

INFORMATION AND COMMUNICATION TECHNOLOGIES

USING LOCATIONAL DATA FROM MOBILE PHONES TO ENHANCE THE SCIENCE OF DELIVERY

Ryan Haddad, Tim Kelly, Teemu Leinonen and Vesa Saarinen

June 2014

WORLD BANK REPORT NUMBER ACS9644



Public Disclosure Authorized

Public Disclosure Authorized

Public Disclosure Authorized

Public Disclosure Authorized

USING LOCATIONAL DATA FROM MOBILE PHONES TO ENHANCE THE SCIENCE OF DELIVERY

Ryan Haddad, Tim Kelly, Teemu Leinonen and Vesa Saarinen

June 2014

WORLD BANK REPORT NUMBER ACS9644

STANDARD DISCLAIMER

This volume is a product of the staff of the International Bank for Reconstruction and Development/ The World Bank. The findings, interpretations, and conclusions expressed in this paper do not necessarily reflect the views of the Executive Directors of The World Bank or the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

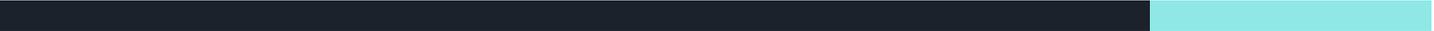
COPYRIGHT STATEMENT

The material in this publication is copyrighted. Copying and/or transmitting portions or all of this work without permission may be a violation of applicable law. The International Bank for Reconstruction and Development/ The World Bank encourages dissemination of its work and will normally grant permission to reproduce portions of the work promptly.

For permission to photocopy or reprint any part of this work, please send a request with complete information to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA, telephone 978-750-8400, fax 978-750-4470, <http://www.copyright.com/>.

All other queries on rights and licenses, including subsidiary rights, should be addressed to the Office of the Publisher, The World Bank, 1818 H Street NW, Washington, DC 20433, USA, fax 202-522-2422, email pubrights@worldbank.org.

CONTENTS



Acknowledgements	6
Executive summary	7
1 Introduction	9
1.1 How locational data can be used	9
1.2 The evolving locational data toolkit	10
1.3 Structure of the report	11
2 How do locational technologies work?	13
2.1 A brief history of locational technologies	13
2.1.1 Cell tower triangulation	13
2.1.2 Global Positioning System (GPS)	14
2.1.3 WiFi Positioning System (WPS)	15
2.2 Current uses of location tracking in mobile networks	16
2.2.1 Data from cell tower triangulation	16
2.2.2 Collecting GPS-embedded data	16
2.2.3 Analyzing GPS-embedded data	17
2.2.4 WiFi Positioning System and location-based services	19

2.3 Potential for the future.....	20
2.3.1 Smartphone developments.....	20
2.3.2 GPS developments.....	21
2.3.3 Indoor Positioning Systems.....	22
2.3.4 Other technologies.....	23
Endnotes for chapter 2.....	24

3 A conceptual framework for studying locational data applications.....25

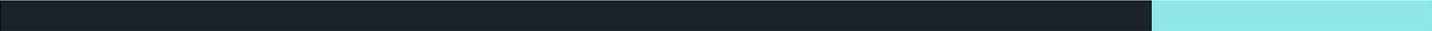
3.1 Methodological frameworks.....	26
3.1.1 Ushahidi Haiti Project Review Framework.....	26
3.1.2 Systems and software Quality Requirements and Evaluation (SQuaRE).....	26
3.1.3 The challenges of implementing new technology in developing countries.....	26
3.2 Proposed framework for the presentation of cases.....	27

4 Case studies of locational data.....29

4.1 Poimapper.....	29
4.1.1 Overview.....	29
4.1.2 Poimapper use cases.....	30
4.2 Ushahidi.....	32
4.2.1 Overview.....	32
4.2.2 Ushahidi use cases.....	33
4.3 Dimagi CommTrack and CommCare.....	35
4.3.1 Overview.....	35
4.3.2 Dimagi use cases.....	37
4.4 Taarifa.....	39
4.4.1 Overview.....	39

4.4.2 Taarifa use cases.....	40
4.5 Comparing the applications.....	41
4.6 Using Big Data to enhance the science of delivery.....	41
4.6.1 Using Big Data to analyze the mobility of people.....	44
4.6.2 Using Big Data to analyze social interaction and economy.....	44
4.6.3 Using Big Data to analyze the spread of malaria.....	45
5 Conclusions.....	47
5.1 Using locational data to enhance the science of delivery.....	47
5.2 Potential uses of locational data for addressing development challenges.....	48
5.3 Recommendations to development practitioners and policy-makers.....	48
5.4 Final reflections.....	50
References.....	51

ACKNOWLEDGEMENTS



This project was undertaken jointly by the ICT Sector Unit of the World Bank and the Media Lab Helsinki at Aalto University School of Arts, Design and Architecture. The World Bank team was led by Dr Tim Kelly, Lead ICT Policy Specialist, who acted as task team leader for the overall program of work and contributed chapter 1, and included Ryan Haddad (consultant), who contributed chapter 2. The Aalto team comprised Prof Teemu Leinonen and Vesa Saarinen, who contributed chapters 3 and 4. The team collaborated on chapter 5 and the executive summary.

The research for the project was undertaken between the project concept note review, which took place virtually, between 8-22 January 2014, and the Decision Meeting held on 4 June 2014, chaired by Randeep Sudan, ICT Sector Unit Manager. The peer reviewers for the program were Ilary Lindy (Innovation Policy Specialist, WBIKE), Siddhartha Raja (ICT Policy Specialist, TWICT) Rosemary Rop (Water Policy Specialist, TWIWP), Saori Imaizumi (Consultant, TWICT) and Samia Melhem (Knowledge and Learning Coordinator, TWICT). In addition, Zaid Safdar (Consultant, TWICT) contributed useful comments. Roberto Pena provided graphic design, layout, and illustration for the report.

The authors would like to thank Suvi Reijonen of the Finnish Ministry of Environment; Petra Hietaniemi, Pertti Lounamaa and Peeter Pruutem of Pajat Inc; and Henna Hakkarainen of Kepa, the umbrella organization for Finnish development aid-related CSOs, for their valuable comments and inputs.

The research program was funded in part by the Finland Ministry for Foreign Affairs through its “Finland as a Knowledge Economy 2.0” Trust Fund.

EXECUTIVE SUMMARY

This report concerns the use of locational data from mobile phones for enhancing the science of delivery in development programs. The report can be summarized in a series of key numbers:

1 There is one objective of this report—to enhance the science of delivery by using locational data from mobile phones. In this context, the “science of delivery” is defined as evidence-based experimentation, and locational data is one of the toolsets becoming increasingly available and useful for this purpose.

2 There are two main audiences for this report. The primary focus is on development practitioners, who are looking to use the locational data toolset to provide a more scientific approach to their work. The secondary focus is on policy-makers, particularly in developing countries, who have development challenges they wish to solve, and who may wish to use locational data for that purpose.

3 There are three main ways in which locational data is used:

- » Locational data recorded by device users (consumers). The main tool would be maps and other navigational aids that combine location-finding services, such as GPS, with data stored on the phone, such as maps.
- » Locational data recorded by service providers (operators). The main tool here is call data records that can be passed on by operators to researchers.
- » Locational data recorded by third parties (neither the user, nor the operator), as part of a survey, or to report incidents. This is the main focus of the applications presented in chapter 4 of this report.

4 There are four main technologies used to generate locational data, as discussed in chapter 2:

- » Cell tower triangulation; the least accurate, but the most widely available;
- » Global Positioning System (GPS), which uses satellites to locate a user; currently the most accurate, but largely restricted in use to smartphones and tablets.
- » WiFi Positioning Systems (WPS), which use WiFi networks to provide

additional locational detail. This is potentially even more accurate, but has the smallest geographical range.

- » Indoor Positioning Systems (IPS), which combine data from the three main technologies with additional sensor-derived data, such as air pressure, heat and infrared sensors, to locate individuals within a building or a university campus. This is the most accurate of the technologies, but remains largely experimental.

5 There are five main survey-type applications that are compared in chapter 4: Poimapper, Ushahidi, Dimagi CommTrack, Dimagi CommCare and Taarifa.

8 There are eight major development challenges, or millennium development goals. All of these are addressable to some extent by locational data, as illustrated in table 5.1.

10 There are ten mini case studies of locational data in action in development programs covered in the report, as described in chapter 4:

- » Tuberculosis monitoring in Thailand (Poimapper)
- » Oral cancer screening in India (Poimapper)
- » Wildfire monitoring in the Russian Federation (Ushahidi)
- » Election monitoring in Kenya (Ushahidi)
- » Supply chain management for community health workers in Malawi (Dimagi CommTrack)
- » Assistance to home-based care providers in Tanzania (Dimagi CommCare)
- » School construction in Uganda (Taarifa)
- » Transport planning in Côte d’Ivoire (Big Data)
- » Poverty mapping in Côte d’Ivoire (Big Data)
- » Malaria tracking in Kenya (Big Data)

SEVEN BILLION There are more than seven billion mobile phone subscriptions worldwide, a number that will soon exceed the human population. Around one billion new smartphones are sold every year, and virtually all of these have GPS and WiFi capabilities, meaning they can make use of all four of the locational data technologies described in chapter 2. They have an increasing range of other sensors—for instance for temperature, pressure, fingerprint recognition, camera, compass, gyroscope, pulse measurement, pedometer, accelerometer, and so on—that can be used in conjunction with locational data to give a richer range of detail. In the hands of development professionals, these smartphones and tablets provide an unparalleled toolset for bringing scientific measurement to bear on the execution of routine tasks. More broadly, they provide more information, and potential control of that information, than ever before. The era of the “quantified self” is at hand.

The locational data capabilities described in this report are part of a wider trend toward quantification and measurement which underlies the emerging science of delivery. Beyond the science of delivery lies predictive analytics, or the ability to predict outcomes, and adapt in a more intelligent way. As a common saying states, if you cannot measure something, you cannot understand it, and if you cannot understand it, you cannot control it. Locational data is a small set along the road to measuring—and better understanding—our world. It could lead to an Orwellian future of control, in which nothing happens without being observed. However, it can also lead to a prosperous future where enhanced understanding reveals better ways to combat poverty. We might not know where we are going, but we can at least try to find out where we are and where we have been.

CHAPTER ONE

INTRODUCTION

More than 70 percent of the world’s inhabitants now own a small computer, better known as a mobile phone. Those phones typically possess more computer processing power than the Apollo rockets that went to the moon in the late 1960s, yet can easily fit in a pocket. This report is about one specific capability of today’s mobile phones—namely, the ability to locate a phone, and therefore its user, in space and time. For the purposes of this report, this ability is referred to as “locational data” though in practice it relates to a range of capabilities. These include the ability of the user to locate him or herself in geographical space, and to track his or her progress. The locational data from multiple devices can also be recorded to show, for instance, how individuals move through a city at different times of day and night, sometimes in real-time.

1.1 HOW LOCATIONAL DATA CAN BE USED

In this report, two specific types of locational data are analyzed:

- » The active, or intentional, generation of survey data as part of a development intervention. Survey data can be geotagged, timestamped, and meshed with other spatial data, allowing, for instance, survey data to be shown on a map along with the time when it was recorded. Five specific examples of active collection of locational data in development projects are discussed in the first part of chapter 4.
- » The passive, or ancillary, collection of locational data, for instance through the analysis of mobile call data records (CDRs). Where operators can be persuaded to release anonymized call data for research purposes, this Big Data database can then be used, for example, to optimize traffic planning or to study the response to a natural disaster. Three specific examples of the passive collection of locational data, and its use for development, are illustrated in the second part of chapter 4.

