application, location based service

I. INTRODUCTION

The Global System for Mobile communication (GSM) has been deployed and exponentially grown during the 1990s. Its evident success has been determined by the co-existence of diverse boosting factors: the positive trend in the western world economy of those years, the transition from analogical to digital technologies, the introduction of pre-paid cards and the Short Message System (SMS) technology. This last element, in particular, immediately encountered an enormous success, becoming a real *killer application* for the market of mobile telephony. Indeed, the presence of an exclusive killer application is a decisive factor that represents a fundamental element in the attempt of altering the trajectory of the market, thus determining the success of a new technology. Customers are pushed to massively buy, and then use, new objects or services only if they feel that the need of those items sensibly surpasses their cost. In this context, we do not have to forget that the "need" of a product can origin both from usefulness and from amusement.

Recent rumors about Toothing practice revealed the high receptivity of the customers toward novel applications that involve both amusement and communication, in a word, *entertainment*, at a competitive cost [1]. By exploiting the Bluetooth technology available on their cellular phones or PDAs, users are able to chat with strangers within the distance delimited by the power of the signal. Originated in the London Tube, Toothing phenomena is now scaling the world, as demonstrated by the ever increasing number of Web sites and Blogs, all over the globe, dedicated to it.

In this paper we present a novel application that enables users in discovering the eventual presence of *Buddies* around them. With the term "Buddy" we intend each other subscriber registered in the electronic index book of the user's mobile device. Without any loss of generality, we can think that Buddies are all those friends whom cellular phone numbers we are storing in the memory of our mobile.

This application could be used by a customer for several purposes. For instance, when she/he is waiting alone to take a train and would like to know whether there are any friends of her/him in the same train station, in order to eventually do the trip together. Another example is represented by the case in which a customer is in a crowded place (e.g., a club, a stadium, a pub, a party, a beach, a manifestation, a concert, a vacation resort, etc.) and she/he wants to be aware of the presence of some friends of her/him. This will can origin from feeling bored, or being alone, or simply because "the more we are, the funnier it is". After having had the appropriate information, the customer can contact her/his friends and reach them. Of course, the proposed system should provide appropriate privacy mechanisms that enable users to be invisible to some other customers.

Being in group is a natural social way that people pursue to have fun and entertainment. An application able to find friends at a walk distance can thus be considered an appealing entertainment application. After the first contact, customers can launch multimedia tools in order to communicate or to share an experience (e.g., they could comment on the ongoing same event they are attending: a concert, a game, etc.). This communication could occur by voice, by text messages, exchanging pictures and videos, or by a combination of various media, only depending on the capabilities of the involved devices. The important thing, however, is to have found a common base on which establishing a connection of interests: the awareness of being in proximity of each other.

We strongly believe that this application, from now on named *Buddy-Finder* (BF), is endowed with all the characteristics to attract a very large number of customers, thus factually representing a novel killer application for the market, at the same level of SMS.

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The main contribution of this work is hence represented by the ideation of the BF and by the discussion of the main characteristics and functionalities that it needs to possess. Moreover, since the wide diffusion of GSM cellular phones, we have decided to start from this architecture to design a possible implementation of the BF. To this aim, we have exploited some features already present in the current GSM architecture in order to devise the simplest and most efficient way to integrate the BF application in the current state of the art.

In the following Section we present a general overview of the GSM architecture in order to be familiar with its various functional elements and with their scopes. Section III discusses the most important methods to locate a mobile. The BF application and its functionalities are explained in Section IV, while in Section V we illustrate the involvement required at the GSM architecture to put BF into practice. Section VI concludes this paper with some comments and proposals for future works.

II. GSM Architecture Overview

In this Section we present a brief description of the GSM architecture and its main functionalities. Our scope here is not that of explaining in detail this technology, but rather to introduce the principal components and functionalities, in order to understand the impact of our proposed application on the current state of the art.

The GSM system is composed by several entities which can be grouped into four broad parts as shown by Fig. 1 [2]:

- Mobile Station (MS): the user's mobile host.
- Base Station Subsystem (BSS): it manages the wireless communication with the MS.
- Network SubSystem (NSS): it controls the connection among the users in the same communication system and those with users belonging to other, wired or wireless, communication systems.
- Operation and Support Subsystem (OSS): it guarantees the correct functioning of the communication system.

