Predict Next User Location to Improve Accuracy of Mobile Advertising

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Abstract. The main feature in the location based on advertising is sending the latest ads from POIs nearest the user. To accomplish the task, the device should transmit the current location at interval time to LBA server, LBA server will provide the latest ads nearest location received from the user. With short interval this procedure will run out the power of a device quickly and high internet bandwidth. To solve this long interval can be used. But another problem arises with fast moving users. User received POIs at a location that has been left. We proposed predict next user’s location for long interval push strategy. The results of our experiments show received POIs more accurate and with long interval will help reduce waste of energy and internet bandwidth in mobile advertising.

1. Introduction

It is acknowledged that micro and medium enterprises have an important role in the development and economic growth, not only in developing countries like Indonesia, but also in developed countries such as Japan, United States and European countries. Despite having a vast role in the economy of the country, micro enterprises still have many constraints [18] one of which is the difficulty of marketing. According to the central bank of the Republic of Indonesia micro-enterprises are businesses with annual turnover less than 100 million rupiah. Micro-enterprises are the smallest type of commercial enterprise in Indonesia and classified as MSE, but this type of business is the largest type of business in Indonesia. Micro-enterprises can usually be found in both home-based and rural regions that are home-based or have no fixed location [19]. According to BPS (Central Bureau of Statistics), the difference between Micro Enterprises (MIEs), Small Enterprises (SEs) and Medium Enterprises (MEs) in the number of workers involved 1-9 workers, 10-19 workers and 20-99 workers.

The product of micro and medium enterprises in Indonesia is very divers and its location is spread in urban and rural areas. It needs a system to be able to promote an effective small business product in their respective areas, so that potential customers know the location and the latest product information automatically. In addition to reach potential customers effectively, the advertising system should be easy to apply, inexpensive installation and day-to-day operations, so that each region can use this system to market its superior product in its area.

The aim of effective potential customers is smartphone users, because in 2017 smartphone users in Indonesia reach approximately 173 million users [12]. The number of users of smartphone, making advertisements on a smartphone or better known as mobile advertising into a new channel based location advertising. This advertising channel is efficient to advertise products to smartphone users.
based on location of usage [5] [12]. The proper use of LBA technology can improve e-business efficiency [6] by linking businesses with possible customers.

LBA has two delivery strategies: push and pull [1] [12]. Pull strategy, user request promotion or ads from mobile device to server. While push strategy, the server send ads to the subscriber automatically according to the location received from the user. In Indonesia, Telkomsel utilizes a push strategy for marketing services [12]. Push strategy is good choice because the ads delivered continuously, automatically sent according to the location of the users, but it involves a continuous query to the server to get the nearest ads from the user, so it will consume a lot of energy[4]. It requires an appropriate approach so push strategy does not waste a lot of smartphone energy and also consume low internet bandwidth.

Commonly there are three technologies [6] used to locate user’s location, by network, by GPS [7], or hybrid combination between network and GPS. GPS-based usage is more accurate [5] but it uses more energy than network usage. There are various strategies for managing GPS usage. Various strategies to manage GPS turned on only at certain times or circumstances [9] [11] [14].

To be affordable by micro enterprises, the use of high performance dedicated servers is avoided. Utilization of web hosting as a server takes precedence because it does not necessitate the purchase of expensive servers with high performance. Traditional push strategy is search nearest POIs using haversine method in short interval time. Short interval time query will consume a lot of energy and internet bandwidth. With long interval wasted energy and internet bandwidth will reduced. But another problem arises with fast moving users. User received POIs at a location that has been leave. We proposed inexpensive push strategy adjusting fast moving users, which can be easily implemented and affordable by micro enterprise.

2. Problem
Mobile apps need to be capable to advertise effective micro enterprises products in their respective areas, so potential customers know the current location and product information automatically. In addition to reach potential customers effectively, mobile advertising should be easy to use, save on battery and internet bandwidth usage. Server installation should be easy and affordable for micro enterprises.

Global Positioning System (GPS) based location tracking systems are good way for tracking the exact location of a mobile user to get the information about his current location [19]. Hybrid approach only requires 12 percent of GPS naive approach that is more efficient 8 times over. This means that with this technique can be decreased the energy consumption of almost 90% [20].

To save battery in m-advertising, the usage of GPS is reduced or better avoided because continuous GPS usage will cause the power run out quickly [5] [9] [11] [14]. Purchase a dedicated server with high performance is also avoided because expensive price is not affordable by a micro enterprises actor. Paid hosting becomes an alternative because it is cheap and does not need server maintenance costs. Therefore, continuous queries to the server should be avoided, and complicated computations are not performed on the server but are distributed to the mobile customer. High hardware specifications on smartphone make computing in mobile client very fast.