In general terms, there are three types of location finding used by mobile devices: using the cellular network of base stations for triangulation, using Global Positioning Systems (GPS), and using WiFi positioning (WPS). A fourth broad type of location finding—Indoor Positioning Systems (IPS)—is beginning to emerge, but is not studied

in detail in this report. Of these, using the cellular network for “multilateration” is the least accurate method, but nevertheless has the advantage that it can be used by almost any mobile phone, including basic ones, and can be used to locate a phone independently of the user, as long as it is switched on. It is also the most widely used in Big Data approaches. GPS is more accurate, but usually requires a smartphone or a similar device. It is the most widely used for survey data. The capabilities of WPS and IPS are still to be explored for development purposes, but commercial uses are beginning to emerge, for instance for tracking students within a university campus.

There are three generic ways in which locational data from mobile devices can be useful:

- » Locational data recorded by device users (consumers). The main tool would be maps and other navigational aids that combine location-finding services, such as GPS, with data stored on the phone, such as maps. In popular applications, such as Facebook or Foursquare, the locational data may be combined with social media or mapping data may be overlaid with other data in mash-ups. One example discussed in this report is where users upload reports to a central database, as in the Ushahidi example covered in section 4.2.
- » Locational data recorded by service providers (operators), or passed on by operators to researchers. The main tool here is call data records and the original motivation for operators was outreach and advertising, for instance to reach people passing a coffee bar with a targeted advert. Location tracking is used by emergency services, and also by law enforcement. With the release of CDRs for research purposes, a number of new services are emerging in this field, for instance in meteorology (measuring the attenuation of mobile signals as a way of measuring humidity) and in Big Data analysis of the transport sector, for instance based on mobile phone traffic. Tracking services are also used in areas like fleet management, congestion charging, and route optimization.
- » Locational data recorded by third parties (neither the user, nor the operator), as part of a survey. Surveyors may collect non-real-time locational

data for research and operational purposes. This again allows for mash-ups or repurposing of data from different sources. A good example here would be the use of locational data to verify progress in a vaccination campaign for disease like polio or TB. In such cases, 100 percent coverage of the target population is essential. Geotagging of photographs of inoculations could be matched with other data (e.g. maps, school records, vaccination cards, etc.) to build up a visual picture of the progress of a vaccination campaign. This is the main focus of the applications presented in chapter 4 of this report.

1.2 THE EVOLVING LOCATIONAL DATA TOOLKIT

Locational data is a toolset that continues to evolve, and development applications tend to lag behind functional capabilities. This is in part because the technical capabilities of mobile phones, which are explored in chapter 2, are still evolving. Although commercial GPS has been around since the early 2000s, it is only in the last few years that the capability has become standard in smartphones and tablets, and even more recently that those smartphones have become widespread, overtaking sales of feature phones globally only in the fourth quarter of 2013 (Gartner, 2014; see figure 1.1).

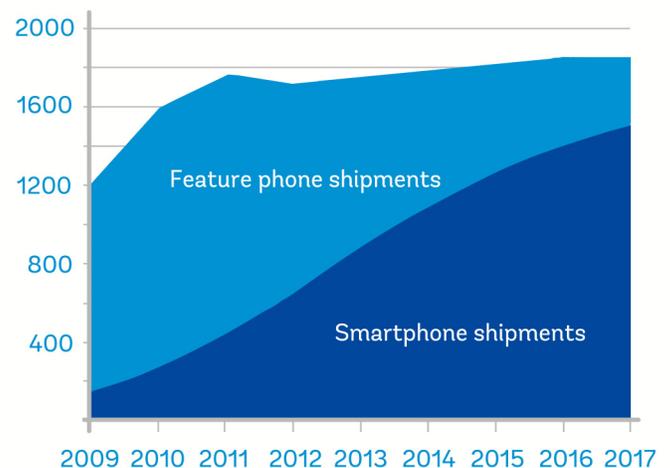


Figure 1.1. Forecast global shipments of feature phones and smartphones, 2009-2017 (millions). Original data: Business Insider / The World Bank.

Because the toolset is still emerging, it is unsurprising that the development community has been relatively slow to absorb these new capabilities of locational data into pilot programs and full-scale implementations. There is typically a five- to ten-year lag between the availability of a particular technical function and its use in applications, as exemplified by the capability to use short message service (SMS). It was included in the technical specifications of mobile phones launched in 1991, but only in widespread use ten years later. In the development community, which is typically not noted for its pioneering use of technology, such delays can be even longer. Nevertheless, as this report demonstrates, locational data holds substantial promise for enhancing the science of delivery, initially within the information and communication technologies for development (ICT4D) community, but ultimately in mainstream programs for economic and social development.

1.3 STRUCTURE OF THE REPORT

The objective of this report is to examine the potential of locational data for the science of delivery in the field of development. “Science of delivery” is a term popularized by World Bank President Jim Yong Kim, and refers to using evidence-based experimentation to improve development outcomes (Walji, 2013). In this context, locational data is a new tool that is beginning to find uses in a variety of development fields including health, education, disaster risk management, traffic planning, etc. In one illustration, mobile call data records (CDRs) were used to track the evacuation of Japanese citizens from a 30 km zone around the Fukushima Nuclear Power Plant after its failure following the tsunami that hit the coast on 11 March 2011 (see figure 1.2). These CDRs could then be meshed with health records to optimize the delivery of emergency health treatment.

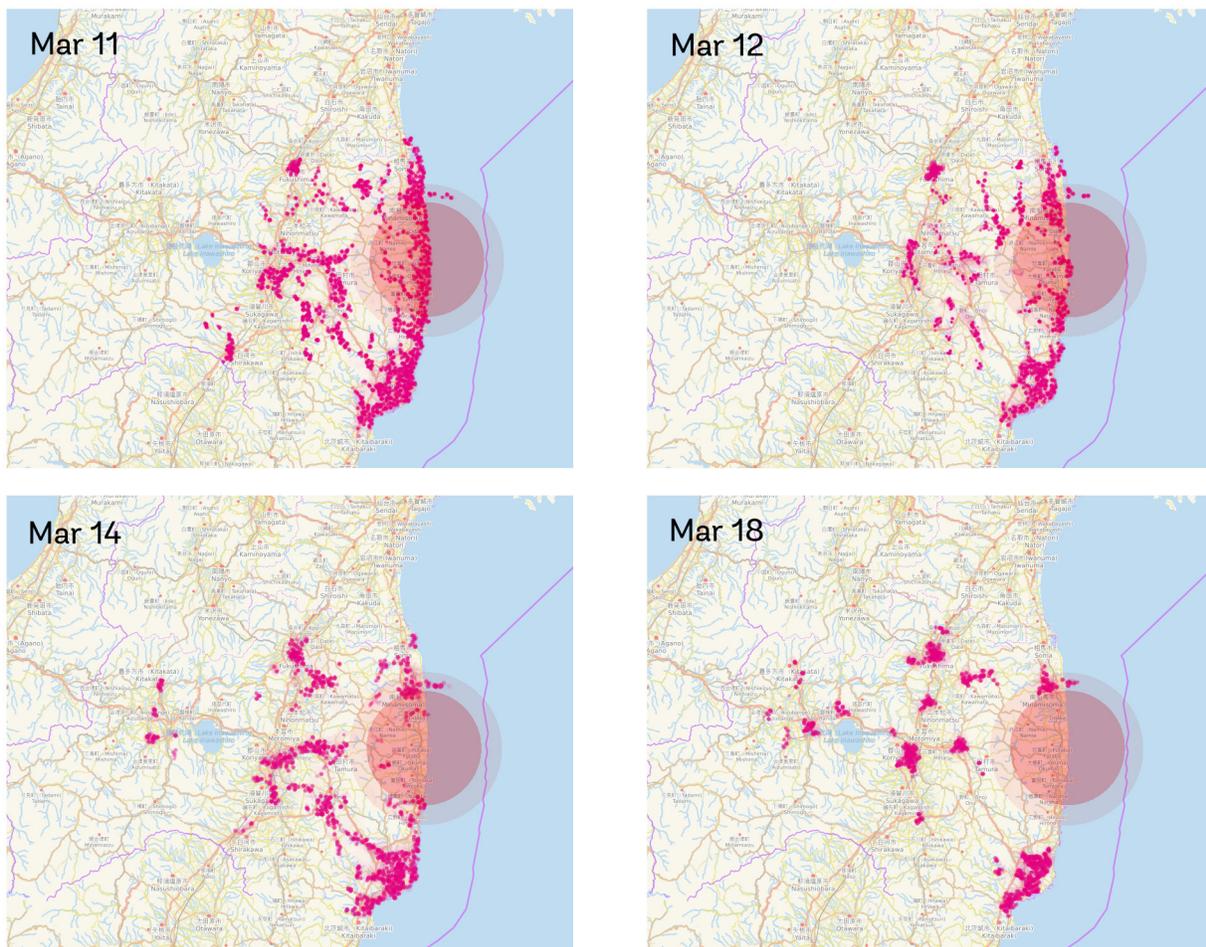


Figure 1.2. Mobile user tracking in the wake of the Fukushima nuclear accident, March 2011. Data: Shibasaki, R. (2014). Map © OpenStreetMap contributors; licensed under CC BY SA 2.0.

Following this broad introduction to the topic in chapter 1, the next chapter explores the technology behind locational data. Chapter 3 presents the methodology followed in this research, and chapter 4, which is the heart of this report, then presents a series of mini case studies of how it is actually being used in a representative sample of different development fields. This is the “evidence-based experimentation” which can be harnessed to improve the science of delivery, and examples of both active and passive collection of locational data are presented. Finally, chapter 5 examines, in broader terms, the longer term potential of locational data as a development tool, once smartphone ownership becomes more widespread. Already, as shown in figure 1.1, shipments of new smartphones will exceed those of feature phones in 2014, and by 2017, smartphones will account for more than 80 percent of all new phones sold. During the period from 2009 to 2017, the average selling price of new smartphones will have halved from US\$360 to US\$180 per unit, while functionality (e.g. battery life, screen size, memory, operating system, etc.) will have improved significantly.

At some stage during 2014, the number of mobile subscriptions will exceed the number of people on the planet, at just over 7.3 billion. With new smartphones arriving on the market at more than one billion a year, it won't be long before a majority of the installed base of phones in use around the world has GPS, mapping functions and a touchscreen as standard. That will become a game-changer in terms of their development potential. Thus, while the pilot programs and applications described in this report may appear experimental in nature, the potential exists for fairly rapid scaling up. But first, their social and economic value for development needs to be proven in action.

CHAPTER TWO

HOW DO LOCATIONAL TECHNOLOGIES WORK?

2.1 A BRIEF HISTORY OF LOCATIONAL TECHNOLOGIES

There are three main location tracking technologies in use worldwide: cell tower triangulation, Global Positioning System (GPS), and WiFi Positioning System (WPS). These are described briefly below.

2.1.1 CELL TOWER TRIANGULATION

In today's developing world, not all phones are smartphones (see figure 1.2); this means that not all mobile phones have the immense technological capabilities which many users in developed economies are growing accustomed to. Such capacities include location-finding technologies, such as GPS, built directly into the handset. Nonetheless, phone companies faced this constraint prior to the advent of GPS-enabled phones and developed other techniques that enable call tracing. One such method—cell tower triangulation—was introduced by mobile phone companies aiming to aid emergency response teams in locating callers if communications were lost, as well as for tracking down wrongdoers.

Cell phones operate as two-way radios; various towers and base stations are arranged on a grid to form networks. These networks comprise different cells around wireless towers from which radio signals are sent and received to and from cell phones (see figure 2.1). This three-way relationship allows phones to communicate with their nearest tower as the base station monitors the signal strength produced by the phone. When moving between cells, base stations in different cells recognize a diminution or a gain in signal strength originating from handset-specific cellular-identification frequencies (cell-IDs). Towers in the cell which the phone is leaving transfer the signal to towers in the cell which the phone is entering (this is called a handover and it is a distinguishing feature of cellular mobile networks).

