Energy Efficient Personal Assistant System With Enhanced Features

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***Abstract*— Location-based applications have become increasingly popular on smartphones over the past years. The active use of these applications can however cause device battery drain owing to their power intensive location-sensing operations. This paper presents an adaptive location-sensing framework that significantly improves the energy- efficiency of smartphones running location-based applications.The underlying design principles of the proposed framework involve proximity alert algorithm to conserve energy.We implement the design principles on Android-based smartphones as a middlewae. It is a location-based reminder application which limits excessive energy expenditure while using the GPS technology. The application also acts as security provider for woman who travels alone. Our method utilizes the distance to the point of interest and the user's transportation mode in order to dynamically determine the location-sensing interval and the location providers (GPS, GSM, or Wi-Fi) to be used.**

Keywords—Location Sensing; Energy Efficiency;Location Based Applications;Smartphone;Point of Interest.

I. INTRODUCTION

Proximity alert service is an enabler for various pervasive applications including but not limited to "personal location-based reminders", "safety apps in case of dangerous neighbourhoods","auto-check-in"[1]. However, proximity alert inherently depends on frequent checking of locations to determine if the device enters or exits from a point of interest (POI).The device's location can be obtained by various location providers (i.e. GPS, Wi-Fi APs (WAPs), Cell towers).

In this work, we first identify the problems in the current smartphone operating systems and propose design principles to overcome the limitations. We specifically focus on Android, however the design principles that we talk about could easily be applied to other smartphone operating systems too.In Android, we find out three limitations that cause proximity alert service to spend too much battery. These are static use of location providers, static and frequent periodicity of location updates and lastly the underutilized inertial sensors that could be useful for saving energy.

Afterwards, we design a proximity alert algorithm that uses user's distance from the POIs and user's transportation mode(i.e. idle, walking, driving) to choose appropriate location provider and optimal location sensing frequency.We implement our proposal as a middleware service in Android by modifying the AOSP.

II. PROXIMITY ALERT IN ANDROID

A. Static use of location providers

Alternatives in Android are GPS .Network localization (cell towers + wifi- APs. All providers are requested regardless of their availabilities. If GPS is available; others are ignored .OTOH,GPS is unavailable indoors and very accurate outdoors. Network location is available indoors but might be inaccurate outdoors. As for energy,Figure 1 shows the energy consumption of different location providers.

B. Static and frequent periodicity of location updates

In Android location is requested in intervals of second. Distance is not considered as a factor. Utilizing the distance and speed of the user to set the periodicity would lead to significant energy savings, however we need to determine the speed.

C. Underutilized inertial sensors

In Android,no other sensor other than GPS and Wi-Fi are used.The use of accelerometer might be useful todetermine the transportation mode.However,accelerometer is not of free cost.

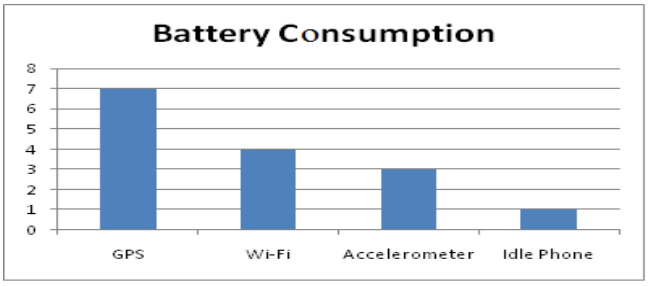

Figure 1. Battery consumption in 10 hours for continuous sensing of GPS,network localization, accelerometer and idle phone.

III. DECIDING ON TRANSPORTATION MODE

For simplicity, we focus on idle, walking and driving modes. These modes exhibits differences in accelerometer readings. In idle mode, we do not move much, and this results in regular low variances. Walking causes regular/patterned changes to acceleration in short periods, which leads to large variances. Finally, while driving occasional changes in acceleration occur, but not as much as in walking..

IV. SYSTEM DESIGN

As shown in the Figure 2, the proximity alert service consists of three basic components, namely Proximity Alert Manager (PAM), Transportation Mode Classifier (TMC) and Phone State Receiver (PSR). PAM initiates, processes, and controls all the operations including processing location updates and sending directives to other components to start/stop them. TMC is responsible for classifying user's transportation mode(idle, walking, driving).

The Conservative distance to the target geo-point, from the User can be defined as:
Cd=dn-ul.accuracy-lp.radius……(1)

Our system use an algorithm in order to detect the transportation mode of the user, based this algorithm an appropriate location provider is selected. This algorithm is referred to as proximity alert algorithm, and given as follows:

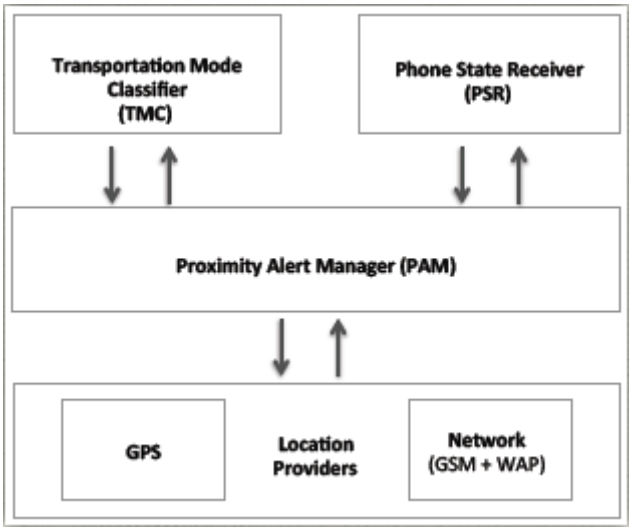

Figure 2 Block diagram of Energy efficient personal assistant system.

