Bfriend: Context-Aware Ad-Hoc Social Networking for Mobile Users

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Abstract - Ad-hoc social networking provides a goal-oriented platform for vibrant communication and value-added interaction among users. Through managing user social relationships in a novel fashion based on establishment of temporary social relationships among users with mutual interest or need, ad-hoc social networks provide an innovative medium for upgrading existing, as well as developing new social relationships. This paper proposes the Bfriend, a location-aware ad-hoc social networking platform based on the Facebook social graph. The Bfriend platform is used by mobile users equipped with a smartphone - after users install and activate the Bfriend client application, they are able to receive push notifications when a certain rule is triggered (e.g., it is Friday evening, Ewan and Luke are drinking beer in a bar and one of their female Facebook friends passes nearby). The proof-of-concept application is available for users possessing Android-based smartphones.

I. INTRODUCTION

Ad-hoc social networks [1][2] provide an alternative, temporary and goal-oriented medium for communication and interaction among users. This kind of social networks represents an innovative platform for handling ego-user current social relationships, as well as provides an effective solution for developing new social relationships.

For example, imagine a person walking downtown. Let us assume that this person is not moving very fast (e.g. is on a bicycle or by foot) nor is moving in an unpredictable manner. This person is shopping, which deems her available to others for social interaction. Indeed, this person has some of their friends close by, which is where Bfriend kicks in. Bfriend is a context-aware ad-hoc social networking platform which gives its users the ability to receive notifications when one of their Facebook friends passes nearby. Both parties get notified as soon as they approach each other close enough to meet each other. This distance is 100 meters by default, assuming that people do find this distance satisfying for meeting somebody who is their friend. In practice, this could be proven useful in cities, where such distance is appropriate for the "same place, same time" principle (see section 3) [3].

This paper is organized as follows. In the Section 2, related work gives an overview of what has already been done in the area of location-aware ad-hoc social networking. After that, Section3 gives an answer to the question *"what does Bfriend do"*. Afterwards, Sections 4 and 5 give answers to questions *"how does Bfriend work"* and *"what does Bfriend have to offer to end-users"*. Finally, Section 6 concludes the paper and gives an overview of the planned future work.

II. RELATED WORK

To begin with, one should grasp at the main keywords used throughout his paper.

Definition of a *context* is given by Dey in [4][5][6] – "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves". Therefore, a context-aware system is "a system that uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". *Mobile users* are nowadays accompanied by their mobile devices, usually smartphones. In February 2012, the biggest *social network* Facebook has had 845 million active users, out of which more than half (425 million) are mobile [7][8][9]. Clearly, the ability to go mobile gives social networks an advantage when it comes to usability and popularity among users. In terms of context-awareness, this enables context information such as ego-user's location, friends' locations, friends of friends' locations, etc.

Facebook Places service is a good example of a well-known service related to the Bfriend system. Facebook is the largest social media website and has a huge amount of users, as already mentioned. In the summer of 2010 Facebook announced a new feature, namely a location based service, called Facebook Places. The idea is that a user can share his or her location by using their smartphone's GPS (*Global Positioning System*) data. This is useful if one tries to find friends using the same service for a night out in town, brag about attending a concert, having a dinner in a restaurant or such [10]. In May 2011, Places already had 1.8 million check-ins globally per day [11].

Other similar services are *Foursquare* [12], *Gowalla* [13], *Brightkite* [14], *Google Latitude* [15] and *Skout* [16], just to name a few. These services give the user an opportunity to keep in touch with friends using location-based data. While Facebook Places has not really invented anything new, the key to its success is the amount of users

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already on Facebook before Places entered the business. An average user might not be interested in a location-based Facebook service if he or she has never heard about it or even more important – none of his or her friends use it. Google Latitude is a location-aware mobile application which uses well-known and widely-used Google accounts for accessing it. It enables users to see locations of their friends (other users of Latitude) and to publish their own location as well. Google expanded the service in late 2009, enabling historical view of previous locations plus some other features on which the user was willing to agree upon. Google Latitude got its own API (*Application Programming Interface*) in May 2010, which enables access to stored user information with explicit user's consent. The main difference between Google Latitude and Bfriend is that the latter gives users an option to control their availability status (i.e. presence) just like IM (*Instant Messaging*) services do. On the other hand, Latitude enables users to publish their current location, while Bfriend does not allow explicit insight into anyone's location, but rather notifies in case of spatial proximity. Moreover, Bfriend application works in the background and requires minimal user input to operate.