Computers connected to the cell base station can determine locations based on the measurements of signal that the station is recording. These measurements include the angular approach of the signal to the cell towers, the time it takes for the signal to travel between multiple towers, and the strength of the signal when it reaches the

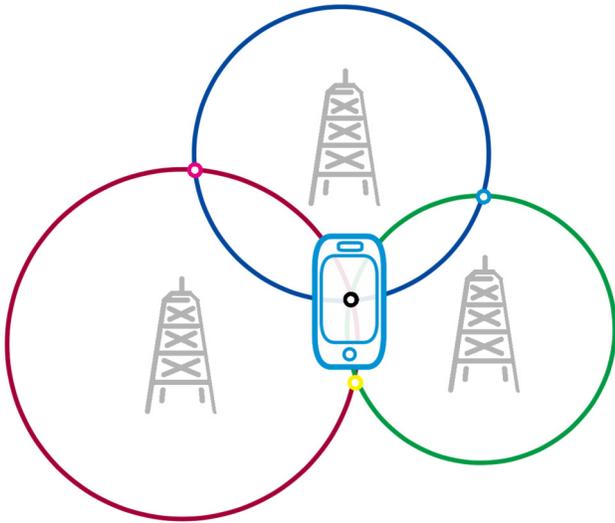


Figure 2.1. Cell tower triangulation.

tower. Cell tower triangulation typically generates results to an accuracy of 100 to 200 m in digital mobile networks (i.e. second generation and above) in urban and semi-urban areas.

In remote or rural areas, cell phone triangulation is less conclusive as it is often the case that towers are located so far apart that they cannot provide consistent signals, base stations are unable to monitor signal strengths and cells do not overlap as much. Furthermore, physical obstacles such as trees, buildings, or mountains can disrupt signals, causing delays or shortages. For instance, cell signal strength in elevators is weak.

2.1.2 GLOBAL POSITIONING SYSTEM (GPS)

Given the relatively low level of positional accuracy associated with cell tower triangulation, mobile phone manufacturers and operators looked to utilize more efficient technologies for enabling location-based services. A particular technological advancement was the incorporation of the mobile phone as a GPS receiver. As with many other functions, such as camera, calculator or web browser, GPS was originally added as a premium feature but is now standard, even in lower-cost feature phones.

Although there are a number of GPS platforms in use, or in development, the most popular system is called Navstar; it was developed and introduced by the United States military during the 1960s and early 1970s. It permits anyone using a device with a GPS receiver to pinpoint his

or her location. The GPS receiver uses communication signals (radio waves) from the 30 or so global positioning satellites to calculate latitude and longitude (see figure 2.2). The satellites transmit their own positions, times, and pseudo random noise codes (PRN) which receivers use to calculate range. These received signals are converted into position, velocity, and time estimates as the receiver calculates the position of the satellite and distance between it and the receiver. Through trilateration (different than triangulation)¹ of these signals, the receiver determines its own position. Some receivers permit users to record and save locations (waypoints/points of interest), sequenced locations (mapped routes), as well as tracked directions of the receiver's movement over time (tracks).

With the advent of the handheld GPS device in the late 1980s, new possibilities were uncovered in the sphere of GPS. By the 1990s and early 2000s, commercial carriers such as Garmin and TomTom began to produce GPS devices operating with various degrees of mobility, and without a fixed electric power source. These technologies started gaining traction and have been utilized in numerous fields (e.g. military, urban planning, maritime safety, private navigation, etc.) for collecting locational data.

In 1999, a Finnish mobile telecommunications company, Twig Com Ltd., (then called Benefon) launched the first ever mobile phone with GPS integrated capabilities (see figure 2.3). This started a trend and at the turn of

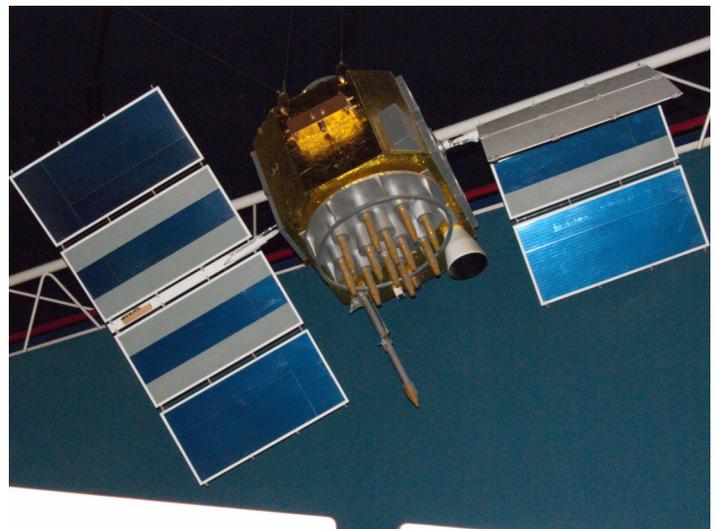


Figure 2.2. Replica of Navstar GPS satellite, Block II. Photo by nostri-imago licensed under CC BY 2.0. Available at: <https://www.flickr.com/photos/nostri-imago/3346241193>



Figure 2.3. 1999 Benefon Esc! Android Authority, found at: <http://www.androidauthority.com/9-greatest-breakthroughs-cell-phones-282324/>

the millennium, various mobile telecom companies began releasing phones with GPS microcontroller chips installed directly into mobile devices, including tablets. Presently, consumers with calling plans and phones equipped with service plans or software that provides navigation can utilize map applications to access a variety of location-based services. Offline use is also possible if map data is preloaded. What started as simple technology to pinpoint exact locations turned into more sophisticated GPS signal receiving mobiles that could understand various programming languages and offer services like turn-by-turn directions or device tracking.

Initially, the accuracy of the US GPS system was deliberately impaired due to security concerns, but the US government eventually lifted this restriction. Currently, experts perceive that locational data produced by mobile phones and tablets, derived strictly from satellite signals, is accurate to within ten meters or less of actual location. However, GPS-location accuracy can falter due to certain signal-blocking inhibitors. Such inhibitors include dense foliage or buildings; this causes radio signals between GPS satellites and GPS receivers/cell phones to be blocked or distorted. Signals may also be deliberately impaired around sites considered security risks by the US government. This is one reason why other governments are developing their own systems, such as the Galileo system in Europe, Global

Navigation Satellite System (Glonass) in Russia, Beidou Navigation Satellite System (BDS) in China, and Quasi Zenith Satellite System (QZSS) in Japan.

2.1.3 WIFI POSITIONING SYSTEM (WPS)

GPS and cell tower triangulation technologies have one major flaw: they do not work accurately indoors, or in densely populated areas, due to signal blockage. With the large-scale proliferation of wireless access points (APs), WiFi Positioning System (WPS) has been used—mostly commercially—to provide location-based services to consumers via WiFi. This may imply that certain limitations will continue to exist in the developing world when it comes to WPS if the commercial potential is considered to be less attractive.

WPS was a term coined by Skyhook Wireless—a global location network with a database containing over a billion WiFi APs. Skyhook Wireless utilizes its database of global APs to install new positioning techniques when WiFi equipped devices are connected to the Internet. Commercial enterprises such as Google, Apple, and telephone companies (telcos) have compiled their own extensive lists of APs by correlating APs and hotspots with the GPS locations of mobile users. So-called “Hotspots” are public WiFi APs, but private APs may also be tracked.

The two most common WPS approaches to pinpointing locations are based on signal strength indicators and “radio frequency fingerprinting.” Much like GPS or tower triangulation, the signal strengths between the device and various hotspots are measured; the signal strength indicates the distance from the AP and a geometric calculation against other AP locations is used to locate the device (trilateration). Signal strength positioning is highly dependent on accurate record-keeping of access points. Fingerprinting, on the other hand, involves the use of previously mapped locations. New radio transmissions originating from the mobile each have their own properties including specific frequencies and signal configurations. Therefore, each signal originator has its own specific “fingerprint.” This on-site data is collected and mapped to locations; then it is compared to the locations of previously mapped hotspots, and in turn the transmission can be assigned its own location. The drawback to fingerprinting is that radio frequencies may change quickly, and thus monitoring them effectively is challenging.

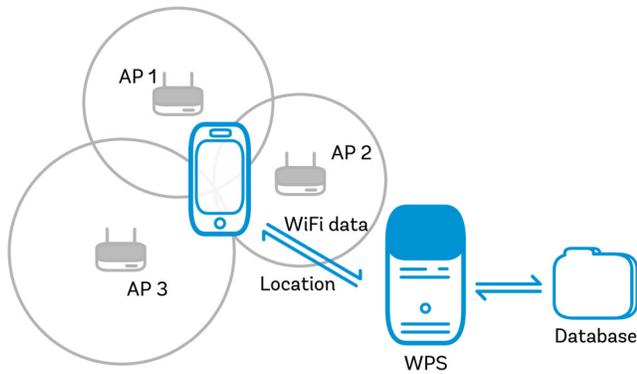


Figure 2.4. Smartphone interaction with APs, server, and database. Adapted from: <http://www.mobizen.pe.kr/724> (2014).

2.2 CURRENT USES OF LOCATION TRACKING IN MOBILE NETWORKS

2.2.1 DATA FROM CELL TOWER TRIANGULATION

In triangulating the signals bouncing off cell towers, as well as recording their time delays, phone companies are able to pinpoint the locations of cell users to within 100 to 200 meters of approximate cell-ID handover positions. This is, of course, dependent on the density of towers available in a certain radius (i.e. more towers produce more accurate results). Low levels of accuracy often require that this method be used in conjunction with GPS or WPS.

By focusing on call data records (CDRs), tower triangulation provides the ability to track a cell phone's presence over time, which is often critical in solving crimes. It can display roughly where the phone was (in proximity to which tower) when a call was made, or a piece of data (e.g. email, text message) was originated or received, as well to which tower the signal was transferred if the phone was moving, and where the cell phone was when it last received a signal or call. Such CDRs, monitored in coordination with the timestamps from outgoing/incoming calls, allow the network operator to track and plot a phone user's path over any period of time (i.e. the route taken plotted by tracking the times when the phone was in use).

It is important to note, however, that tracking a cell phone user's route does rely a little on logical inference. For instance, not all originated and terminated calls take place in different cells on a map. They may take place in the same cell so all that can be concluded is that specific user's location on the map at that time. Nonetheless, if time passes and the user's next call is made from the same cell—for instance, on the next morning—it can be inferred that said user slept at that respective location. “Always on” mobile broadband services provide a higher level of accuracy because the usage of the phone is more regular. That being said, accuracy depends on the density of towers in a given area used to triangulate the location—one tower may display that a signal originated near that tower, but signal strengths captured by other towers are needed to narrow the area's range where the cell is located. It also depends on usage and the phone's battery life.

Historically, this method has been used by law enforcement agencies in order to narrow down an area where a suspect might have been at the time that a crime took place, or to track movement of suspects. There are relatively few commercial data-collection applications which depend solely on cell tower triangulation as this method typically relies on access to CDRs from major carriers, and this raises privacy concerns. With access to CDRs, millions of pieces of data can be mapped into a program to show movement over time (as displayed from the University of Tokyo Project; see figure 1.2), but the utility is reduced if the data is anonymized. Software companies generally do not have access to CDRs, nor do they have access to a database with respective tower locations. However, some enterprises, like ArcGIS, have analytic tools (ArcGIS 10.2 – Cell Phone Analysis) which allow forensics teams (mostly law enforcement) to analyze cell tower data via CDRs acquired from wireless service providers. In the trend towards “open data” more mobile operators are willing to release generic, anonymized CDRs, but mainly for research, rather than commercial, usage.

2.2.2 COLLECTING GPS-EMBEDDED DATA

Recently, due to the evolution of mobile phone/tablet devices and the widespread adoption of mobile GPS chips, GPS-enabled data collection applications have begun to

proliferate in the market. These applications (e.g. Ushahidi and Poimapper, described in chapter 4, and OSMtracker and Cybertracker.org) enable mobile phones, and their users, to become accurate geotaggers of data with their respective data collection sites.² They permit users to utilize applications which enable the mobile device to view routes (for instance, when navigating), record/save GPS tracks (for instance, in fitness applications), and store waypoint coordinates (for instance, for locating photographs taken).

