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Performance Assessment of Geo-triggering in Small Geo-fences: Accuracy, Reliability, and Battery Drain in Different Tracking Profiles and Trigger Directions

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Abstract

Geo-fencing has been predicted to be a multi-billion dollar market in areas such as retail, ambient intelligence, entertainment, healthcare, etc. Businesses have been adopting geo-fencing technology, and now there are several platform providers such as Google, Qualcomm, Esri, Urban Airship, and others. These tools are continuing to attract application developers; however, best practices for choosing the specific performance options within this technology is still ambiguous. For example, Esri provides a geo-trigger service that allows developers to send targeted messages to users when they enter, exit, or dwell in a geo-fenced area. This service also provides the ability to choose higher levels of accuracy or battery saving by offering different location tracking profiles. This paper investigated two geo-trigger tracking profiles (Fine and Adaptive) to assess their performance in small, outdoor, geo-fenced areas; these two profiles are the most accurate but vary in their battery-use. The results show the Adaptive tracking profile to provide 100% reliability and average accuracy of 68.53 meters in geo-fences between 20-70 meter radii. In addition, the Adaptive tracking profile saved 15.20% battery-life while the user is stationery and 9.23% while the user is moving.

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Keywords: Mobile device; geo-trigger; geo-fencing; accuracy; battery drain; Esri; location-based services; app; iphone; developers.

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1. Introduction

Geo-fencing as defined by ACM SIGSPATIAL GIS Cup 2013 is a virtual perimeter for a real-world geographic area that allows users to receive notifications whenever they enter or exit a specified area; Ravada et al. [2]. Geo-fencing is used in location-based advertisements and child location services; Ravada et al. [2], road safety and gaming; Munson and Gupta [3], and even more critical purposes such as geo-targeted alerts and warnings [9]. The geo-fencing process requires two steps: the "geo-definition of the targeted area" and "geo-delivery of the message to recipients within the targeted area" [9]. According to Zhou et al. and Ravada et al. [1, 2], the geo-definition of the area may be a polygon or a radius around a specified point. One of the common ways to deliver end-to-end geo-targeted notifications' system is through cellular phones which have the capability of location tracking using the Global Positioning System (GPS) or wireless access (Wi-Fi) [9]. However, receiving continuous, accurate, locations using cellular phones results in a tremendous energy cost that reduces the value of locations-based applications; Kim et al. [5].

A number of researchers have attempted to mitigate the problem of battery life loss by reducing the location update that consumes energy, using lower power sensors, or by sharing location information with nearby devices. For example, Huang et al. [11] developed E2A2 location service that detects and groups collocated deceives and use them to represent individual device location. Loyola et al. [4] used an algorithm that reduces the number of requests to the LBS server made by the application thereby saving up to 45% of the battery. Bulut et al. [8] presented a method that utilized the user's speed and distance to the POIs to achieve energy efficient proximity alert for Android phones. Kim et al. [5] introduced SensLoc that "correctly detects 94% of the place visits, tracks 95% of the total travel distance, and still only consumes 13% of energy than algorithms that periodically collect coordinates to provide the same information". Kjærgaard et al. and Bhattacharya et al. [6, 7] also discussed the ability to reduce battery drain compared to other state-of-the-art position tracking systems using the EnTrackedT system. Lin et al. [12] proposed a-Loc that helps reduce mobile devices' battery drain as different degrees of accuracy are required by different locations and subsequently lower energy and lower accuracy tracking methods such as Wi-Fi could be used. One of its goals is to address the accuracy challenge that faces application developers and simplify the use of current and future location technologies. In all these different alternative techniques, accuracy has been a trade-off or a concern.

Commercial offerings have also tried to address this problem [14]. Esri recently introduced geo-trigger services which this paper will assess. This service provides different tracking profiles allowing an application developer to choose the most suitable one for the scenario on hand. However, two issues arise here. First, application developers are not always well informed about the differing accuracy levels a certain tracking profile may offer to a specific pre-defined geo-fence size and may not be informed enough to make an efficient and beneficial decision. Second, the accuracy of the direction dimension, the time at which the trigger should be fired (upon exiting or entering a geo-fence area), has not been tested. Given the fact that some applications cannot sacrifice accuracy, the National Academic of Sciences (2013) discussed the use of geo-targeted alerts and warnings, outlining the research opportunities and associated implementation challenges in this research gap area regarding the use of this new technology. Some of the questions that arose were: "How can new technologies developed by the private sector be adapted quickly and effectively for delivering geo-targeted alerts and warnings? What is the role of the third-party developers (e.g., smartphone applications) in delivering geo-targeted alerts and warnings?"[9]. Munson and Gupta [3] stated that Location-Based Notifications systems should offer the ability to precisely locate users, define geo-fences, and detect entrance to geo-fences in short time periods. The objective of this study was to assess geo-trigger services in small geo-fences along three performance dimensions: accuracy, battery drain, and trigger direction. The goal was to create an empirically based assessment to aid developers in considering performance tradeoffs associated with geo-trigger services. This research also addressed the need to compare the variation of performance of the proposed energy efficient tracking solutions to the widely used periodic tracking techniques in small-predefined geo-fences in terms of reliability (missed trigger action) and accuracy (travelling distances needed from the ideal point where the trigger action should have been received).