It is the context-awareness that those services have in common, making them stand out from other mobile or social services. The context-awareness within the Bfriend system includes:

- *Social context* – i) ego-user's friends; and ii) ego-user's presence information;
- *Geolocation context*;
- *Temporal context*.

III. BFRIEND MODEL – SAME PLACE, SAME TIME

Context information is necessary and crucial for new social interactions and connections. In Figure 1. the referent *Person A* is cycling down the street, going to meet his/her *Friend B* and *Friend C*, who are already at the bar. *Person A* does not know exactly where they are, so he/she decides to try out his/her luck. Soon after, if all three of them were *Online* on Bfriend, they would receive a notification saying that they are close to each other, giving them the ability to meet at the same bar. It is all about being in the same place, at the same time.

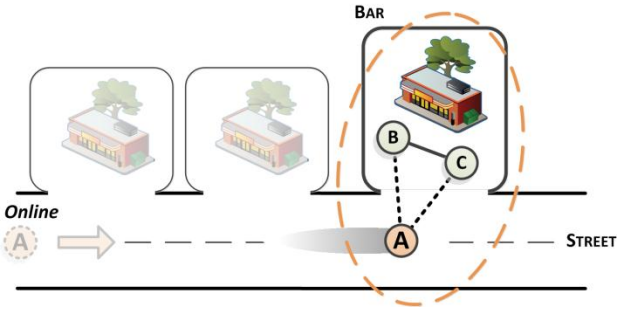


Figure 1. Social, geolocation and temporal information as a context

Bfriend model is based on a social graph, which can effectively be used to describe social connections. First, Bfriend uses the Facebook graph as a starting point. In Figure 2. referent *Person A* is a friend with *Person B* and *Person C* on Facebook. What happens next is that they end up being in the same place at the same time (i.e. context information includes gelocation and time). Besides *Person B* and *Person C*, *Person D* is also in company of ego-user *Person A*. *Person D* is a friend of the *Person C* which makes him/her a friend-of-a-friend for the referent *Person A*. *Person A* and *Person D* interact with each other and find out that their application Bfriend "sees" them as friend-of-a-friend to one another. The same could be said for *Person B* and *Person D*, as well. This allows them (pair *Person A* and *Person D*, as well as pair *Person B* and *Person D*) to connect and become friends on Facebook just by being in the same place, at the same time, while having mutual direct friends on Facebook.

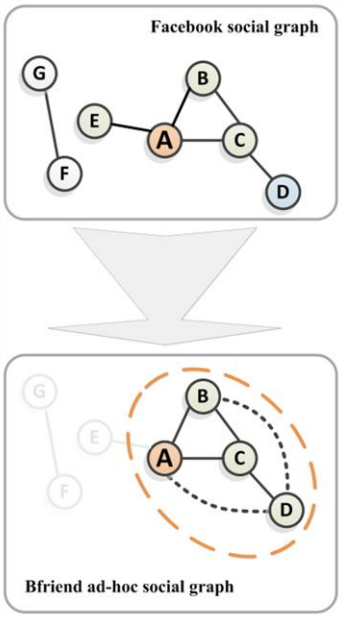


Figure 2. A social graph translation from Facebook to Bfriend

IV. BFRIEND SYSTEM ARCHITECTURE

Bfriend system is based on client-server architecture and consists of three types of servers and a thin client [17], as shown in Figure 3. A *central server* holds all the logics and computing algorithms for the Bfriend application. It is connected to a database in which the user data and social graph (connections between users) are stored. The central server connects to the *Facebook server* (using Facebook Graph API) for retrieving friend lists for Bfriend users. Prior to that, the user has to grant access to his private data on Facebook, hence the connection between the two. Push service is utilized through *Xtify*[1] *servers*, which enable notification delivery. Push servers are used solely to deliver content; the content itself is generated by the central server that sends the data towards push servers to complete the delivery. Push server needs to know where to send the content; therefore it has to have its own internal tracking of Bfriend users (their IP (*Internet Protocol*) addresses, to be precise).