Mobile applications provide a wide array of data-collection capabilities depending on the phone. In smartphones and some newer feature phones, these capabilities allow for media files—such as images/raster files and audio—to be collected and geotagged with GPS coordinates (latitude/longitude). Almost all phones—including older feature phones—have applications which allow other qualitative data (such as digital questionnaires and forms) to be geotagged when populated in the field. Applications (like Poimapper from Pajat Solutions Ltd.; see section 4.1) permit forms to be customized in a way that allows users to be very specific in the type of data they are capturing, filtering (i.e. usually through metadata tags), and recording prior to geotagging the data.

Typically, data collected in the field is updated and edited offline prior to being uploaded into central databases with which the collection tools interact directly. These databases, or content management systems (CMSs), can be accessed from the “cloud” (i.e. using remote databases accessible from the Internet), on the local premises at a data center, and in some cases, offline, where the device has sufficient memory storage to create a data cache. Some CMSs, like GeoNode.org (utilized by a number of World Bank projects) and MapBox’s TileMill, are open source and web-based, permitting a variety of devices to access the same content from a web browser. GeoNode empowers developers to integrate its geo-capabilities into existing platforms and applications—a handy feature for customization of any tool which wants to develop a Geographic Information System (GIS). Lastly, GeoNode allows developers to deploy spatial data infrastructures (SDI) which empower multiple users and tools to interact with stored spatial data in a multitude of ways. Others, like Poimapper (proprietary) and CloudGIS’s Mobile Data Collection Tool, allow for existing data, previously collected and stored in private databases, to be edited

offline. Such GPS-embedded data can be downloaded, edited, and then uploaded back to the server (Moss, 2012).

In some mobile applications like Taarifa or Poimapper, real-time geotagged data collection is possible. Real-time data collection can make an impact in various sectors. For example, it can help monitor infrastructure installation/maintenance or assist in resource allocation decisions for public utilities like water.³

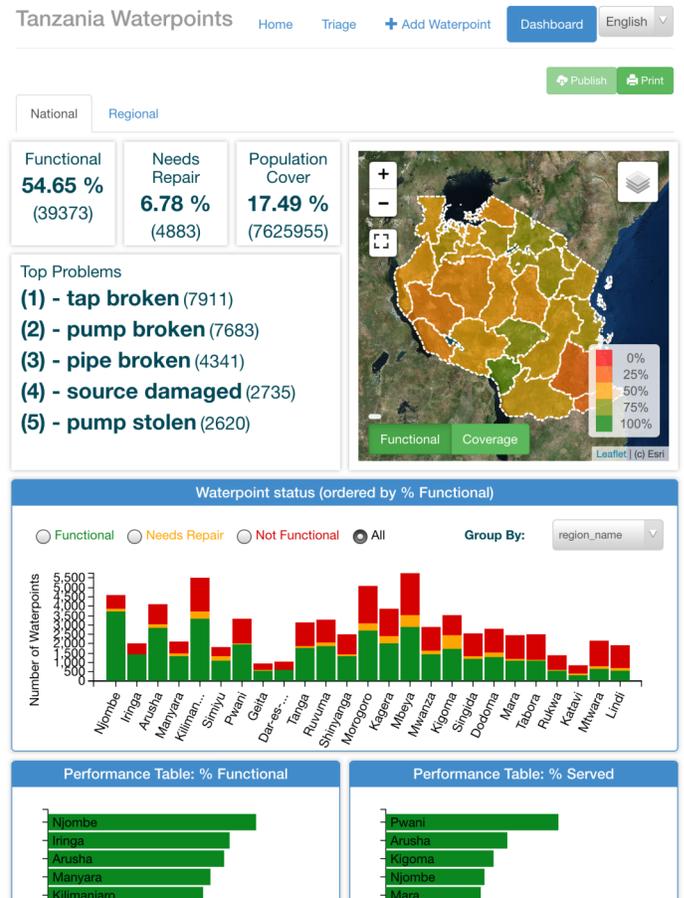


Figure 2.5. Screenshot from the Taarifa tool. Source: <http://dashboard.taarifa.org/#/dashboard>

2.2.3 ANALYZING GPS-EMBEDDED DATA

As researchers and development specialists have discovered, locational data can provide immense insights into the movement patterns of particular communities (e.g. commuters, water seekers) as well as ongoing infrastructure projects, etc. GPS-generated data is basically useless on its own; however, certain computing programs, such as GIS, provide tools that help specialists, through digitized maps, manage and visualize location-enriched data collected in

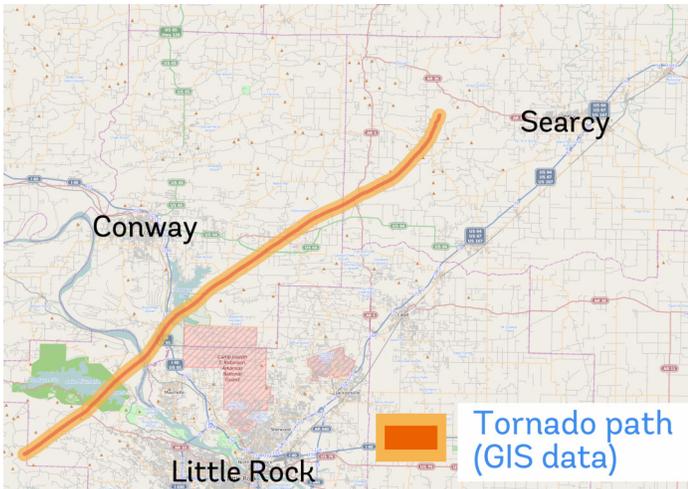


Figure 2.6. Vector data points displayed over a map of Arkansas, USA, plotting the trajectory of a tornado’s path over time. Map © OpenStreetMap contributors; licensed under CC BY SA 2.0. Data: 2014, ArcGIS, <http://storymaps.arcgis.com/en/gallery/#s=0&n=30&d=1>

the field. These maps can be manipulated to present the data in comprehensive and telling visualizations (e.g. time-lapse depictions of municipal transport projects).

Geo-data, when stored on a GPS-enabled device, can be transferred via a direct connection (e.g. USB, WiFi, Bluetooth, or 3G data connection) to a data server or computer with GIS software (assuming, of course, that a direct connection is available). Not all GIS are “smart” enough to interact with GPS data in its raw form. Sometimes, data must be converted (typically through an online conversion tool) into GIS-readable languages and formats (e.g. *.gpx*⁴, CSV, or shapefile—a vector data format). Vector data is the geometric data format (points, lines, and polygons) traced onto a map.⁵ Vector layering directly on a map, in conjunction with temporal information, can, for example, enable time-series evaluations, as mentioned above.⁶ Moreover, vector data can be collected through mobile technology and later uploaded into applications other than GIS, such as web-based interactive community maps (e.g. OpenStreetMap). The crowdsourced map can then be used by data collection and visualization tools to provide more accurate templates and reference points when mapping waypoints, routes, or tracks offline.

In general, most of the mobile data collection tools discussed do not have customizable maps built into their programming as many feature phones cannot replicate or readily update (due to low bandwidth, processing power,

and small screen size) the visual displays of maps on their screens. Instead, they house generic maps on their data-center servers (usually of the region/country where the application is being utilized) obtained from third parties such as OpenStreetMap, MapQuest, or Google Maps. Newer smartphones can access such maps offline in order to add geo-specific data (Lounamaa, 2012). Certain applications (e.g. GIS Cloud Mobile) allow for waypoints, routes, or areas to be traced through a field office’s desktop server’s map portal; newer mobile devices can sync with the desktop server and be used to gather more information in the field (Holmes, 2014). Older, “basic” phones simply house automatically georeferenced data until it is uploaded to the tool’s congruent in-office platform to be mapped.

Some online geospatial CMSs (like GeoNode.org and TileMill) are not strictly classified as a GIS, but still have mapping capabilities, as well as other features that create a central hub for managing and visualizing data after it has been uploaded. Whereas GeoNode does not permit map edits directly on a mobile device, those carried out on a computer are saved to the cloud and the populated maps may be published to suitably-equipped mobile devices for field use during other data mapping exercises. Alternatively, this data can still be extracted directly from a mobile application in the form of a CSV file, a shapefile, or another format like KML⁷ and imported into a compatible GIS for more advanced mapping and statistical analysis.

While certain online technologies and some geospatial CMSs are appropriate visualization tools for basic mapping, GISs like QGIS (open source) and Esri’s ArcGIS (proprietary) provide much more powerful analytic tools. ArcGIS has recently released a cloud version of its software—ArcGIS Online. ArcGIS Online, in conjunction with the ArcGIS mobile and tablet apps (for Android, iOS devices, and Windows) make it accessible and fully functional from any of the above mentioned mobiles or tablets with a data connection (see figure 2.7). Furthermore, the ArcGIS Runtime SDK (software development kit) enables mobile developers to build mapping applications (for iOS, Android, and Windows) which utilize the mapping, geocoding, and other functions of ArcGIS’s online and desktop tools; this includes a handful of geoprocessing tasks and real-time updating which can be used before, during, and after data has been

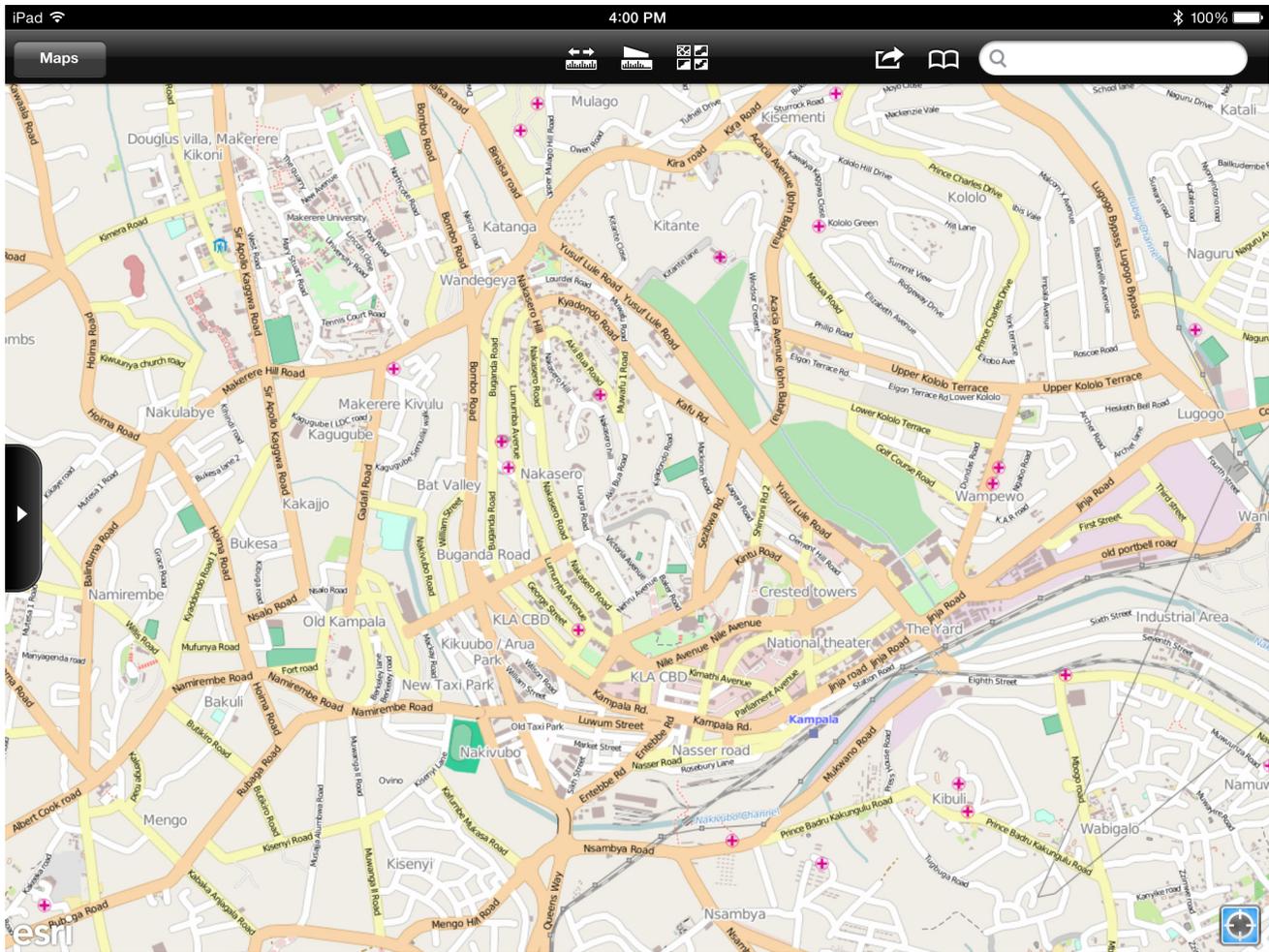


Figure 2.7. Map of Kampala, Uganda. Screenshot from the ArcGIS Online iPad app (2014).

collected. This gives subscribed users universal access to the locational data and content regardless of the location and device where the data was originally collected and uploaded.

