Computer System Department
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Wireless Outdoor Location Estimation in Based Urban

a thesis submitted as a partial fulfillment of the requirements for the degree of Master of Science in Computer and Information Sciences.

By

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بسم الله الرحمن الرحيم

وقل رب زدني علما

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Abstract

Location awareness in general is emerging a tremendous interest in different fields and scopes. Position is the key element of context awareness. Although Global Positioning System (GPS) produces an accurate position, it requires an open sky and does not work indoors. It is obvious that GPS provides most accurate positions; it is commonly used with navigation applications and some of emergency applications. Moreover, some of the traffic analysis applications use GPS-enables smart phones as probes for traffic data collection. Since GPS requires a line of sight to the satellite and not all the phones are equipped with GPS, more attention has been given to other alternatives like Wireless Fidelity (WiFi). It is commonly used in the urban and sub-urban areas, hot spots are everywhere. WiFi has been used for localization in many researches and commercial applications.

However, WiFi-based localization techniques address several challenges but unfortunately not all the cellular phones are equipped with WiFi. Hence, Global System for Mobile Communications (GSM) based localization techniques appear again. GSM represents about 85% of today's cell phones. GSM consumes minimal energy if compared to WiFi and GPS. After the revolution of the smart phones and the development of the mobile applications, some approaches have been implemented, especially those who use accessible parameters from operating systems and do not require any modification on the software or hardware layer. Most of these approaches use parameters like Received Signal Strength (RSS) and Time Advance (TA).

GSM-based phones are also used in traffic monitoring services as dynamic probes or Floating Car Data (FCD). In a default scenario, when Mobile Entity (ME) moves around in the GSM network, it is unavoidable to change between different geographical areas. To know which cell the ME should communicate with, the ME constantly listens to the signals sent out from the different (Base Transceiver Station) BTSs. The signals are measured at certain threshold values of the signal strengths, the ME will decide that it needs to change its serving cell and initiates what is called by a handover (HO) procedure. To measure the different signals, the ME stores information about the currently serving cell, as well as up to six other cells of which it has received the strongest signals, called neighbour cells. All these information are stored in Network Measurements Report (NMR), which is sent to the core network every 480 millisecond in active (in call or data transfer) mode. However, core network can receive same NMR in idle mode by sending paging message to UE.

This thesis presents a set of mobile positioning techniques and methodologies, which can be applied on different types of handhelds. Each technique focuses on one concept like the accuracy, availability or dependency and tries to address the challenges that are faced by the similar system. This thesis also considers using the GSM-based phones as probes for traffic estimation which includes a set of important principles like the travel direction detection, speed estimation, sampling mechanisms and privacy concerns. All the techniques have been practically tested in Egypt roads by using the commercial smart phone and the results concluded were compared to the latest approaches in similar environments.

List of Abbreviations

3G	3rd Generation, Mobile Telephony Communication Protocol
AFLT	Advanced Forward Link Trilateration
AGPS	Assisted GPS
AJAX	Asynchronous JavaScript and XML
AMPS	Analogue Mobile Phone System, American Mobile Phone System
AoA	Angle of Arrival
BID	Base station ID
BSC	Base Station Controller
BSS	Base Station System, Base Station sub-system
BTS	Base Transceiver Station
CDMA	Code Division Multiple Access
CI	Cell Identity
CID	Cell ID
CMC	Computer Mediated Communications
COO	Cell of Origin
DAB	Digital Audio Broadcasting
D-AMPS	Digital American/Advanced Mobile Phone System
D-GPS	Differential GPS
DoA	Direction of Arrival
DS	Distance between Samples
DSRC	Dedicated Short Range Communication
E-911	Enhanced 911 (Public Safety Answering Point)
ECEF	Earth-Centered, Earth-Fixed
EDGE	Enhanced Data Rate for Global Evolution

EFLT	Enhanced Forward Link Trilateration
EgTNS	Egypt Traffic and Navigation Systems
EMI	Electromagnetic Interference
ETC	Electronic Toll Collection
FCD	Floating Car Data
FM	Frequency Modulation
GDOP	Geometric Dilution of Precision
Geo-	Associate Internet Resources with geographical locations
GEO	Geostationary Orbit
GERAN	GSM EDGE Radio Access Network
GIS	Geographical Information System
GLONASS	Global Navigation Satellite System
GML	Geography Markup Language
GPRS	General Packet Radio Service
GPS	Global Positioning System
GPX	GPS exchange format
GRASS	Geographic Resources Analysis Support System
GSM	Global System for Mobile Communications
GSMA	GSM Association
HAR	Highway Advisor Radio
HSGPS	High Sensitivity GPS
HTML	Hyper Text Markup Language
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPDL	Idle Period Down Link
IT	Information Technology
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
LBS	Location Based Services

LEO	Low-Earth Orbit
LMU	Location Measurement Unit
LOS	Line Of Sight
MCC	Mobile Country Code
MNC	Mobile Network Code
MPEG	Moving Pictures Experts Group
MS	Mobile Station
MSISDN	Mobile Station International ISDN
NB	Node B (UMTS Systems)
NMEA	National Marine Electronics Association
OGC	Open Geospatial Consortium
OMA	Open Mobile Alliance
OSM	Open Street Maps
OTDoA	Observed Time Difference of Arrival
PDA	Personal Digital Assistant
PDE	Positioning Determining Entity
PND	Personal Navigation Device
PPP	Public-Private Partnership
PVT	Position Velocity Time
RDS	Radio Data System
RNC	Radio Network Controller
RSS	Real Simple Syndication - Received Signal Strength
RSSI	Received Signal Strength Indication
RTT	Round Time Trip
RXLEV	Reception Level
SMLC	Serving Mobile Location Center
SMS	Short Message Service
SNR	Signal to Noise Ratio
SOAP	Simple Object Access Protocol
SOS	Letters which represent the radio telegraphic signal (... --- ...), Cry for help

TA	Timing Advance
TDMA	Time Division Multiple Access
TDoA	Time Difference of Arrival
TETRA	Trans European Trunked Radio
TMC	Traffic Message Channel, Traffic Management Center
TMSI	Temporary Mobile Subscriber Identity
TOA	Time of Arrival
TTFF	Time To First Fix
UE	User Equipment
UMTS	Universal Mobile Telecommunication System
UTRAN	UMTS Terrestrial Radio Access Network
WAAS	Wide Area Augmentation System
WCCL	Weighted Corrected Centroid Localization
WCL	Weighted Centroid Localization
WiFi	Wireless Fidelity
XML	Markup language

Publications

- Ahmed M. Hamad, Mohamed H. Abdel Meniem, R. Medhat, Towards a Complete Navigation/Traffic Integrated System Adapted to Egypt Roads, The International Navigation Conference, Melaha 2010, Egypt.

- Mohamed H. Abdel Meniem, Ahmed M. Hamad, Eman Shaaban, Fast and Accurate Practical Positioning Method using Enhanced-Lateration Technique and Adaptive Propagation Model in GSM Mode.

-Mohamed H. Abdel Meniem, Ahmed M. Hamad, Eman Shaaban, Practical Positioning and Traffic Estimation Techniques using Relative Received Signal Strength RRSS in GSM mode.

- Mohamed H. Abdel Meniem, Ahmed M. Hamad, Eman Shaaban, Speed Estimation and Travel Direction Detection using Handover in GSM.

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