A communication in the Bfriend system is quite complex, as shown in Figure 3. as well. First, there is the communication with Facebook Graph API which dedicates a unique Facebook ID for the user, after which

[1]Xtify (www.xtify.com) is a company that developed push-servers for smartphone-based content delivery.

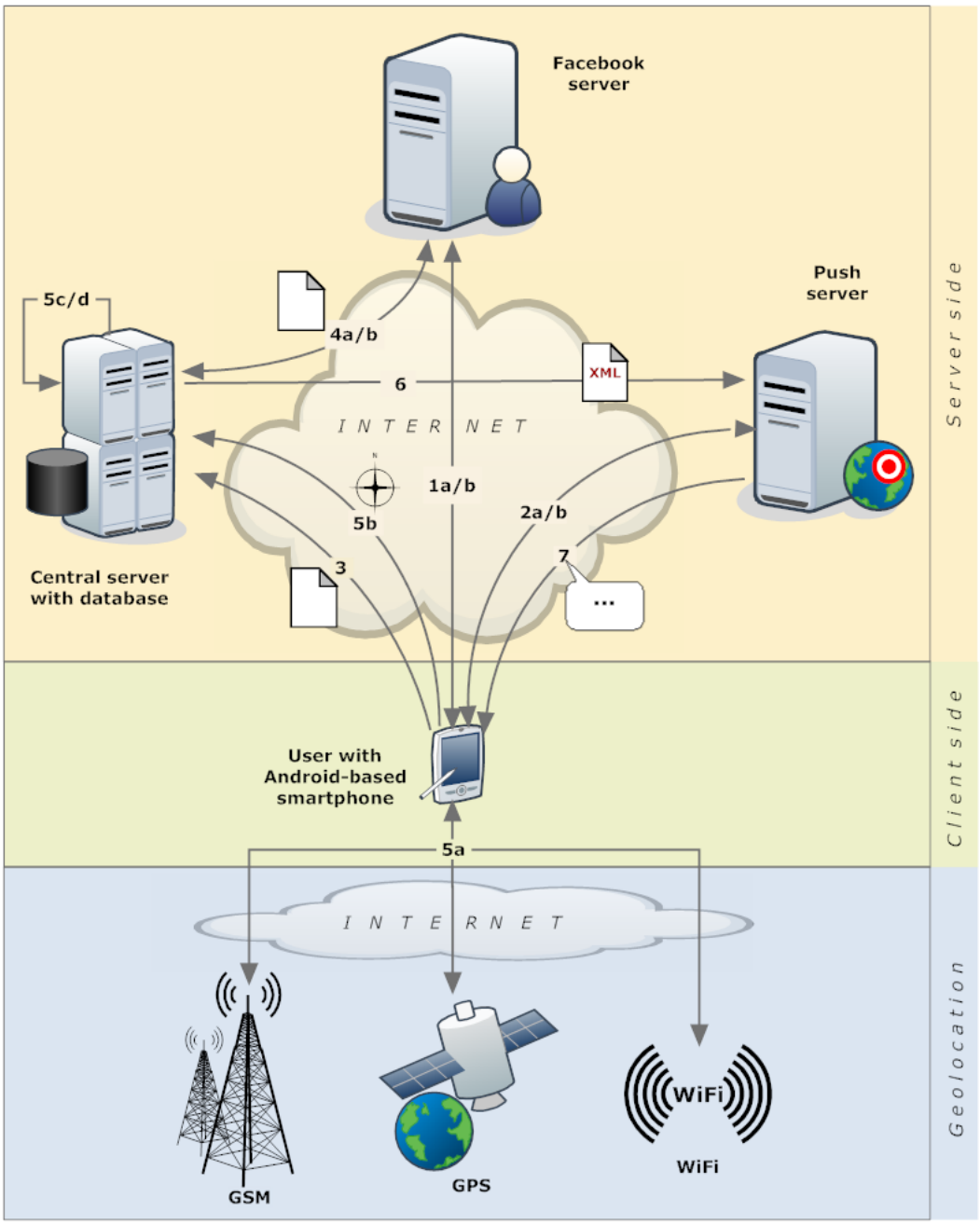


Figure 3. Bfriend system: an architecture and communication

the user has to allow access to his or her personal data on Facebook (*steps 1a, 1b*). Next is the communication with the push server for retrieving an Xtify ID (*steps 2a, 2b*). This is necessary in order to be identified by that server for notification delivery later on (*step 7*). The initialization process of the Bfriend applications begins with the *step 3*, in which the user's device sends initial data (i.e. Facebook ID an Xtify ID), so that the central server can bring those in correlation with the user. After the initialization step, the central server can proceed with algorithms – refreshing user's friends list (*step 5d*) by retrieving the data from Facebook (*steps 4a, 4b*) and periodically calculating the distances between Bfriend (i.e. Facebook) friends to be aware of any spatial proximity that triggers notifications between them (*step 5c*). In the meantime, for the central server to have the