Algorithm:Proximity Alert Algorithm

1.procedure PROXIMITY ALERT(ul)
2.cdmin=Min.cdi for all monitored regions
3..if cdmin>=DT1 then
4.Check loc.after cdmin/dvmax
5.else if dT2<=cdmin<dt1 then
6.if ul:pr= = Network then
7.Check loc.after cdmin/dvmax
8.else
9.if ut= =Driving then
10.Check loc.after cdmin/dvmax
11.else if ut= =WALKING then
12.Check loc.after cdmin/wvmax
13.else if ut= =IDLE then
14.Stop location updates
15.end if
16.end if
17.else if dR__cdmin <dT2 then
18.if ut= =DRIVING then
19.Keep requesting location updates
20.else if ut= =WALKING then
21.check loc.after cdmin/wvmax
22.else if ut==IDLE then
23.Stop location updates
24.end if
25.else
26.if ut= =DRIVING OR ut= =WALKING then
27.Keep requesting location updates
28.else if ut= =IDLE then
29.Stop location updates
30.end if
31.end if
32.end procedure

PAM keeps track of all proximity alerts by monitoring the user's transportation mode and the minimum distances to the registered POI regions. Whenever a location update arrives or user's transportation mode changes, PAM updates the periodic checking parameters by running Algorithm. Before dealing the algorithm in details, we define the following terms:

- ul: Location of the user.lu has the latitude(ul.lat), longitude(ul.lng),accuracy(ul.accuracy),and provider(ul.pr).
- lp:location of the POI. lp has the latitude(lp.lat), longitude(lp.lng),andradius information(lp.radius).
- ut:transportation mode of the user: idle, walking or driving.
- dn:distance of the user to the targeted point.
- cd:conservative distance to the target point.
- dt:threshold distance to activate the TMC. Since the energy expenditure for location providers are different,we have two different threshold dT1and dT2.
- dr:crictical distance to end periodic location update.
- dvmax:maximum driving velocity,and its value is 60mph.
- wvmax:maximum walking velocity,and its value is 3.1 mph.

Algorithm: The Proximity Alert Algorithm is used to identify the transportation of the user and based on the transportation mode appropriate location provider is selected.

Initially algorithm determines the conservative distance of the user to target geo-point from all monitored regions. From these, select the minimum distance as Min_cdi and assign to cdmin.

The remaining steps in the algorithm are based on cdmin.If cdmin is greater than or equal to dT1 then cdmin falls in the first interval(see figure.3).In the first interval GPS is the preferable location provider, and request the location update after cdmin/dvmax interval. If cdmin is greater than or equal to dT2 and less than dT1, then cdmin falls in the second interval. In this,interval network location provider is used for periodic location checking and location updates after the cdmin/dvmax interval.If cdmin is greater than or equal to dR and less than dT2 then it implies that the user will be at the target very soon. If TMC is not running, then start it to detect the transportation mode of the user. Suppose if the user is driving, then request for frequent location update. While in the case of walking, location updates are needed after cdmin/wvmax interval. In idle condition of the user, location updates are not needed. Finally, if cdmin falls at the fourth interval, it smeans that the user is almost at the target point .In this case our system continuously request for location updates till the user ends in an idle state.

As illustrated in Figure 3, imagine that a user is travelling from a place called 'A to B'(2 km) . After crossing 1km it sense Once..Again after o.5 km, it sense twice Travelling further, after 0.25 km it sense three times. Again after 0.125 km it sense four times. That is reaching the destination the number of times the location sensed increases. This is to improve accuracy.

Figure 3. Threshold distances to the POI. Distance is decreasing from left to right.

V. RELATED WORKS

A. Location Sensing

Our work is the first work to investigate the energyefficiency of high-precision proximity-alerts in Android, however, energy consumption of location sensing in smartphones has received interest in recent years. In [4], authors identify four factors that waste energy: static use of location sensing mechanism, absence of use of other sensors, lack of cooperation among applications, and finally ignoring battery level while sensing. In [5], authors argue that using a history of cell-id sequences, one can determine the user's location with accuracy comparable to GPS. In [6] authors utilize the location-time history of the user along with user's past velocity and activity ratio to duty-cycle GPS. In a related vein, in SensLock [7], authors explore the possibility of continuous location tracking in an energy efficient way. They utilize Wi-Fi AP beacons for localization, use accelerometer to duty cycle sensing, and GPS for path tracking.

B. Activity Recognition

Due to the proliferation of sensors in commodity mobile devices, identifying the physical activity of a user has recently gained attention in pervasive community. Aside from using sensor motes to recognize user's activity [9], there has been an increasing interest on using smartphones to perform activity recognition. In [10] authors use accelerometer in smartphones to recognize different activities including walking, jogging and standing. In [11], authors use sensors to infer the user's status to share it on user's social network.This work adopts a split-level classifier to perform some part of the classification on the server. Finally, similar to our work, in [12], authors use smartphones to determine transportation mode of a user. Different than our approach,they utilize both accelerometer and GPS sensors. Due to the energy consumption of GPS, we opt-out of GPS and instead rely entirely on accelerometer.

VI. CONCLUSION

In this paper,we consider the problems of energy efficient- location sensing on smartphones.We first identify three factors that affect energy efficiency of location-sensing with GPS through extensiveexperiments. These factors are

static use of location providers, static and frequent periodicity of location updates and underutilized sensors.We design proximity alert algorithm that uses user's distance from the POIs and user's transportation mode(i.e.idle,walking,driving) to choose appropriate location provider and optimal location sensing frequencyWe implement these design principles as a middlewareon Android-based smartphones by modifying the Application Framework..

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