These GIS utilize data sources called libraries (e.g. plug-ins with instructions on how to provide interoperability for data files between the GIS and the Geospatial Data Abstraction Library—GDAL/OGR) to read and write vector data formats; such libraries can be added to proprietary collection applications, enabling use of the various formats discussed, as well as others (e.g. .gpx, KML, PostGIS, GeoTIFF).

2.2.4 WIFI POSITIONING SYSTEM AND LOCATION-BASED SERVICES

Currently, but mostly in more developed nations, WPS enables application developers and major companies the chance to offer location-based services (LBS) on mobile

devices (i.e. phones and tablets) when connected to the Internet. This includes accurate positioning and LBS even when indoors, and indeed this generic category is often called “indoor positioning systems” (IPS), though more correctly IPS uses a variety of different sensor techniques, as shown below. As mentioned above, poor WiFi infrastructure hinders the accuracy and ability of WPS altogether. Additionally, even though WPS empowers LBS in devices without GPS capabilities, LBS usually works better when WPS is complemented by GPS.

Commercial uses of WPS are typically employed in the areas of marketing (e.g. adverts received when passing a particular store). WPS also enhances GPS in order to strengthen functionality and navigation. From a marketing standpoint, when a smartphone, with its WiFi receiver turned on, is within a certain range of hotspots or APs, some applications (e.g. Foursquare) utilize this data in conjunction with data assigned to geo-referenced physical locations pulled from the application’s server database.

The application processes this data relationship in order to push (i.e. serve) location-specific advertisements to the smartphone user for various businesses which are within a certain range of that user's vicinity. WPS also enables devices to "check-in" to georeferenced locations (this simply means that the physical location has a mapped presence online derived from its AP addresses). Voluntary check-ins are also accessed by some applications to index a user's preferences in order to serve advertisements of interest in the future. Moreover, voluntary check-ins allow users to geotag social media (e.g. photographs on photo sharing platform Instagram). Such features are similar to the real-time data updates and data-geotagging capabilities which GPS-enabled data collection tools described above offer.

At present, not many data collection tools similar to those which generate GPS embedded data exist solely for use with WPS. Nonetheless, many developers are exploring this space and potential capabilities as hotspots become more abundant. Some current initiatives include indoor mapping applications which employ the mobile GIS technology discussed.

One such application is the Smart UJI Campus; this application is a map-based web service which enables staff, students, and visitors at the Universitat Jaume-I to locate points of interest, review and search geotagged information (including the whereabouts of various

campus services or employees), as well as other resource management features all empowered by WPS (Vicent et al 2013). The application developer used a mobile device, equipped with the ArcGIS SDK and a set of basemaps (two visual maps of the geospatial information provided by a central directory containing campus data), to register different access points from campus infrastructure, as well as fingerprints from indoor locations. In essence, the application provides a map of the whole area (i.e. campus), as well as a map of the interiors of buildings—including floor-by-floor schematics. All of the points of interest are stored in a geodatabase which also contains relevant information; moreover, users can use WiFi fingerprinting in order to register new points indoors. A tool such as this can work to enhance the information-communication capabilities of smart buildings and to provide navigational functions for large indoor structures.

2.3 POTENTIAL FOR THE FUTURE

2.3.1 SMARTPHONE DEVELOPMENTS

In developed countries, GPS-enabled smartphones have already reached the mass market. That is, they are typically affordable to the everyday user. General affordability, however, remains a major concern in the developing world. It is perceived that as the costs of smartphone ownership and mobile connectivity go down, user uptake in marginal communities will increase. This was the case with the feature phones which were a luxury in developing countries a decade ago but are now much more affordable. This, of course, is also true for the various proprietary data collection applications, mapping, and analysis tools discussed thus far. Thus, the "trickle down" effect of rapidly falling device costs and mobile broadband prices will democratize the services described here in developing countries in the near future, following a similar model to that observed in developed economies.

In parallel, as stakeholders begin to understand the power of harnessing geospatial data, current open source technologies like OpenDataKit (for data collection) or GeoNode.org and QGIS (for data storage and analysis) may encourage a trend toward open source and more functional geo-enabled tools (e.g. ArcGIS's catalog of

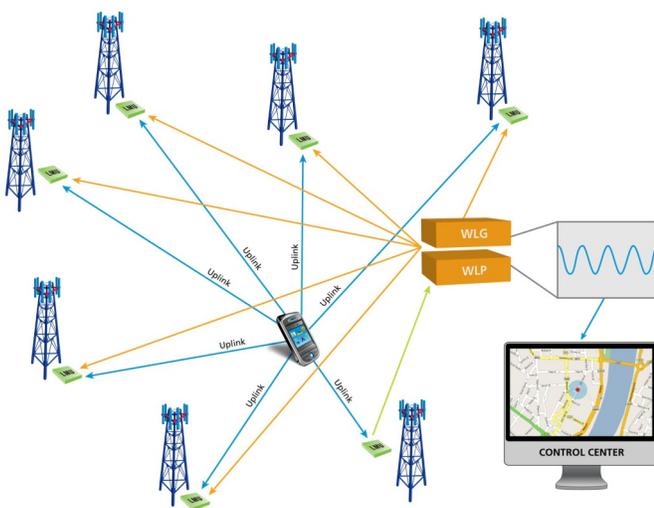


Figure 2.8. Diagram of WiFi positioning system for use in mobile apps. Source: <http://www.directionsmag.com/articles/trueposition-tackles-indoor-locating/329384>

tools). Furthermore, there are initiatives which endeavor to promote the use of such tools. One group, the Open Geospatial Consortium (OGC), has developed standards and specifications that make geospatial data interoperable between different OGC-compliant interfaces, data stores, and GIS platforms. Standards range from open web mapping services to compatible markup languages (e.g. GML or SQL); however, compliance with few or some of the standards does not ensure compliance with all the standards. Until then, data-based initiatives associated with tower triangulation and GPS-enabled feature phones will be the widely prescribed norm in developing countries.

WPS also faces cost-related constraints for the future. As WiFi infrastructures improve in the developing world (i.e. through investments into larger-scale connectivity and an influx of public access points), and as WiFi-enabled phones become more common in marginal communities—the likelihood of using WPS to collect and monitor locational data will increase. Instead of relying on field work and georeferencing to tag/capture data from physical locations, these locations will have with their own hotspots and the data mining and analysis procedure will be much easier. In short, data collection globally is shifting from active and conscious to passive and unconscious.

That being said, when using smartphones to record tracks or calculate user stay-points, locational accuracy may not be perfect. Data scientists recommend cross-checking the accuracy of tracks, routes, and waypoints collected via mobile technology with other references containing similar data. This could include data reinforcement techniques through tower triangulation, Radio Frequency Identification (RFID) tags built into public transportation infrastructures, or online maps; when dealing with specific data, even images produced by traffic cameras, planes, drones, or satellites (this has been least prescribed considering such images may lack accuracy due to weather) can enhance data analysis techniques. Recently,⁸ the US government has lifted restrictions regarding the accuracy of satellite images; earlier, companies were restricted from using satellite images where visible features were smaller than 50cm. The lifted ban enables the use of more accurate imaging and can allow certain companies to make the highest quality images available to their consumers, data analysts and development specialists included. One proprietary application—Navizon—successfully empowers indoor

and outdoor LBS through accurate geographic positioning by utilizing a crowdsourced global database of the geographic locations of WiFi access points and cell towers, collected by registered users. This can then be triangulated against the GPS location of a phone. Navizon has enhanced healthcare by offering its services on a variety of smartphone platforms and enabling healthcare professionals to deliver better patient care, maintain patient safety (regardless of location), manage assets and resources, and optimize workflows. It is unique in the way it utilizes the interaction of all three mentioned location-finding technologies in order to provide accurate positioning on campuses and inside buildings, down to specific rooms.

2.3.2 GPS DEVELOPMENTS

Navizon, and other tools like it, rely on the established and functioning infrastructural components that enable tower triangulation and WiFi. That is, it requires more than simple GPS to provide its users full functionality. The American military's GPS system—Navstar—has been the sole global, space-based satellite navigation system for decades. This has meant that location-based services and location data collection have relied extensively on that satellite system; this can create bottlenecks, for instance when it comes to real-time data collection, in areas where connection is spotty and signal blockage occurs. However, other nations have begun constructing their own global navigation satellite systems. One such nation is Russia, which has successfully deployed the “Global Navigation Satellite System” (GLONASS); the 22-satellite system endeavors to complement the traditional GPS system. In 2012, carriers began integrating GLONASS radios into smartphones. This technological inclusion has meant that newer smartphones (e.g. iPhones released after the 4S generation, Blackberry Z10/Q10, and some Samsung Galaxy handsets to name a few) are able to be located and capture geospatial data much more accurately than earlier devices. Qualcomm estimates that the interaction between GPS and GLONASS improves accuracy by 50 percent in “deep urban environments.” As these satellites interact, they are able to trilaterate more accurately as more satellite signals are picked up by the handset. This is expected to continue to improve as more nations develop their own navigation satellite systems; China is working

on the Beidou-2 system which is anticipated to be serving customers by 2020, and the E.U. plans to operationalize its Galileo satellite system by 2019.

2.3.3 INDOOR POSITIONING SYSTEMS

Nonetheless, the satellite systems will still falter when it comes to creating accurate location fixes indoors. A handful of indoor-positioning systems (IPS) have been developed, but they mostly rely on WPS or some sort of less accurate, hybrid GPS method (e.g. the phone captures GPS coordinates, then uses sensor data from its digital compass, pedometer, barometer and accelerometer to determine indoor locations). One such system was developed by Broadcom, which in 2012 launched a smartphone chip that supports GPS, WiFi, and Bluetooth. The chip makes note of the phone's entry point (via GPS) then counts steps, directions, and altitude by relying on sensor data produced by the accelerometer, gyroscope, and altimeter, respectively. Given the modest rates of smartphone proliferation in developing countries, adoption of these technologies is lagging relative to some of the commercial, more social uses (e.g. applications which provide parents real-time monitoring of their children's indoor locations, or those which can identify, for users, the number/location of other users, in the same application, with similar interests, or even automate pings and phone calls based on locational positioning) that have spurred in higher-income economies. The potential functionality is limited only by the imagination of the developers. On the other hand, the widespread penetration of such functionality is limited by security and privacy concerns when it comes to data, as well as—again—general connectivity and affordability.

Other companies, like Nokia, are experimenting with the use of Bluetooth beacons and sensors to enable offline, low-energy location based services. With the correct application (e.g. INSITEO for Android or indoo.rs for iOS and Android), the newest iteration of Bluetooth—Bluetooth 4.0 or Bluetooth LE—enables users who have set up, tagged (fingerprinted), and registered a handful of customized Bluetooth beacons to send and receive signals between the handset and the beacons in order to provide real-time localized information and navigation indoors. For developing nations, this is more affordable than establishing entirely new WiFi infrastructures at the macro

level. However, individual users may find this system costly, as they will be required to order large numbers of beacons in order to offer much greater accuracy.