latest geolocation of each user – user's devices have to periodically check for their current location and send that data to the central server (*step 5b*). This is done by means of GSM (*Global System for Mobile Communications*), GPS or WiFi, all of which provide different degrees of precision for retrieving user's current location (*step 5a*) [18]. When two or more users are close to each other (e.g. within 100 meters), distance calculation algorithm (*step 5c*) triggers the server to generate an XML (*Extensible Markup Language*) document with a notification's content. Figure 4. presents a flowchart which describes the algorithm that calculates the distances between friends in the Bfriend social network periodically, every 60 seconds. The XML document generated in *step 5c* is sent to the push server (*step 6*) which delivers the content to the target user in a form of the notification (*step 7*).

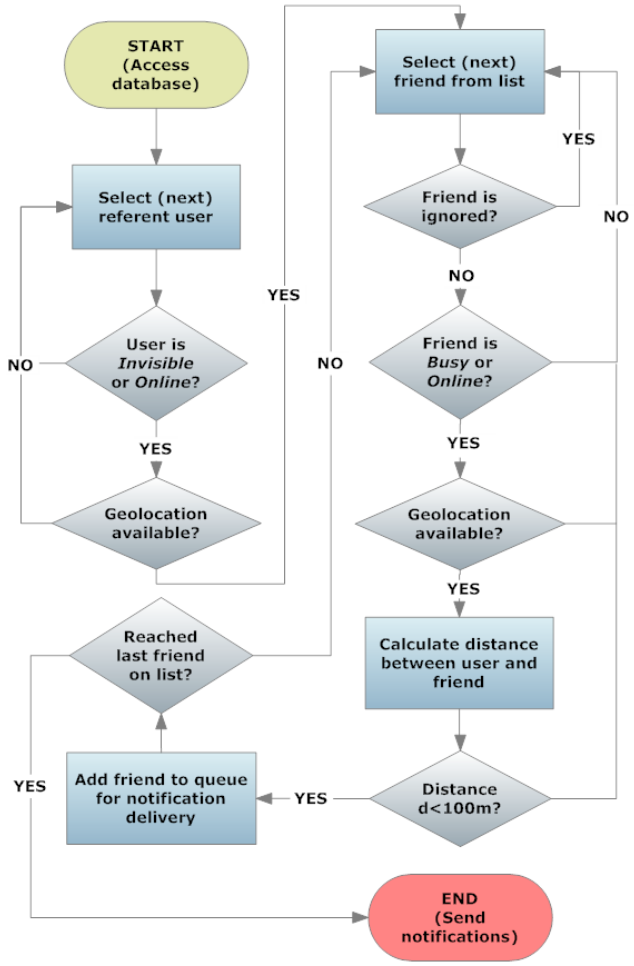


Figure 4. A flowchart of the distance-calculating algorithm

V. PROOF-OF-CONCEPT FOR BFRIEND PLATFORM

In order to use the Bfriend service, one should have an active Facebook account, a smartphone with an available Internet connection and Bfriend application installed. The application is available for Android OS (*Operating System*), using screen notifications for content delivery.