The interconnection among the diverse functional entities is ensured by the means of specific standard interfaces [3].

The customer has access to the GSM services through a terminal called the Mobile Equipment (ME) and a smart card called the Subscriber Identity Module (SIM). The SIM is decoupled from the ME, and by plugging the SIM in another terminal, the user receives the calls on the new one. Each ME is uniquely identified by a 15 digits code named International Mobile Equipment Identity (IMEI) [4]. The SIM card contains, among the other information, the International Mobile Subscriber Identity (IMSI) that uniquely identifies the subscriber to the system.

The BSS is composed of several Base Transceiver Stations (BTS) and each one controls a certain area of the territory called *cell* by the means of a radio transceiver. The BTSs are divided into groups managed by a Base Station Controller (BSC). The BSCs also handle the handovers (when a MS moves from a cell to another one) and the connection between the MS and the Mobile Service Switching Center (MSC) [5].

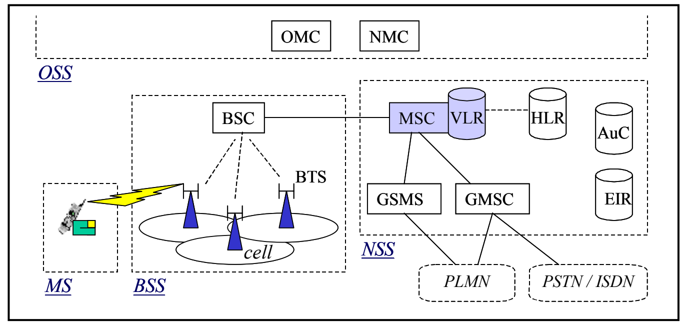

Figure 1. GSM Architecture.

The MSC is the core component of the NSS and manages the starting of the calls, the authentication procedures, the charging of the customers and the routing of the calls to the right MS or to a fixed phone. In this latter case, the communication occurs through the Public State Telephony Network (PSTN) or the Integrated Services Digital Network. (ISDN). The Gateway Mobile Switching Center (GMSC) receives and forwards the calls coming from other phone call providers (wired and wireless), while the Gateway Short Message Service (GSMS) takes charge of receiving and delivering the SMSs between MSs. The Home Location Register (HLR) and the Visitor Location Register (VLR), represent two databases exploited by the MSCs to discover the routing for the calls and the roaming capability [6, 7]. The HLR contains the administrative information about every subscriber and the current location of the corresponding MS. Each MSC controls one or more BSCs, supported in this by an associated VLR. In fact, VLRs provide selected information, from the HLR, regarding the geographical area they are responsible for. The NSS also comprises the Authentication Center (AuC) and the Equipment Identity Register (EIR), which are other two databases utilized for authentication and encryption; the former stores a copy of all the valid IMSIs while the latter contains a list of all the valid IMEIs.

Finally, the OSS includes various Operation and Maintenance Centers (OMCs) that monitor the correct functioning of the GSM network, and a Network Management Center (NMC) that controls all the OMCs.

III. Location Discovery Techniques

Developing a location based application for mobile phones over a GSM network could be done by exploiting a plethora of techniques [8]. The most interesting location methods are described here in follow.

The effortless way to obtain indications about the localization of a MS is to rely on the discovery of the hosting cell. Each cell, in fact, is uniquely identified by a *Cell ID* that corresponds to a single BTS. Having this information and knowing the position of the BTS, it is possible to have a rough localization of the MS by approximating its location with the BTS coordinates. Therefore, the error in the measurement depends on the geographical area covered by the referring BTS, which can vary from tens of meters in urban areas to kilometers in rural ones.

Signal strength and triangulation techniques could be coupled with the preceding one to enhance the accuracy of the measurement. In fact, analyzing the strength of the signals received by three diverse BTS and knowing the signal level at the sources, it is possible to calculate the position of the MS as the intersection of three circumferences having in the considered BTSs their centers. On the other hand, this scheme requires that all the signals follow the same uniform attenuation law. It assumes to have a two-dimensional geometry, omnidirectional BS antennas and absence of obstacles. This is obviously almost impossible in an urban scenario.

