Global Geodetic Reference System in Support of Location based services

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February 7, 2013
Definition of LBS

A wireless IP service that uses geographic information to serve a mobile user (OGC, 2005). Leverages a user’s current physical location to provide an enhanced service or experience.

Adapted: (Brimicombe, 2002)

- Cell ID used in GSM/3G networks
- GPS
- Assisted GPS – combination of cellular networks & GPS
Location Data Information Available to LBS User

Dahunsi, F.M., 2012
Different Types of context in LBS

Dahunsi, 2012
DRIVERS OF LBS

- Explosion of smart phones, deployment of high speed broadband wireless infrastructure, digital cameras & GPS integrated circuits
- Surge in social networking tools
- Degree of fit between technical feasibility & marketing strategy guiding its use (bottom line $$$- mobile advertising could exceed $12 billion by 2014 – (Shek, S., 2010)
DRIVERS OF LBS

- Shift in consumer preferences
  - Quest for seamless integration of location information, customer needs $ vendor offerings
- Regulatory pressures forcing Carriers to accurately position wireless emergency calls – E911 in the US & E112 in the EU.
- Demand Drivers
  - Point of need information
  - Niche Consumer applications
  - Industrial/Corporate
DRIVERS OF LBS

Navigation with maps & GPS—primary Drivers

- Finding friends (22%); Locating venues (26%); checking public transport (19%); checking in to social networks (13%) – interest in Location-based social networks rising 50% on 2011’s data – Rusell, J., 2012)
## Evolution of LBS

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Authorization for SA of GPS signals to be removed, implemented on 2 May 2000</td>
</tr>
<tr>
<td>1998</td>
<td>In the USA, cellular network providers compelled to provide the location of 911 calls as part of Enhanced 911</td>
</tr>
<tr>
<td>2000</td>
<td>Java Micro Edition standards first approved</td>
</tr>
<tr>
<td>2003</td>
<td>JSR 179 Location API reaches final release</td>
</tr>
<tr>
<td>2004</td>
<td>Qualcomm announces first successful test of assisted GPS on mobile phones (<a href="http://www.3G.co.uk">www.3G.co.uk</a>, 2004)</td>
</tr>
<tr>
<td>2005</td>
<td>Google maps goes live (February). Google maps API released (June)</td>
</tr>
<tr>
<td>2006</td>
<td>Google Maps for Mobiles released</td>
</tr>
</tbody>
</table>
# Evolution of LBS...

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>Apple releases the first iPhone; Wifi positioning</td>
</tr>
<tr>
<td>2008</td>
<td>Apple releases the App Store for iPhone -August</td>
</tr>
<tr>
<td>2009</td>
<td>IBM Seer application for wimbledon released, running on Wikitude augmented reality browser –June (Mobilizy, 2009)</td>
</tr>
<tr>
<td></td>
<td>Galileo – 5 dB improvement in signal power, ranging code signal that enables tracking of signals in extremely noisy environment, broadcast over wide bands –improved robustness/ to multipath</td>
</tr>
</tbody>
</table>
Evolution of LBS…

Evolution of GNSSs is improving the performance of LBSs as more satellites become available & accuracies improve.

Steve Jobs in the Apple iconic iPhone transformed simple geographic coordinates into popular applications emulated by location services like Foursquare, TripAdvisor & Facebook Places
Location based service (LBS) will become a $13B business by 2013.
Market Forecasts

- Market forecast undertaken for Galileo by the EC funded by the EC suggests that LBS will be the prime application wrt No of users & revenue potentials.
- Revenue from Middle East and Africa by 2013 - $20 million (13B) $60 million by 2014.
- Traditional Advertising for Middle East & Africa –
Demographics of USA phone users making use of LBS applications

Zickuhr, K., 2012
Pew Research Centre’s Internet $ American Life Project
Availability of Different classes Mobile Phones in Africa

Dahunsi, F.M., 2012
## Location Based Services in 4 African Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Company</th>
<th>Penetration Rate</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>Mobinil, Vodafone, Etisalat</td>
<td>58% (05/2008) 66.3 million</td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td>MTN, GloMobile, Airtel-Zain, Starcomms, Mtel, Etisalat, Multilinks – Telkom Visafone</td>
<td>60% (10/2010) 90 million</td>
<td>Person tracking</td>
</tr>
</tbody>
</table>