Some solutions are revolutionary in themselves as they require no extra WiFi or Bluetooth infrastructure whatsoever. One such solution was introduced by IndoorAtlas, a Finnish company. The method relies on the Earth's innate magnetic field to ascertain a handset's position. The Earth's entire surface emits a magnetic pulse, and with a map of these magnetic fields, users can accurately navigate the outdoors and the indoors. IndoorAtlas has developed a smartphone application which relies on the sensitivity of the smartphone's magnetometer to create magnetic field maps that are accurate up to 10 centimeters. This application populates the map as users walk around picking up new magnetic signals; eventually the application will be able to provide extensive indoor location services where magnetic maps have previously been established. Another company, ByteLight, sells a new form of technology that powers location services through LED lighting. Essentially, ByteLight has created an IPS based on visible-light communication; the technology is entirely reliant on LED lighting systems which have ByteLight compatibility previously built in. This is promising for developing nations, as most of the buildings in the world have not yet switched to LED lighting and the cost of adding ByteLight compatibility is negligible. On the other hand, it is less convenient for any present users of LED lighting systems, as ByteLight cannot be built into LED structures after the bulbs have left the factory. When LED lights have ByteLight's middleware built in, the technology powers the chips in bulbs and handles the applications that work, through smartphone cameras, to identify the unique ID of each lamp. It does not require any beacons or networking equipment. ByteLight controls the pulses of LEDs to generate certain patterns; these patterns are picked up by the camera in smartphones or tablets and, by using the data from the LED transmission, a device can work with an app to perform client-side (as opposed to server-end) calculations and locate the device's whereabouts indoors.

IPS will become very important in the coming years as indoor LBS (e.g. in hospitals or schools) becomes essential for development outcomes. The ability to deliver automated services in the public sphere based on a beneficiary's indoor location will be paramount in creating

stronger feedback loops and engaging citizens in policy-making decisions. Consider the possibility of serving valuable instructions or digital documentation pertaining to business registration, directly to a citizen's mobile device via an application or web service that recognizes when the entrepreneur has entered the building housing the local business registrar's office. Smart Cities can be made even smarter by incorporating IPS technologies in order to create indoor maps of major commercial, municipal, and government centers.

2.3.4 OTHER TECHNOLOGIES

As costs are driven down and infrastructures improve, a handful of newer technologies will become available in the developing world. For instance, Broadcom has introduced a battery-conserving GPS chip for smartwatches. Such watches will initially permit wearers to collect geotagged fitness and health data. In the future, the watches may be used to monitor continuous tracks of locational data and as complementary devices to validate GPS data generated by mobiles—not to mention the convenience of a wearable, as opposed to a handheld, device.

Another (relatively expensive) wearable device that has yet to widely penetrate consumer markets is enhanced spectacles, such as Google Glass. The hands-free smart eyewear is classified as a wearable computer with a head-mounted, transparent optical display that reflects images for the user and displays information in a smartphone-like format. Through voice commands, users can take pictures and videos, make calls, send messages and emails, request navigation, as well as other features typically associated with handheld mobiles. Furthermore, like smartphones, applications for collecting geospatial data and geotagged media files exist. BAE Systems recently introduced the GXP Explorer Snap app which “enables Google Glass users to quickly snap photos and record a report title and brief description using only their voice. The report is automatically geotagged, timestamped, and uploaded to a GXP Explorer server, where it is immediately shared and accessible to the rest of the enterprise. The hands-free benefit makes it an ideal technology for use in reconnaissance missions and disaster relief operations” (Ratzer, 2014).

Google has been one of many driving forces behind geospatial-related initiatives—from its highly adaptable

smartphone platforms (Android, Google Glass) to its popular, adaptable mapping software (Google Maps). However, perhaps Google's most intuitive contribution is the advent of data-collecting vehicles. These cars are equipped with a handful of technologies and sensors which enable 3D locational data to be collected, stored, and utilized to improve Google Maps. The data includes images which endow street views of georeferenced locations. Google is also working on another type of car—a driverless one. These cars use sensors, a handful of optical devices, and built-in navigation systems to safely move through streets; they have been tested in the following U.S. states: California, Nevada, Michigan, and Florida. The prospect of a driverless car, equipped with the data collection tools from the Google Maps cars, presents many opportunities for quickly collecting locational data in the field in hard-to-reach areas. This is especially true in fragile or conflict-ridden states where field workers' lives may be in danger. Furthermore, like the ability of Google Glass to pull data from paired mobile devices or laptops, innovations in driverless cars could theoretically enable real-time data collection and streaming to paired devices. This could further improve monitoring processes in infrastructure projects, identify structural and transport problem areas in marginal communities, and empower field workers in a handful of industries to remotely observe and track achievements or setbacks for a given project.

At the consumer level, Google is apparently poised to introduce a 3D imaging tablet that puts its street view technology into the hands of users.⁹ As might be expected, applications for these new devices lag behind the availability of the technology, but the potential applications are limited only by imagination.

The power of the technologies described in this chapter, and of the data they capture, will be discussed below in a handful of specific cases, mainly focused on aid programs. It should be noted that the applications currently used in the development community lag some way behind the potential described here, but there is a catching-up process underway. This chapter has provided a brief technical overview of how the technologies interact with one another and with the data they generate. It is not meant to be a guidebook for developers or designers who have chosen to incorporate geo-enabled functions into their existing tools and applications. For that purpose, it is recommended that mobile and web developers turn

to development kit guides and tutorials provided directly by the originator of the desired platforms, tools, and applications.

ENDNOTES FOR CHAPTER 2

¹ Trilateration incorporates distances into its mathematical process while triangulation is strictly a geometric calculation based on angles.

² See, for instance, ProFor (2014) Information and communication technology for Forest Law Enforcement and Governance; Lessons from a Two-Country project in LAO PDR and Moldova, page 14, 50.

³ Pajat Solutions Ltd. (2014) NetHope.org Poimapper Case Study, http://solutionscenter.nethope.org/case_studies/view/poimapper-real-time-field-data#

⁴ Wikipedia (2014) “GPS Exchange Format”, http://en.wikipedia.org/wiki/GPS_eXchange_Format

⁵ Wikipedia (2014) “Shapefile”, <http://en.wikipedia.org/wiki/Shapefile>

⁶ QGIS.org (2014) “Vector Data”, https://www.qgis.org/en/docs/gentle_gis_introduction/vector_data.html

⁷ Wikipedia (2014) “Keyhole Markup Language”, http://en.wikipedia.org/wiki/Keyhole_Markup_Language

⁸ See BBC (16 June 2014) <http://www.bbc.com/news/technology-27868703>.

⁹ See BBC (24 May 2014) <http://www.bbc.co.uk/news/technology-27538491>.

CHAPTER THREE

A CONCEPTUAL FRAMEWORK FOR STUDYING LOCATIONAL DATA APPLICATIONS

While the science of delivery can be improved using a variety of innovations, technologies, and techniques, the focus of this study is on how it can be enhanced by using applications and other software-based solutions that use locational data on mobile phones. The focus is on general-purpose mobile phones rather than specialized devices (such as GPS trackers) and on consumer-market devices which are affordable to the broad mass of users.

This question is answered by presenting applications and real-life cases where the applications have been used. The applications presented are related to mobile phones and their ability to track the phone and its user, using at least one of the technical possibilities presented in the previous chapters. The presentation of applications, and cases where they have been used, is carried out in sections 4.1-4.4. These are then presented and compared with each other in section 4.5. The tables presented in section 4.5 are intended to provide a diagnostic tool to assist potential users in identifying which of the applications reviewed is best to use for different objectives and in different aid delivery programs. In addition to applications and cases presented, location-based Big Data can also be used, for example, in development-related research and policy-making. In section 4.6, some cases where Big Data has been used successfully in development interventions are presented.

When reviewing applications, cases and Big Data solutions, three frameworks are used to provide a conceptual framework. First, learnings gained from the implementation of Ushahidi following the Haiti Earthquake Project (Morrow et al, 2011) are used. Second, when presenting the applications and the case studies, and when making qualitative comparisons, an ISO standard called SQuaRE (Software product Quality Requirements and Evaluation) is used as a loose framework. Third, implementation challenges are briefly discussed. Since these three frameworks consist of a large number of factors, an umbrella synthesis framework, consisting of two simple research questions, is built from them and presented in section 4.5. Because of the nature of this research, the frameworks are applied in an agile manner. They provide a backdrop for presenting and benchmarking applications and case studies, but are followed in an interpretative qualitative manner.

3.1 METHODOLOGICAL FRAMEWORKS

3.1.1 USHAHIDI HAITI PROJECT REVIEW FRAMEWORK

In their review paper “Independent Evaluation of the Ushahidi Haiti Project” (2011), Nathan Morrow at al present and evaluate a development aid project conducted between 2010 and 2011 in Haiti. The Ushahidi Haiti Project (UHP) was a large-scale volunteer-driven effort to produce an application-based crisis map after the devastating January 2010 earthquake in Haiti.

While the review paper presents and reviews the UHP case in general, and while it presents the use of the Ushahidi platform in the Haiti case in detail (Ushahidi is one of the cases presented in chapter 4), the paper also provides a framework, or a set of research questions, for evaluating the impact of a certain application. That framework is also used in this research paper, for example as part of the umbrella framework presented later, and while summarizing the research in the final chapter. The UHP framework consists of four factors, or sets of categorized questions. They are:

- » **Relevance:** to what extent does the application address the needs of beneficiaries?
- » **Effectiveness:** to what extent did responders actually make decisions based on the information the application provided? Why was the information used or not used?
- » **Efficiency:** how did the application add value to a project?
- » **Sustainability:** what has the application created? For example, has it created new groups, has it been institutionalized, or has it stimulated commitment from donors or other actors?

3.1.2 SYSTEMS AND SOFTWARE QUALITY REQUIREMENTS AND EVALUATION (SQUARE)

In addition to using Ushahidi Haiti Project review’s framework, the ISO standard SQuaRE (ISO/IEC 25010:2011) is used loosely as a tool for describing both applications and their use cases. SQuaRE is an

international ISO standard. It is used to describe “the relationship between a quality model, its associated quality characteristics and software product attributes with the corresponding software quality measures, measurement functions, quality measure elements, and measure methods” (Lepmets et al., 2011).

In SQuaRE, the attributes the standard describes are:

- » functional suitability,
- » reliability,
- » usability,
- » performance efficiency,
- » maintainability,
- » portability,
- » security and
- » compatibility.

In a thorough SQuaRE analysis, the quality of a software application can be evaluated by measuring its internal attributes (typically by evaluating the application’s static measures), its external attributes (by evaluating the behavior of the application’s code) or by the quality of the application’s attributes (by an examination of the use of the application) (Lepmets et al., 2011). In this research, we will focus on the third metric: the qualitative attributes of each application.

3.1.3 THE CHALLENGES OF IMPLEMENTING NEW TECHNOLOGY IN DEVELOPING COUNTRIES

When applications are implemented in new environments, such as developing countries, they often face a common set of problems. The general challenges of implementing new technology are well researched and documented. For example, according to Annie Evans (2013), implementation manager for CompassLearning, there are ten general challenges that an implementable technology will face:

1. Avoiding using technology for technology’s sake: is the application really useful?
2. Creating a vision: is the vision behind the application really good?
3. Money: where does the funding come from?
4. Professional development: is the development process of an application done properly?
5. Getting everyone onboard: how to win over naysayers with the technology?

6. Scheduling of use: where and when is the application used?
7. Good systems and procedures: making functional systems, and taking account of the challenges in environment, such as poor connectivity.
8. Unlocking motivation: how to keep users motivated?
9. Data and progress monitoring: follow-up and, when necessary, update goals.
10. Maintain enthusiasm: keeping users and developers enthused over the potential outcomes.