The computation of the signal Time of Arrival (TOA), represents another localization method which makes use of triangulation. In particular, commercial systems exploit a slightly modified scheme that is based on time differences rather than on absolute values. This scheme is named Time Difference of Arrival (TDOA) technique [9]. Unfortunately, these methods requires phones to be active, thus needing a forced handover to exit the eventual idle state. For this reason, such solutions would imply consistent modifications to the current hardware and software.

The Angle of Arrival (AOA) method is based on the computation of the angle between the imaginary line connecting the MS with a BTS, and a referring axis (antenna array) [10]. Utilizing at least two BTSs, it is possible to determine the position of the MS as the intersection of those imaginary lines. Moreover, AOA can be coupled with TOA to create a hybrid scheme that requires a minimum of just one BTS equipped with an antenna array [11]. Even if these two schemes have been developed by several companies to endow mobile phones with the Enhanced 911 (E911) American emergency wireless service, they still require expensive antenna arrays diffusion at BSs [12, 13]. Nonetheless, the accuracy of the AOA and of the hybrid methods depends on the number of measurements that can be done and on line-of-sight propagation conditions.

Database Correlation Method (DCM) is based on collecting signal information in a database [14]. The stored samples, named *fingerprints*, generally represent the strength and the time delay of the various signals. When the location service is required, the current fingerprint of the signal is compared with those stored in the database to discover the position of the MS. Clearly, this method needs to have distributed servers able to process all the requests in a reasonable time.

Finally, a popular and widely commercialized mechanism to compute the position is represented by the Global Positioning System (GPS). GPS is a Satellite Navigation System able to compute the coordinates of a device with a very high accuracy of the measurement. On the other hand, GPS is not available in all mobile devices; indeed, this method requires the integration of a specific GPS hardware component.

IV. BUDDY-FINDER: THE USER'S PERSPECTIVE

BF could be implemented on diverse devices also exploiting different communication technologies. In this work, we have focused our attention on the most diffused mobile communication system available: the GSM network. We are foreseeing a scenario having millions of GSM subscribers running the BF application from their mobile phones. In this context, BF can be run by a customer looking for her/his Buddies in the surrounding area and having their MSs turned on. Only in this latter case, in fact, the GSM network can localize a MS, with the mechanism explained in Section V.

When a user wants to find her/his Buddies, she/he sends a request for the BF service to a specific number. This request may be in the form of a simple SMS containing the phone numbers of the MSs whose proximity the customer intends to verify. After a while the system will respond to the user forwarding her/him a SMS message containing the numbers (or other identifications) of her/his Buddies who are in the neighborhood and are permitting the user to discover them.

The will of the Buddy to be "seen" is a very important part of this system. Each subscriber, in fact, should be able to decide, for each of her/his buddies, whether to be seen or not. Moreover, she/he should be able to change in every moment this constraint. This can be attained in three ways whose technical details will be further explained in Section V: i) via SMS exchange with the Buddy; ii) by the means of a control signal that produces a real time request on the Buddy's MS; iii) allowing the subscriber to use a user interface to set in advance their preferences. Examples for the three cases are shown in Fig. 2. However, case iii) should be preferred since the customer receives a prompt automatic response from the Buddy's MS, instead of waiting for a human answer. In cases i) and ii), in fact, if the Buddy does not notice immediately the BF request, she/he could involuntary delay the answer, thus forwarding a response too late for being still useful.

Each time a customers find her/his Buddies, she/he will most likely start one or more connections which could involve text messages, voice communication, videos, or any other multimedia tools available on the utilized mobile devices. Since these communications among Buddies represent further traffic generated only by the awareness of proximity offered by the BF application, and since the phone call providers charge for those multimedia services, we can say that BF is able to satisfy an entertainment need of customers and, at the same time, to produce income for the phone call providers. A smart strategic decision would thus be that of stimulating the use of this application by avoiding to charge the customers for utilizing it.