February 7, 2013

United Nations Global Geospatial Information management 2nd High level forum- Doha, Qatar, 4 – 6 February, 2013
# Location Based Services in 4 African Countries

<table>
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<tr>
<th>Country</th>
<th>Company</th>
<th>Penetration Rate</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Vodacom, MTN, Cell C, 8.ta, Virgin Mobile, Red Bull Mobile</td>
<td>92% (2010) 45 million</td>
<td>Emergency calls, Distress calls, person tracking, points of interest, Asset tracking,</td>
</tr>
</tbody>
</table>
Positioning mechanisms

Positioning with respect to LBS involves two steps:
- Signal measurements
- Location estimate based on measured signals

5 methods are widely used:
- Mobile Positioning System (MPS) based on Cell Global Identity (CGI)
- Cell Global Identity + Timing Advance (CGI + TA)
Positioning mechanisms

- Uplink Time of Arrival (TOA),
- Enhanced Observed Time Difference (E-OTD)
- and
- Global Positioning System (GPS) assisted.
Satellite Based Position

GNSS Augmentation

Augmented Systems
- WAAS – Wide Area Augmented System
- EGNOS – European Geostationary Navigation Overlay Service
- Differential GPS
- INS - Inertia Navigation Service
- Assisted GPS

GNSS Development

Whitehead, 2012

Where is GNSS heading?

<table>
<thead>
<tr>
<th>GNSS</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>30 (current)</td>
</tr>
<tr>
<td>GLONASS</td>
<td>24 (current)</td>
</tr>
<tr>
<td>Galileo</td>
<td>27 (2019)</td>
</tr>
<tr>
<td>QZSS</td>
<td>3 (2013)</td>
</tr>
<tr>
<td>COMPASS</td>
<td>35 (2020)</td>
</tr>
<tr>
<td>IRNSS</td>
<td>7 (2014)</td>
</tr>
</tbody>
</table>

Streaming More Bands: L1, L2, L5, etc
Comparison of different positioning methods (Chatre & Ludwig, 2003)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Cell-ID</th>
<th>E-OTD</th>
<th>OTDOA</th>
<th>A-GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Poor 200m-20km 2D only</td>
<td>Avg 100m-500m 2D only</td>
<td>Avg 40m-150m 3D</td>
<td>Very Good 5m-10m 3D</td>
</tr>
<tr>
<td>TTFF</td>
<td>Excellent 1s</td>
<td>Very good 5s</td>
<td>Very Good 5s</td>
<td>Very Good 5s</td>
</tr>
<tr>
<td>Roaming</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Expansion</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Comp</td>
<td>Excellent</td>
<td>Poor</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Terminal Cost</td>
<td>Negligible</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Overall cost</td>
<td>Excellent</td>
<td>Poor</td>
<td>Average</td>
<td>Good</td>
</tr>
<tr>
<td>Summary</td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
<td>Good</td>
</tr>
</tbody>
</table>

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GNSS Services

The ability to provide time-dependent coordinates to features is fundamental for many location based applications.

A well defined global reference frame is essential for any meaningful and exploitable point positions.

Global and Regional applications rely on the availability of ITRF.

Components of the precise geodetic infrastructure combine in the realization of the ITRF.
International Terrestrial Reference Frame

ITRF provides the anchor for nearly all ground based applications prominent among which is the LBS.

ITRF is an indispensable reference required to ensure integrity & inter-operability of GNSS such as GPS, GLONASS, Galileo, Compass, etc.

ITRF will require sufficient number & globally distributed co-location sites.
IGS Stations

United Nations Global Geospatial Information management
2nd High level forum- Doha, Qatar, 4 – 6 February, 2013
CORS in Africa
Stations Archived by AFREF

Active stations being archived at AFREF Operational Data Centre (May 2012) – Wonnacut, 2012
Inter-disciplinary cooperation

Number of disciplines make use of GNSS signal in space:
- Geodesy: AFREF
- Seismology: Africa Array
- Meteorology: AMMA-GPS
- Space weather: SCINDA

Wonnacot, 2012
Issues in LBS

- Privacy of data, ownership of position data and permissions
- Handset based vs handset assisted
- International roaming
- Accuracy due to various positioning techniques in different networks
- Inter operability with the other operators results in mass marketing the services giving the necessary critical mass
Issues in LBS

Integration of GNSS in the Geodetic infrastructure
- Targeted approach to establishment and maintenance of geodetic network - user “hot spots” and specific applications
- Method of access to real time signals (e.g. Smart phones); format of data (RTCM); & level of accuracy, integrity and security.