A. *Bfriend application for Android OS*

Figure 5. presents a screenshot of a Facebook login form when a user starts the Bfriend application for a first time.

Figure 5. Facebook login form in the Bfriend application

After logging in, the user is prompted to allow Bfriend to access his/her basic information on Facebook social network (Figure 6.).

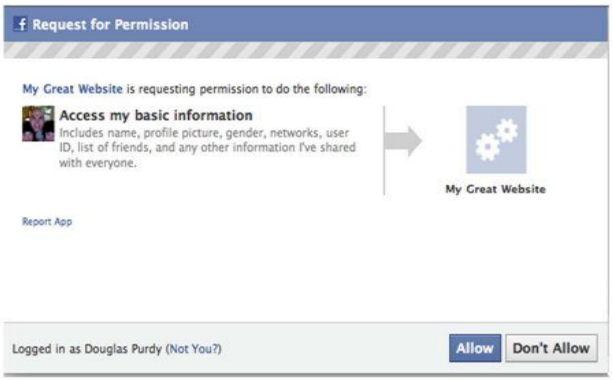
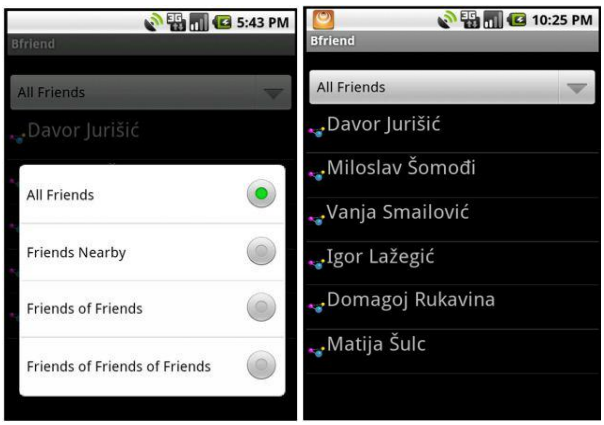


Figure 6. Bfriend request for accessing ego-user's info on Facebook

By allowing access, user gets the following options (Figure 7. a):

- view *All friends* list on Bfriend;
- view *Friends Nearby* list on Bfriend;
- view *Friends-of-friends* list on Bfriend;
- view *Friends-of-friends-of-friends* on Bfriend.

The *All Friends* option is not context-aware and thus shows all of the ego-user's friends, i.e. Bfriend and Facebook friends (Figure 7. b). *Friends Nearby* shows friends within a given distance (the default is 100 meters), which makes it context-aware. *Friends-of-friends* and *Friends-of-friends-of-friends* lists are similar context-aware lists of people that are two and three degrees away from the ego-user, respectively.



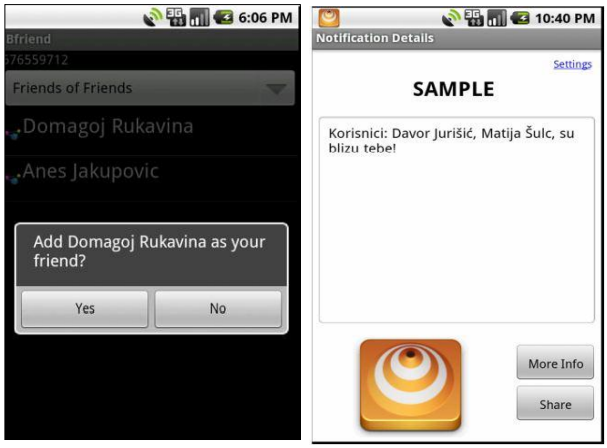
a) b)

Figure 7. a) Bfriend application home screen; b) The *All Friends* list

In case the ego-user wants to add some new friends from Friends-of-friends or Friends-of-friends-of-friends list in the Bfriend application, he or she can do so easily. After adding a friend in Bfriend application, user is prompted to do the same on his/her Facebook page as well, to keep his/her social connections up to date[2] (Figure

[2]At the time of writing this paper (Jan 2012), Facebook API did not allow this process to be automated, but instead demanded explicit user action.