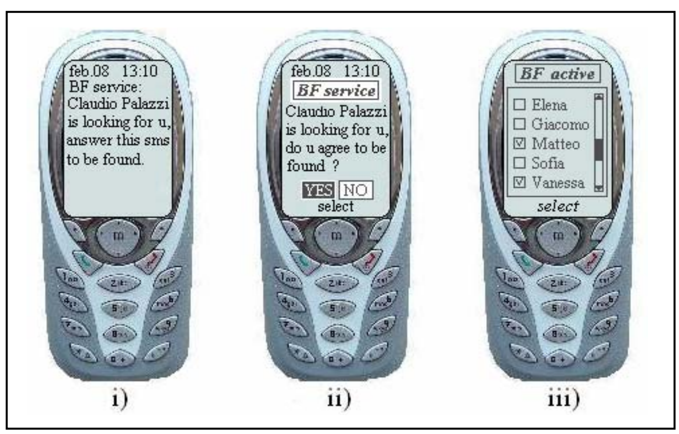

Figure 2. Three possible privacy handling tools for BF.

V. BUDDY-FINDER IN THE GSM ARCHITECTURE

In order to really deploy the BF scheme in a pre-existing and widely utilized architecture as GMS, we have to be able to integrate the novel application with as less modifications as possible to the current state of the art. This can be done by exploiting the information already present in the GSM architecture and relaxing the accuracy prerequisite in the localization scheme, as well as the other general requirements for location systems listed in [15].

The information about a MS eventually activating the BF, in fact, is stored in the VLR associated with the BSC hosting it. As well, the same VLR also contains the identifications and the connected BTS codes of each MS located in the same BSC and, thereby, even of the customer's Buddies eventually present. Moreover, the scope of our proposed application does not necessitate a precise localization of any MS, but it simply has to provide a rough concept of proximity between Buddies. To this aim, being in the same cell can be considered a sufficient condition to determine whether two Buddies are close to each other. This also helps us in avoiding the burden of complicated schemes, as those analyzed in Section III, which are required in case of looking for a precise localization.

The contemporary presence of a Buddy in a cell could be easily found by checking, in the VLR, whether the Buddy's MS is associated with the code of the BTS controlling the considered cell. Discovering even those Buddies that are located in the neighboring cells, only requires to take into consideration also those codes which refer to the adjacent BTSs. In order to minimize the impact on the ME software to run the BF application, we suggest that those adjacent BTS codes would be determined by the referring MSC. However, an alternative approach could be that of having those codes directly provided by the MS. The MS, in fact, in order to always utilize the best channel available, periodically measures and stores the signal received from the various BTSs around.

In essence, the scheme could work as follows. When the customer sends the SMS request for the BF service, the destination number corresponds to the specific BF service hosted at each MSC. The MSC verifies, in its associated VLR, which of the phone numbers listed in the SMS are located in the same cell, or in adjacent cells, of the requesting MS. At this point, the MSC has to determine the will of each Buddy in being discovered by the BF initiating customer. As already introduced in Section IV, this can be attained in three ways. A first possibility is that the MSC forwards a request via SMS to the Buddy and then waits for an eventual positive answer, again via SMS, as depicted by case i) in Section IV and Fig. 2. Case ii) in Section IV and Fig. 2 suggests an alternative possibility. The MSC could forward a request via control signal to the Buddy, which MS is endowed with the capability of receiving and interpreting these requests and propose them to the evaluation and decision by its human owner. Finally, case iii) in Section IV and Fig. 2 requires that the Buddy's MS would be endowed with a graphical interface allowing her/him to instantaneously change her/his status from *visible* to *invisible* respectfully to each of the phone numbers (or any other identifier) registered in her/his index book.

The MSC also takes charge of collecting the visible Buddies in a SMS that is then sent back to the customer who has executed the BF application on her/his MS.

VI. CONCLUSIONS AND FUTURE WORKS

In this paper we have presented BF: a proposal for a novel location based application for mobile devices. Its simplicity and attractiveness could make BF a very popular entertainment tool, also potentially able to boost up the utilization of the various multimedia services available on modern mobile devices. We have shown how BF may work, both from a user's point of view and from a GSM network standpoint. The almost effortless impact on the current GSM architecture has been highlighted. Moreover, the concept of a rough proximity employed by the application, as a relaxed location requirement, allowed us in avoiding complex and computationally heavy algorithms for an accurate position discovery.

Possible extensions of this work include, of course, the creation of a prototype; this, however, requires the participation of some GSM provider allowing us to utilize its antennas and functional entities (i.e. BSCs, MSCs, VLRs). Finally, further works may regard the applicability of the BF scheme on other mobile architectures (e.g., UMTS, Wi-Fi, Bluetooth, etc.).

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