Beyond general challenges in software implementation, there are some additional challenges in implementing applications in the developing world. For example, Edward F. Hsieh argues in his paper “Investigating Successful Implementation of Technologies in Developing Nations” (2005) that certain common factors can be identified which are important to sustainable technology implementation in developing nations.

According to Hsieh (2005, 16), the most important factor is the ability of the community to maintain the product. The next most important factors were the local need for the technology and the ability to produce the technology locally.

In Hsieh’s paper, other relevant factors when implementing technologies in developing countries include the issues of participation (including the participation of international NGOs or local governments) and the question of finance. Hsieh argues (2005, 17) that the financial support given by an NGO or some other partner can work to either help or hinder the success of the project: “The problem [that] can arise is that the community becomes dependent on the subsidy, and abandons the project when the NGO program ends.”

While implementing technologies in developing nations, a broader context of successful development aid projects should be taken into consideration. While opinions vary on which methods of development aid are the most beneficial, Kosack (2002) argues that those which seek to improve the quality of people’s aid are often the most effective. He links successful development aid projects to efforts to encourage democratization. This is something that arguably can be advanced using the survey-based applications described in the first part of chapter 4, but would not necessarily apply to Big Data applications.

For the future of the applications and technologies presented, it is vital for companies, volunteers and activists working with the technologies to identify the challenges of implementation and to understand the broad context of development aid. Since the technologies presented here have been in use only recently, it is also evident that their challenges have not been researched thoroughly. Thus, it remains to be seen which applications can tackle the challenges they face, and follow-up research on the challenges the technologies face is needed.

3.2 PROPOSED FRAMEWORK FOR THE PRESENTATION OF CASES

The following chapter presents several applications, use cases, and Big Data solutions which use at least some of the technological possibilities presented in chapter 2, and which might be expected to enhance the science of delivery. A synthesis between the two frameworks briefly described earlier—UHP review, SQuaRE, and the implementation challenges—is applied, using qualitative interpretation.

In this synthesis framework, a set of research questions are posed:

1. What are the key features of the applications?
This question derives especially from the SQuaRE framework, but also from the learnings of implementation challenges and UHP review.
2. What are the key learnings and outcomes of cases where applications have been used? This question derives from the UHP review, but also from the learnings of implementation challenges. This question is answered after the presentation of each case.

All the applications and cases are presented in a similar structure: beginning with a description of the application and the vendor and following with a series of use cases and a brief summary of outcomes achieved.

Following the presentation of survey data applications and cases in sections 4.1-4.4, and a comparison between them in section 4.5, section 4.6 looks at the possibilities of Big Data for enhancing the science of delivery. While Big Data solutions are not directly comparable to the survey data applications, the same synthesis framework questions are posed.

The concluding chapter returns to the initial frameworks of UHP, SQuaRE and to implementation challenges, and discusses what has been learned from the analysis of the cases. There are also further questions posed by the research, in particular concerning security and privacy issues, that are beyond the scope of the current study but would be suitable for possible follow-up research.

CHAPTER FOUR

CASE STUDIES OF LOCATIONAL DATA

This chapter presents a series of mini case studies of mobile applications that use location-based data for enhancing the delivery of development assistance. It also presents real-world cases where the applications have been used, and analyzes the applications presented in a series of comparative tables. The applications are reviewed based on the synthesis framework provided in chapter 3.

The survey data applications presented are Poimapper, Ushahidi, CommCare, CommTrack, and Taarifa. While there are other applications that use locational data for development aid purposes, some pre-selection had to be made, for a number of reasons. These five applications were selected, based on the following criteria:

- » They provide a representative view on the use possibilities of different mobile-based technologies described in chapter 2.
- » They have both similarities and clear differences with each other, and can be relatively easily compared.
- » They have already proven successful in documented real-life cases, and they show good potential for replication and scaling up.
- » They are among the better known and documented applications.

In addition to the aforementioned survey data applications, there are also cases where Big Data approaches have been used to enhance the science of delivery. While Big Data and its use cases are not directly comparable to the survey data applications presented, they nevertheless provide an interesting possibility to develop research and policies to improve societies. Various sample cases are explored in section 4.6.

4.1 POIMAPPER

4.1.1 OVERVIEW

Poimapper is an application for collecting location-based point-of-interest (POI) data, developed by Pajat Solutions Inc, a Finnish software company, in cooperation with Plan International. Poimapper is a tool for “collecting and utilizing point-of-interest (POI) data with cost-effective mobile technologies”.

Poimapper is a multiplatform application, which is used to collect, view and share data gathered about POIs. Poimapper is typically used by field workers, experts, or



Mobile data collection with Poimapper empowers your field workers and managers.

1. Build forms  2. Collect data  3. Monitor & Analyze 

Allows mobile users to collect, share, and visualize geographically tagged data in real-time. We support teams in rural health care, industrial inspection, international development and market research.

How will you use Poimapper?



Figure 4.1. Poimapper offers a multiplatform way to gather location-based point-of-interest data. Source: <http://www.poimapper.com>

volunteers of development aid organizations, but it can also be used for other data collection and analysis. The targeted users are organizations carrying out point-of-interest-related development aid projects, their field workers, and management-level employees.

According to Pajat, the primary development emphasis of Poimapper has been on its usability. The application is designed to be simple to use, even for people with very little experience with mobile phones, and it can be used by a wide variety of mobile phones, ranging from the latest smartphones to cheaper feature phones, as long as they are equipped with a camera and a GPS unit.

The secondary guiding principle in the development of Poimapper is that the application has been built for use in “rough” conditions. It can store data in offline mode, and it can be used without a reliable mobile network.

The key capabilities of Poimapper allow field workers, for example, to:

- » Define and maintain points of interest, routes and

areas, from which data (text, numbers, single/multiple choice alternatives, conditional questions, pictures) is collected;

- » Collect data using a multitude of platforms, along with other people using Poimapper via different mobile platforms;
- » Edit and add to the collected data;
- » Upload (or download) collected data to/from a database, using either cellular network or a computer with an Internet connection; and
- » Research, display, maintain and visualize information.

The data gathered using Poimapper can be accessed, administered, edited, and visualized using a web application, and accessed via a computer with a service-compatible browser. The main focus of visualization is in maps: data is presented via a map interface, using both Google Maps and OpenStreetMaps.

Technologically, Poimapper is offered as three versions: as a J2ME implementation (introduced in 2010), as an Android application (2011), and as a HTML5 application (spring 2014). It uses a PostgreSQL database, stored in a large commercial cloud service.

4.1.2 POIMAPPER USE CASES

Tuberculosis Monitoring (with Plan Thailand)

Tuberculosis Monitoring is an ongoing project where Poimapper is used to track tuberculosis (TB) treatment in the Chiang Rai province of Thailand. The project is coordinated by Plan Thailand with the objective “to strengthen migrants and ethnic minorities to be NGO-organized Community-Based Volunteers (CBV)/Migrant Health Volunteers (MHV) to do Directly Observed Treatment (DOT) provision and/or treatment for TB care, including TB suspect referral.”

The Directly Observed Treatment watcher will support patients’ daily tuberculosis treatment, under supervision by community-based volunteers and/or migrant health volunteers (CBV’s and MHV’s) and Plan Thailand’s staff. Poimapper is used to collect information relating to tuberculosis patients when they are visited by staff. In 2011, the project had approximately 20 Poimapper users.

Key outcomes and results

The following key outcomes in using Poimapper in tuberculosis monitoring project have been identified:

- » Poimapper has helped to update the project’s progress more quickly. Project staff can update information on patients immediately.
- » The information collected using Poimapper has helped to estimate the prevalence of tuberculosis in a given area. If the area has a high prevalence, it can be targeted for appropriate follow-up by researchers and policy-makers.
- » Tuberculosis patients received follow-up care continuously: patients were monitored and visited more systematically than before.
- » It was possible to change staff during the project, since all relevant data—including the locational data of residence of a patient—were stored and easily accessed. A new MHV could easily pick up and continue a colleague’s work.
- » Staff could see the history information of a certain area, and could see a whole picture of the incidence of tuberculosis in a given region.
- » The design of information collected using Poimapper facilitates reporting by Plan Thailand to the donor.

- » Poimapper “is estimated to save 3 days/month work time for health volunteers and 2 days/month for field officers” for Plan Thailand’s project.

Plan Thailand’s tuberculosis program manager said that monitoring visits and proper treatment programs would not have happened on such a scale if Poimapper had not been used.

Early Intervention Oral Cancer Screening Program (with Biocon Foundation, India)

Poimapper was used in India by the Biocon Foundation, by their field workers and communal health workers, to improve oral healthcare in rural areas.

According to Biocon Foundation (Pajat and Biocon, 2013), oral cancer represents around 40 percent of all cancer cases in India (compared to just 4 percent in UK). Oral cancer is a major problem in rural areas of India, and thus it is a large-scale problem, since rural India contains over two-thirds of India’s population, with half living below the poverty line. Chewing betel, paan and areca (and other tobacco-related health risks) are known risk factors in developing oral cancer. Early intervention against tobacco-related habits and early diagnosis of oral cancer are critical issues when reducing the number of oral

IN THEIR OWN WORDS

PAJAT

“Poimapper is developed by Pajat Solutions Ltd, a mobile software solutions company with personnel in Finland and development partners in Kenya and in India. Pajat key personnel have a long track record of developing new technologies and businesses both in small companies and in large multinationals. We believe innovation will be increasingly driven by major opportunities in Asian, African and Latin American growth markets. Our mission is to provide affordable, useful and meaningful mobile solutions that are globally relevant. We also provide consulting services, including ICT4D.”



Figure 4.2. Using Poimapper in tuberculosis monitoring. Source: Pajat and Biocon (2013).

cancer cases in India.

According to Biocon Foundation, “community health workers provide primary healthcare in rural areas, but lack skills to perform oral cancer diagnoses.” To address this problem, Biocon equipped community workers with mobile handsets using Poimapper. Field workers took photos and videos of the mouths of people at risk of oral cancer and stored the images and locations of patients in a database. Doctors who studied the images were able to diagnose the patients remotely, using web applications. Data collected by Poimapper was uploaded to OpenMRS, an open source medical health record data system.

Key outcomes and results

The early intervention project was executed in two sites in Karnataka, India: Mangalgudda village and Anakanur village. A total of 583 people were screened. Of those, 66 had lesions and 56 needed a biopsy. A typical person with lesions was a male of 40+ years.

According to Biocon Foundation, early intervention screening can help people to change his or her tobacco-related habits, and thus reduce the possibility of contracting oral cancer.

The information collected also:

- » gave doctors 24/7 access to oral cancer information, which reduced the time for patients to start the treatment;
- » gave patients medical assistance right “at their doorstep;”
- » made tracking the progress of patients easier;
- » made planning of follow-up treatments possible;
- » made it possible for doctors to help, supervise, and

research large regions, and

- » reduced general healthcare costs, thanks to early intervention procedures.

4.2 USHAHIDI

4.2.1 OVERVIEW

Ushahidi is a not-for-profit technological corporation, based in Kenya, which specializes in developing free, open source software for data collection, visualization, and interactive mapping. Its leading product is the Ushahidi Platform, a web application to “easily crowdsource information using multiple channels, including SMS, email, Twitter and the web”. Other Ushahidi tools include Crowdmap, a tool for “anyone wanting to tell a story with a map” and Ping, a simple app which allows “teams to check-in with each other” (Ushahidi.com).

According to Ushahidi (2014), “the platform is used worldwide by activists, news organizations and everyday citizens.” It is an application used especially for crowdsourcing projects: Ushahidi Platform is used to collect bigger portions of data from larger crowds.

Use cases suggested by Ushahidi are:

- » Monitoring elections. “Using the power of the crowd to monitor and visualize what went right and what went wrong in the election.”
- » Mapping crisis information. “Whether it’s a natural disaster, epidemic or a political crisis, the tool can be used to handle information coming out of a crisis.”