A lot of research has been performed in the LBS and LBA fields for finding nearest objects from users. Search POI by polygon, either by ZIP code [13]. Sharing if the user has still on made partition space automatically based on a query from mobile customers, using Voronoi diagram [3] [10]. Another search POI using Euclidean distance on server [1] haversine [2], this method is simpe efficient for LBA push strategy, queries executed continuously with time interval. Short interval time query will consume a lot of energy and internet bandwidth. However using long interval, wasted of energy and internet bandwidth will be reduced. But another problem arises with fast moving users. User received POIs from location that has been leave. To solve this we add prediction [22][23] of next user location in our push strategy.
We propose an improved push strategy using the haversine method with a long interval. Also, we add the prediction of the next user location based on the previous user location. Gathering previous information, distance, and angle movement of users, we can predict the next user location using this information.

| Strategy                          | Required Special Server | Complexity | Continuous query (Push Strategy) | Display POIs |
|----------------------------------|-------------------------|------------|---------------------------------|--------------|
| Haversine method, directly from Nearest POI, Calculation On Server | Not required            | Simple     | Query performs every short interval | Nearest POIs |
| Based on region of input user (dynamic region) using the Voronoi diagram | Required special server | High computation on server | Query performs only when a user arrives at a new region/ZIP code area | Nearest POIs |
| Based on static region or polygon/ZIP code region | Not required            | Simple     | Query performs only when a user arrives at a new region/ZIP code area | All POIs in ZIP Code Area |
| Our proposed Push Strategy, User send current location and previous location, Server predict next user location, Server search nearest POIs from predict next user location | Not required            | Simple     | Query performs every interval | Nearest POIs from predicts user location |

### 3. Methodology

**A. Algorithm**

Our prediction algorithm is based on previous user location. We calculate angle by comparing the location of the current location with the previous location. Next, we calculate the distance from the current location with the previous location. In figure 1, the angle between the current location and the previous location is 9 degrees, and the distance between the current location and the previous location is 0.472 kilometres. Now, we know the angle and the distance between the current location and the previous location, with this information, we can predict the next user location in 9 degrees with a distance of 0.472 kilometres. As we can see in figure 1.
Using haversine methods we calculate nearest location from predicted user location.

**Figure 2.** Find nearest POIs from predicted user location

Algorithm:

```
interval = 0
while (true)
    interval = interval + 1
    if(interval % 3000)=0)
        angle = getAngle($lat1, $long1, $lat2, $long2)
        distance= getDistance($lat1, $lon1, $lat2, $lon2)
        predictLocation = getPredict(angle, distance)
        arrayPOI[] = searchHaversine(predictLocation)
        displayPOI(arrayPOI)
    end if
end while
```

```
function getAngle ($lat1, $long1, $lat2, $long2) {
    $dLon = ($long2 - $long1);
    $brng = 0;
    $y = sin($dLon) * cos($lat2);
    $x = cos($lat1) * sin($lat2) - sin($lat1) * cos($lat2) * cos($dLon);
    $brng = atan2($y, $x);
    $brng = rad2deg($brng);
    $brng = ($brng + 360) % 360;
    clockwise
    return $brng;
}
```

```
function getDistance ($lat1, $lon1, $lat2, $lon2)
{ $R = 6371; // Radius of the earth in km
    $dLat = ($lat2 - $lat1) * pi() / 180; // deg2rad below
    $dLon = ($lon2 - $lon1) * pi() / 180;
    $a = 0.5 - cos($dLat) / 2 + cos($lat1 * pi() / 180)
    *cos($lat2 * pi() / 180) * (1- cos($dLon)) / 2;
    return $R * 2 * asin(sqrt($a));
}
```
function getPredict ($lat, $lng, $brng, $dist)
    { $rad = 6371; // earths mean radius
        $dist = $dist / $rad; // convert dist to angular distance in radians
        $brng = deg2rad($brng); // conver to radians
        $lat1 = deg2rad($lat);
        $lon1 = deg2rad($lng);

        $lat2 = asin(sin($lat1) * cos($dist) + cos($lat1) * sin($dist) * cos($brng));
        $lon2 = $lon1 + atan2(sin($brng) * sin($dist) * cos($lat1), cos($dist) - sin($lat1) * sin($lat2));
        $lon2 = fmod($lon2 + 3*M_PI, 2*M_PI) - M_PI;
        $lat2 = rad2deg($lat2);
        $lon2 = rad2deg($lon2);