8. a). Finally, in case the user has one or more friends nearby and has a presence value set to *Online* or *Invisible*, he or she will get notified as it can be seen in Figure 8. b). Only friends that are not on the *Ignore List* (i.e. they are not ignored when in the ad-hoc network) are stated in the notification.



a) b)

Figure 8. a) Adding a new friend through Bfriend; b) Example of a notification alerting about three friends nearby

B. User presence

There are four presence states supported by the Bfriend – *Available*, *Busy*, *Invisible* and *Offline*. These are important to acknowledge as they represent a significant and distinctive feature of the Bfriend system. TABLE I. describes presence states in more details.

TABLE I. USER PRESENCE

Presence	User visible to others in the network	Notifications can be delivered to the user
Online	Yes	Yes
Busy	Yes	No
Invisible	No	Yes
Offline	No	No

C. Prerequisites to usage scenarios

User scenarios described below have certain prerequisites. First, the ego-user should be logged into the Bfriend application from his Android-based smartphone. In order to achieve this, ego-user has to have an active Facebook account that enables Bfriend system to access described private data about the ego-user.

D. Common usage and basic functionality

"Let us say a student named Ewan is sitting in the classroom, listening to the introductory lesson of a certain subject. He was hoping that his friend Luke would be in the same group as him, but he is not there. During the break, as he is walking to the cafeteria, he receives a notification on his smartphone saying that his friend Luke is at the college too, close to his current location. They meet up and discuss changing subject groups in order to attend lessons together."

A typical scenario, such as this one, describes the basic functionality and the main feature of the Bfriend system – informing the ego-user of Facebook friends nearby. The distance which triggers notifications is not great; it is a value of tens of meters or so. Figure 9. shows a use case diagram showing steps of basic functionality.

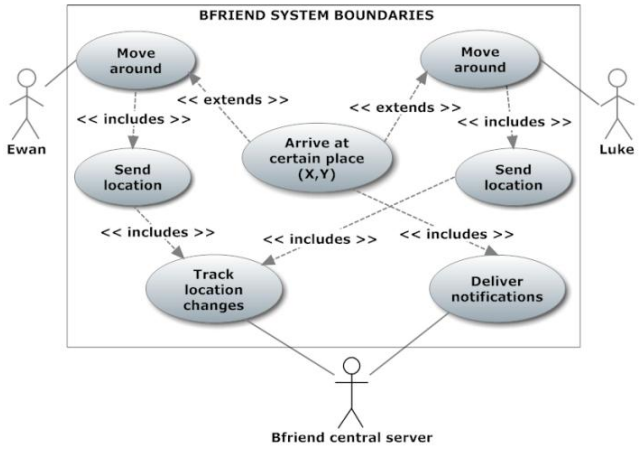


Figure 9. Use case diagram showing basic usage of a Bfriend system

Figure 10. presents a sequence diagram of the scenario describing Bfriend's basic usage. It reveals in what order processes from Figure 9. interact and execute.

