Chapter 10

Incremental Location Matching for Human Travel Route Anomaly Detection

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ABSTRACT

According to a forecast, the worldwide smartphone sales surpassed the world PC sales at the end of 2011. Smartphones are a kind of mobile handheld devices with phone capability or mobile phones with advanced features. Typical smartphone features include microbrowsers, emails, short message services, mobile games, GPS, et cetera. The feature of high mobility and small size of smartphones has created many applications that are not possible or inconvenient for PCs and servers, even notebooks. Location-based services (LBS), one of mobile applications, have attracted great attention recently. This research proposes a location-based service, which uses location information to find travel route anomalies, a common problem of daily life. For example, an alert should be generated when a school bus misses part of a route or a pupil does not arrive at school on time. Different kinds of route anomalies are discussed, and various methods for detecting the anomalies are proposed in this chapter. The major methods use a technique of incremental location search, which finds matched routes as the search route is entered location by location. An alert is generated when no matched routes exist. Preliminary experiment results show the proposed methods are effective and easy-to-use.

INTRODUCTION

The worldwide PC and mobile phone sales are given in the Table 1 according to various market research reports (BNET, 2004; Canalys, 2007 & 2010; CNET, 2006a & 2006b; Gartner, 2005-2010; GsmServer, 2004; IDC, 2008). The number of smartphones shipped worldwide has passed the number of PCs and servers shipped worldwide in 2011 and the gap between them is expected to keep bigger. The emerging smartphones have created many kinds of applications that are not
possible or inconvenient for PCs and servers, even notebooks. One of the best-seller applications is location-based services (LBS) according to the following market research:

- Gartner (2009, November 18) identifies the LBS will be the #2 mobile applications for 2012 because of its perceived high user value and its influence on user loyalty.
- Gartner (2009, July 07) reports worldwide LBS subscribers would grow from 41.0 million in 2008 to 95.7 million in 2009 and was forecast to more than 526 million in 2012 while revenue increased from $998.3 million in 2008 to $2.2 billion in 2009.
- Juniper Research (2010, February) predicts LBS market is to exceed $12 billion by 2014 driven by the following three factors:
  - Increased apps store usage like Apple’s App Store and Nokia’s Ovi Store,
  - High smartphone adoption as 166 million units shipped worldwide in 2009, and
  - New hybrid positioning technologies including GPS (Global Positioning System), cell tower signals, wireless internet signals, Bluetooth sensors, etc.

This chapter proposes location-based research, which uses location information to find route anomalies, a common problem of daily life. For example, an alert should be generated when a pupil does not take the daily route to school or a deliveryman does not follow the scheduled route to make the delivery. Various methods are proposed to find route anomalies. The major methods use the technique of incremental search, which checks the possible routes location by location. Route information is collected before the methods are used. If no routes are available for checking, an alert is generated. Experimental results show the proposed methods are effective and easy-to-use.

Location-based services and applications using travelling routes are critical subjects of mobile computing these days. This research is to design and implement a strategy for route anomaly detection, which includes the features below in order of importance:

- **Effectively, accurately detecting route anomalies:** It is the major objective of this research.
- **Easy to use and apply:** Many security methods are abandoned because the users are reluctant to learn how to use them.
- **Easy to adapt to each individual owner and new routes:** When the device owner

### Table 1. Worldwide PC and cellphone sales

<table>
<thead>
<tr>
<th>Year</th>
<th>Mobile Phones (Million)</th>
<th>PCs and Servers (Million)</th>
<th>Smartphones (Million)</th>
<th>PDAs (without phone capability) (Million)</th>
<th>Tablet PCs (Million)</th>
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</thead>
<tbody>
<tr>
<td>2002</td>
<td>432</td>
<td>148</td>
<td>—</td>
<td>12.1</td>
<td>—</td>
</tr>
<tr>
<td>2003</td>
<td>520</td>
<td>169</td>
<td>—</td>
<td>11.5</td>
<td>—</td>
</tr>
<tr>
<td>2004</td>
<td>713</td>
<td>189</td>
<td>—</td>
<td>12.5</td>
<td>—</td>
</tr>
<tr>
<td>2005</td>
<td>813</td>
<td>209</td>
<td>—</td>
<td>14.9</td>
<td>—</td>
</tr>
<tr>
<td>2006</td>
<td>991</td>
<td>239</td>
<td>64</td>
<td>17.7</td>
<td>—</td>
</tr>
<tr>
<td>2007</td>
<td>1153</td>
<td>271</td>
<td>122</td>
<td>—</td>
<td>—</td>
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<tr>
<td>2008</td>
<td>1220</td>
<td>302</td>
<td>139</td>
<td>—</td>
<td>—</td>
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<tr>
<td>2009</td>
<td>1221</td>
<td>306</td>
<td>166</td>
<td>—</td>
<td>1</td>
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<tr>
<td>2010</td>
<td>1609</td>
<td>346</td>
<td>286</td>
<td>—</td>
<td>17</td>
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