Non professional users with little understanding of accuracies and datum issues but with accuracy requirement exceeding that achievable without taking proper account of datum issues
Issues in LBS

Challenge of a plethora of wireless and GNSS standards wrt the provision of equipment that employs telecom networks to improve position accuracy and speed-

- need for A-GNSS common standard –internetworking, interoperability,
- backward compatibility- so as not to jeopardize the implementation of existing A-GPS in the future

For cost-effective & scalable LBS, targeting and feedback should be pinpointed and accurate in real-time at the planning, trafficking, creative and management levels.
Issues in LBS

• No regulatory body on LBS Services
  QoS not assured
• Limited cell density – drop call rates translates to reliability challenges with LBS
• Limited LBS infrastructure – location estimation devices like Location Management Unit & smart devices are not sufficiently available
• Coverage & Quality of available spatial data
• Poor town planning & address system

Wonnacot, 2012
Issues in Developing Effective Global Reference Frame

- Policy makers and the Public are largely unaware of the nation’s reliance on geodetic infrastructure
  - Very limited sustainable long-term funding
  - Dilapidated and loss of geodetic stations
  - Sparse density of geodetic controls
  - Dearth of trained workforce to develop and maintain geodetic infrastructure.
Issues in Developing Effective Global Reference Frame...

Different systems/frames although connected or related to ITRS/ITRF

- WGS84 for GPS, PZ-90 for GLONASS; CGCS2000 for COMPASS; GTRF for Galileo; and JCS for QZSS

Six regional geodetic organizations

- AFREF for Africa; NAREF & SIRGAS for North and South Americas; EUREF for Europe and APREF for Asia and Pacific, and SCAR for Antarctica

- Defined wrt the ITRS/ITRF, realised and maintained by regional entities, eg. ETRS89 for Europe, NAD83 for North America; and SIRGAS for South America.
Issues in Developing Effective Global Reference Frame...

- Shared cost of deployment and maintenance New Zealand & Australian example
  - Commercial services; via commercial system owned & operated by Govt. With real-time corrections sold to industry
  - Wholly Govt. Owned that provide access to data for post-processing with value addition by private sector for real time capability
  - Consortium infrastructure – industry, academia, government & community group share costs, maintenance & benefits with value addition and distribution provided by private industry.
Issues in Developing Effective Global Reference Frame...

- Proliferation of active GNSS vis a vis compatibility with national datums; datum fragmentation & need for homogeneous geodetic infrastructure
- Densities of Active and Passive GNSS’s
- Status of classical geodetic network
- Insufficient Enthusiasm & Commitment to regional cooperation, e.g. AFREF
Recommendations

- High precision GNSS national networks to be established and maintained similar to other infrastructure like roads, telecommunications and made available in real time without restrictions
- National participation and support for international geodetic services and commitment to maintaining the ITRF – IAG - Global Geodetic Observing System
- Improved funding and incentives to train requisite workforce
- Shift from legacy datums to GNSS-supported reference frames - ITRF
Recommendations

Global Approach is needed – UN (GGIM)

- Promote legal framework required to ensure standardization
- Support regional initiatives for developing common frameworks and methodology
  - Technology governance
  - Data governance
  - Standards governance
Recommendations

- Placement of Regional body within the structure of the political structure like the AU for AFREF.
- National Geodetic networks should as a first step be converted to the regional frame, e.g. AFREF.
- A Global Reference Frame should be the goal using existing technology (and under development) to migrate to a Global Reference Frame.
Food for thought for all of us

Whitehead, 2012 has suggested different strategies for consideration

- Scientific, commercial, Government (or a mix)
- Sparse Density vs optimal Density
- Static (Passive) vs Dynamic (Real Time)
- Progression Plan – Evolution of technology
Conclusion

LBS realises its full potential and value when anchored on a shared common framework, ITRF, and internationally accepted standards.

A Common Framework and standard provide enhanced communication, cooperation and coordination and amplifies the impact of collaboration.