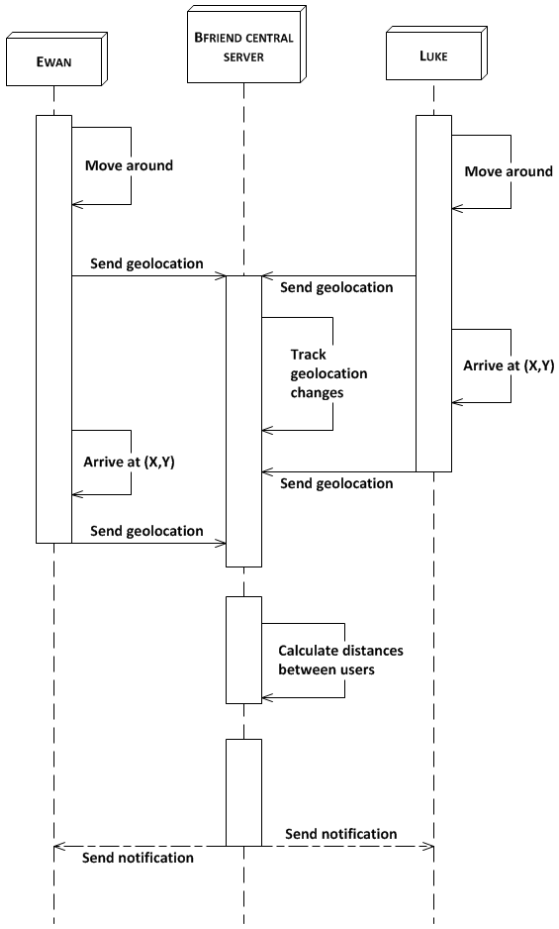


Figure 10. A sequence diagram showing Bfriend's basic usage

E. Advanced Features

"Ewan is walking towards the main square to meet his girlfriend. He sets his availability status to Invisible, as he does not want to be present in the ad-hoc network with his friends but, nevertheless, wants to be aware of other friends nearby. As he passes by the most famous pub in

the city, he receives a group notification saying that five of his friends are close by. On the other hand, his friends did not receive the notification about his proximity as he is invisible in the network. Despite being in a hurry, he decides to drop by just to say hello. On his way out, he quickly checks for friends of friends' names because he did not have much time to meet everybody properly. Maybe he will add them as his direct friends some day."

This example shows advanced functionalities and features Bfriend has to offer. Ewan is invisible throughout the entire scenario and, eventually, uses "friends-of-friends" feature to find out more about people he just met. Similar scenario would include meeting new people in a disco club during a night out (using friends-of-friends feature) or using some other availability statuses (e.g. *Busy*) while attending a business meeting.

F. *In case of emergency*

"Ewan is driving in his car when suddenly he hears on the radio that there has been a traffic accident nearby. At the same time, he receives a notification that his friend Luke is close to his current location. He figures – Luke could be in serious danger. He proceeds to the site to find out that his friend has been injured and is unconscious. The paramedics are already on their way, so Ewan waits there to help them identify Luke and to notice them of any medically relevant information they should be aware of – such as drugs Luke is taking, any diseases he has been treated for, as well as certain allergies he suffers from or possibly his blood group."

In this example, there has been an accident in which emergency services, such as 112, often need some additional information about injured people involved in the accident. Close friends or family are a great source of such information. For more effective means of communicating than using radio transmitted information regarding the accident, dedicated hardware and software could be used instead. Currently, eCall is an example of such project, assisting in traffic accidents by providing additional information prior to sending emergency teams or others to help [19].

VI. CONCLUSION

Advances in ICT (*Information and Communication Technology*) during the last decade have enabled telecom operators and other providers to go mobile with a wide range of services and social networking services are not an exception. Context-awareness, such as being able to pinpoint the user geographically or know whether he or she is at work, in school or just shopping downtown, is critical for dynamic, goal-oriented and temporal approach that ad-hoc social networks assume. Users are no longer satisfied just with "being connected", they need their PC's, laptops and smartphones to be aware of where, when or how they are connected. The Bfriend system makes use of those facts by making them the core user requirements of the service – users create, maintain and end their own, temporary ad-hoc social networks using spatial proximity with their friends as context information.

Future work will include adding more features to the Bfiend service, e.g. implementing a chat service available to users within the ad-hoc network, adding a personalization layer on top of the service (making the experience more personal to the user), raising context-awareness in terms of part of a day (i.e. day or night), giving users the ability to sign-out and sign-in with different Facebook accounts or even viewing map with locations of their friends nearby.

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