        Location.lat = $lat2;
        Location.lng =$lon2;
        return Location;
    }

B. Haversine Method
To calculate the distance between user and array POI object we used Haversine Method [2].

\[
\Delta \text{lat} = \text{POI.lat2} - \text{POI.lat1} \\
\Delta \text{long} = \text{POI.long2} - \text{POI.long1} \\
\text{a} = \sin^2\left(\frac{\Delta \text{lat}}{2}\right) + \cos(\text{lat1})\cos(\text{lat2})\sin^2\left(\frac{\Delta \text{long}}{2}\right) \\
\text{c} = 2\arctan\left(\sqrt{\frac{\text{a}}{1-\text{a}}}\right) \\
\text{d} = \text{R.c} \quad \text{Information:} \\
\text{R} = \text{radius of the earth by 6371} \text{ (km)} \\
\Delta \text{lat} = \text{amount of changes in latitude} \\
\Delta \text{long} = \text{amount of changes in longitude} \\
\text{c} = \text{calculation axes intersect} \\
\text{d} = \text{distance (km)} \\
1 \text{ degree} = 0.0174532925 \text{ radians}
\]
Likewise, before we use in trigonometric functions the angle of the latitude and longitude should be converted from degrees to radians.

C. Push Strategy
We considered our strategy should be easy to implement and inexpensive. Mobile users get current location, then send his current location and previous location to server. Server calculate angle and distance between current location and previous location. Server predicts next user location and search nearest POIs from predict location using haversine method

Figure 3. Proposed push strategy
D. Data preparation

We performed experiments with actual information, approximately about 624 micro enterprises are scattered in the city of Jakarta, DKI Jakarta. micro enterprises data consist of latitude longitude coordinates, name and Zip Code of the micro enterprise.

| No | Name       | Latitude  | Longitude | Zip Code |
|----|------------|-----------|-----------|----------|
| Eko Ongan | -6.2941    | 106.738   | 11610     |
| Bu Eka    | -6.2751    | 106.743   | 11610     |
| Jannahathan | -6.2065   | 106.742   | 11610     |
| Pandegelang | -6.2441   | 106.744   | 11610     |
| Rere      | -6.2351    | 106.748   | 11630     |
| Jaya Bahari | -6.2077   | 106.741   | 11610     |
| Citra Jaya | -6.19781   | 106.742   | 11620     |
| Hidayah   | -6.19367   | 106.743   | 11620     |
| Bukit Salasiah | -6.23606  | 106.7   | 15151     |
| Berlian Jaya | -6.22273  | 106.963   | 17134     |

Figure 4. Our data set, micro enterprises location in Jakarta, Indonesia

4. Experiment

A. Experimental Setup

For the experiment, we used Linux share hosting with 500 MB capacities of the POI server database. For testing mobile client, we used LG Optimus L7 P705 Qualcomm MSM7227A Snapdragon, 1 GHz Cortex-A5, GPU Adreno 200, 512 MB RAM, 3G HSDPA, 21 Mbps, HSUPA, 5.76 Mbps. We use old android device (2012) to ensure mobile advertising running on lower specification.

Figure 5. Location of performing experiment
B. Experimental Result

With interval of three minutes, we capture results of experiments

**Figure 6.** Result of POIs from predicted user location

**Figure 7.** Result of POIs (User move from below then turn left at the intersection)

**Figure 8.** Result of POIs (User move from above then turn right at the intersection)
5. Discussion
From result experiment we see two options, first is when user received POIs from their current location, and second when users received POIs from predict location. As we have seen from figure 6. For fast moving users, instead received advertising in a nearest old location. We call nearest old location, because the old location will leave in second by fast moving users. Will be much better if users accept ads from the location to be traversed. Nearest location will be more accurate, rather they received POIs from the old location. In Figure 8, there is a failure, user turn right at the intersection but predicted location is far below.

6. Conclusion
Traditional push strategy is search nearest POIs using haversine method in short interval time. Short interval time query will consume a lot of energy and internet bandwidth. With long interval wasted energy and internet bandwidth will reduced. But another problem arises with fast moving users. User received POIs at a location that has been leaved. We propose improve push strategy using haversine method with long interval. We add prediction of next user location based on previous user location. Gathering previous information, distance and angle movement of users we will be able to predict next user location using this information. Using prediction result, users will receive ads from the location to be traversed, received POIs will be more accurate rather they received POIs from the current location. Unfortunately prediction failed in some situation, especially at the intersection, when user turns right or turn left at the intersection.

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