

# Privacy-Preserving Context-Aware Friend Discovery Based on Mobile Sensing

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**Abstract**—With the advancement of smart phones, wearable devices and communication technologies, it becomes very convenient to obtain various types of data through mobile sensing, where data can be sensed via embedded sensors, stored, processed, and transmitted to anywhere. Mobile sensing has been studied extensively in both academy and industry, and has been applied in many novel applications in the past few years, such as environment and traffic monitoring and mobile health. In this work, we propose a new application scenario called context-aware friend discovery based on mobile sensing, where contextual attributes such as location, weather and temperature are utilized to enhance the existing friend discovery schemes. However, data privacy becomes a major concern for consumers to accept this application. To address this issue, we further propose a privacy-preserving context-aware friend discovery scheme, where a user's sensitive data is well protected. Security analysis shows the correctness and privacy guarantee of the proposed scheme.

**Index Terms**—Mobile Sensing, Cloud Computing, Data Privacy, Friend Discovery

## I. INTRODUCTION

The past few years have seen tremendous development in smart phones, wearable devices, and communication technologies. As devices become smarter, many types of sensors have already been or will be embedded in smart phones and wearable devices, such as *GPS*, accelerometer, gyroscope, digital compass, temperature sensor, image sensor, ambient light sensor, and so on. Also, the storage and computation capabilities of smart phones and wearable devices have been greatly improved. Meanwhile, new communication technologies such as body area network (*BAN*), device-to-device (*D2D*) communication, and long-term evolution (*LTE*) networks provide smart phones and wearable devices better communication capability. As a result, it becomes very convenient to obtain various types of data through mobile sensing, where data can be sensed, collected, stored, processed, and transmitted using smart phones and wearable devices. Mobile sensing has been intensively researched and utilized in many applications [1]–[5]. One big category of mobile sensing-based application is called crowdsensing, where a data requester may collect sensing data from ubiquitous mobile phone users for further aggregation and analysis. Typical applications of crowdsensing include environment and traffic monitoring. Another category of mobile sensing-based application is the mobile health (*mHealth*), where patients may get physiological data via

mobile sensing, and receive timely and convenient healthcare and medicare services at home. Thus, the availability of the limited hospital resources can be greatly enhanced.

In this work, we propose a new mobile sensing-based application scenario called context-aware friend discovery. Friend discovery is a very important social application in modern society, because it can enable people to make new friends, and make the world easier connected. Existing friend discovery applications, such as Facebook and LinkedIn, mainly employ a user's profile (e.g., age, gender, profession, hobbies, etc.) in friend discovery. While the contextual attributes (e.g., real-time location, weather, temperature, etc.) [6] are seldom or not fully utilized. This cannot provide the best friend discovery results. For example, a user Alice may want to find new friends to chat with, and she has the requirement that the potential friends should be about her age, and be close to her current location. Obviously, existing profile-based friend discovery scheme alone cannot meet Alice's needs. Therefore, we propose a context-aware friend discovery scheme taking both a user's profile and real-time contextual data into consideration. Combining both user's profile and context will provide more personalized friend discovery and better user experience.

However, there are serious security and privacy issues in some current mobile sensing-based applications such as [7]–[12]. This is because a user's sensitive data such as location, disease, height, and weight will be transmitted to a third party (for instance, the Cloud) for analysis [7], [9], [10]. As a result, a user's data becomes out of control, and may be used illegally. Therefore, a user will be reluctant to use these applications if their sensitive data cannot be well protected. To address this issue, we further provide an enhanced scheme called privacy-preserving context-aware friend discovery, where each user's data will be encrypted before sending to the Cloud. With the enhanced scheme, a user's data privacy is well preserved throughout the friend discovery period, and no one else will be able to know the user's original data. Meanwhile, the enhanced scheme can still guarantee the functionality of context-aware friend discovery even if a user's data is encrypted.

**Our Contributions:** we summarize our contributions as follows:

- We propose a context-aware friend discovery scheme based on mobile sensing.