The possible stakeholders in these use examples could be, for example, NGOs or other larger organizations interested in monitoring elections, or even active tech-savvy individual citizens, who are interested in building crowdsourcing-related projects. However, since Ushahidi is a platform as much as an application, many other use cases—and thus possible stakeholders—can be recognized, from commercial uses to needs of individual active citizens.

The key features of the Ushahidi platform are:

- » That it can collect information from several different sources, such as SMS messages, MMS messages (images, video), and smartphone applications.

- » The information collected is usually shown on an interactive map, accessed over a web interface.
- » The information can also be visualized using a timeline: reports from a certain location can be seen in chronological order, allowing for instance to visualize reports at different times of the day or week.

The primary developmental emphasis of the Ushahidi Platform lies in its adaptability. The Ushahidi Platform can be adapted for use in many different scenarios. The platform is designed to be easy to use, from the perspective of the end-user. This is intended, for example, to encourage ordinary citizens to become content providers and to facilitate “citizen journalism.”

To start using the Ushahidi Platform, it needs to be installed on a server, which uses one of the Ushahidi-supported operating systems (OS). The Ushahidi Platform uses a MySQL database and the Google Maps API for geocoding information provided to the platform. Installing, configuring, and administering the Ushahidi Platform requires high-level knowledge in installing and administering server-side software.

In addition, Ushahidi provides a ready-made hosted version of the platform, called Crowdmap “Classic,” which offers some of the functionality of the Ushahidi Platform. Crowdmap “Classic” is not as configurable, as flexible, or as secure as a dedicated Ushahidi Platform installation. However, Crowdmap “Classic” might be a sufficient solution for some straightforward cases of location/time-based data collection and visualization.

IN THEIR OWN WORDS

USHAHIDI

“Ushahidi—a Swahili word which means ‘testimony.’

“We build tools for democratizing information, increasing transparency and lowering the barriers for individuals to share their stories.

“We’re a disruptive organization that is willing to take risks in the pursuit of changing the traditional way that information flows...

“Since early 2008 we have grown from an ad hoc group of volunteers to a focused organization. Our current team is comprised of individuals with a wide span of experience ranging from human rights work to software development. We have also built a strong team of volunteer developers primarily in Africa, but also Europe, South America and the U.S.”

4.2.2 USHAHIDI USE CASES

Map of Russian wildfires

The Russian Federation experienced a heat wave during the summer of 2010. Wildfires caused by the heat wave were a major challenge which required a rapid response. Many people lost their homes and property, and officials and journalists faced several challenges in addressing the problem. But a volunteer project called “Help Map” was built using the Ushahidi Platform.

Help Map was used to 1) crowdsource and map unprecedented wildfires, and 2) to offer help to individuals

who had suffered losses because of the wildfires. With Help Map, people in need were connected to people willing to help.

Ushahidi was used to aggregate two kinds of reports from the general public.

Those in need of help answered the question “what is needed?” Those who were willing to help responded by reporting “I wish to help.” Offers to help included transportation, food, clothing, homes and shelters, etc. (Mora, 2011).

The project started as a Ushahidi Crowdmap “Classic” project, but was soon migrated to an independent Ushahidi Platform service running on an independent server, that can still be seen at <http://www.russian-fires.ru>. According to Global Voices Online (2010) magazine, the project “quickly became an important base for volunteers to provide resources and lend a hand during weeks of crisis” and it is one of the most successful uses of Ushahidi so far.

Messages sent to the Ushahidi Platform included tweets, emails, SMSs and web form submissions. Messages

were analyzed and, as in other Ushahidi implementations, were categorized, geolocated, verified and mapped. When location data could not be automatically determined, users were actively encouraged to indicate their location on a map, for more precise localization. (Mora, 2011).

Key outcomes and results

According to Mora (2011), outcomes reported from the Help Map project included:

- » People in need were successfully connected with people willing to provide help during the wildfires.
- » Implementation of Help Map revealed the altruistic potential of the Russian society, especially in light of the tardy response from government officials.
- » Online communities and Internet users took on responsibility in helping people in need, and demonstrated that the Russian online community is not a passive audience.
- » The willingness to help of the Russian online community took on new, more creative forms.

The Help Map community, for example, helped to develop volunteer firefighter units. The Internet provided a platform for 24-hour coordination of help and exchange of help information, and Help Map was one of the core hubs in this.

Similar examples include responding to the Haiti earthquake of 2010.

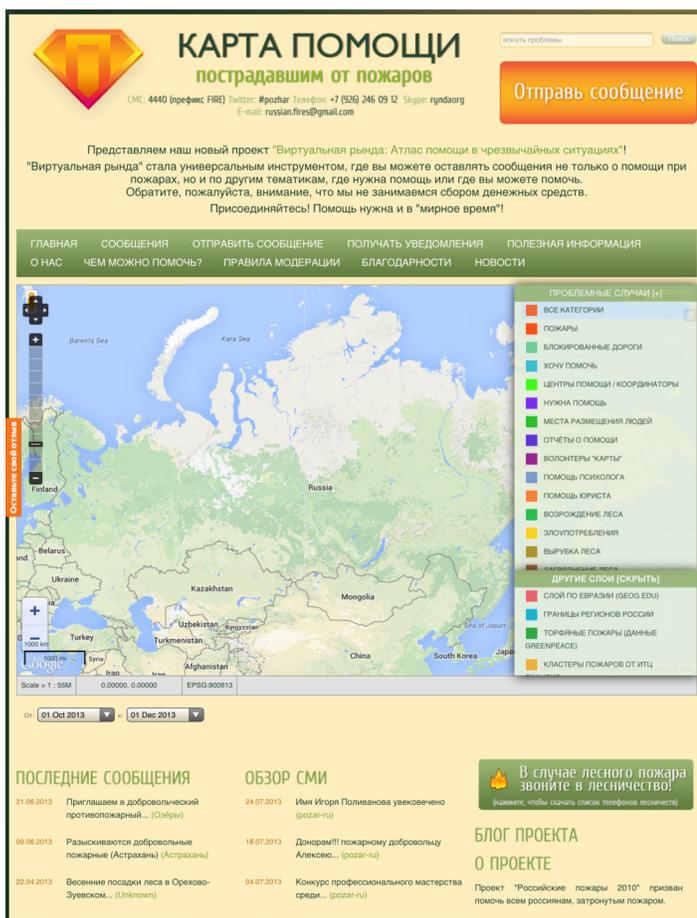


Figure 4.3. Ushahidi used in Help Map. Source: <http://www.russian-fires.ru>

Uchaguzi: communicating with the public on the Kenyan Referendum

The initial impetus for creating Ushahidi came in the wake of the post-election violence in 2008. With more time to plan, in 2010 Ushahidi collaborated with several partners to create and utilize the “Uchaguzi-Kenya” platform. The platform, built using the Ushahidi Platform, was built to be a channel for Kenyan citizens to communicate openly about the 2010 Kenyan referendum on the new Constitution, where similar violence was feared.

- The goals of Uchaguzi-Kenya were to
- » provide space for information sharing and collaboration;
 - » amplify the voices of Kenyan citizens;
 - » increase the efficiency and transparency of

election monitoring systems, and

- » Create a mechanism through which citizens could monitor and report incidents witnessed in election locations and the election process in general.

Uchaguzi-Kenya was a joint operation of Ushahidi, CRECO, SODNET, HIVOS and Urala. According to the broad case study (Uchaguzi – A Case Study, 2012) carried out on the Uchaguzi-Kenya project: “Uchaguzi was a new endeavor, not only in technology, but also in partnerships and information flows.”

In Uchaguzi-Kenya, information from election locations was collected mainly from SMS messages, but tweets and emails were also sent to report information from voting locations. A broad communications campaign was initiated to encourage people to send SMS messages if they saw incidents worth reporting during voting—not only reports of violence, but also evidence of peaceful public participation.

In addition to encouraging the general public to send information, a number of CRECO volunteers were trained to use the pilot Uchaguzi platform. The volunteers sent information to Uchaguzi by using a predetermined code card: using predetermined codes enabled volunteers to send more structured information in short form.

During election day, some 550 CRECO volunteer election monitors sent SMS information to the platform. In CRECO offices, 10 staff members analyzed and mapped the data sent and, when necessary, provided user support for volunteers.

During the election process, a total of 2,492 Uchaguzi messages were received (1,900 SMS, 571 Twitter, 21 email). Some 51 percent of these reports were verified.

Key outcomes and results

The “Uchaguzi-Kenya” initiative was later benchmarked by Ushahidi, Knight Foundation and the Harvard Humanitarian Initiative. They found that the Uchaguzi-Kenya platform was a general success (Uchaguzi – A Case Study, 2012). The platform was also an example of using the Ushahidi Platform in conditions where smartphones were not widely available.

According to the report, the main successes were 1) its collective approach to problem solving, and 2) strong leadership which focused on overall goals of the project.

During the voting in the 2010 Referendum:

- » a relatively high number of reports were sent from

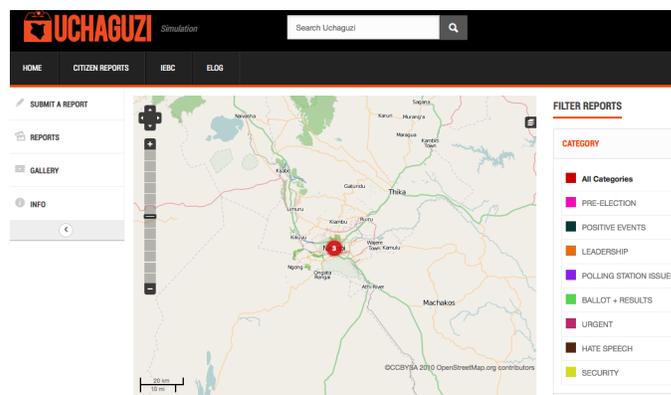


Figure 4.4. Uchaguzi-Kenya screen capture. Source: Uchaguzi.

a geographically representative range of different voting locations;

- » over 1500 “actionable” reports were sent from voting locations, and 194 “action taken” reports were eventually sent;
- » marketing was (partially) successfully used to advocate active citizenship and use of the Uchaguzi platform;
- » different organizations collaborated successfully in using and advocating a new technology, and
- » a significant number of volunteers were successfully trained to use and advocate the Uchaguzi platform.

Since the first usage of Uchaguzi in 2010, similar initiatives have been successfully implemented in general elections in Tanzania (2010), Zambia (2011) and again in Kenya (2013).

One of the key changes from 2010 to 2013 was the implementation of smartphone applications: during the general election of Kenya in 2013, people could send information from election sites using SMSs, tweets, emails, and web-based forms, and downloadable apps were available on devices running iOS and Android.

4.3 DIMAGI COMMTRACK AND COMM CARE

4.3.1 OVERVIEW

Dimagi is an American social enterprise, founded in 2002. It offers several applications for improving the science of delivery, including CommCare and CommTrack.

According to Dimagi, their CommCare tool is “an easily customizable mobile platform for frontline workers to track and support their interactions with clients,” while CommTrack is “a tool for mobile logistics and supply chain management.” In addition to these applications, Dimagi also provides developer frameworks for building new SMS/web applications (RapidSMS) and Android-based survey tools (Open Data Kit), but these tools are not presented or discussed here.

Dimagi CommTrack

Dimagi describes CommTrack as “a mobile logistics management system for low-resource settings.” It is a multiplatform, open source application used to improve stock tracking, requisition planning, and delivery acknowledgement.

CommTrack’s original purpose was “to support health workers and other mobile agents who manage commodities in low-resource settings”. But it can also be used in other field cases, for instance:

- » to monitor stock activity and capture logistics data, i.e. the in-stock status of certain tracked items, and where the items currently are;
- » to track and approve specific stock-related orders, and
- » to report indicators on various forms of non-stock data, such as the number of cases treated in a medical program.

Stakeholders potentially interested in CommTrack might be, for example, organizations interested in the delivery of development aid in its most narrow sense: for instance, the delivery of goods or other stockable items, such as emergency food supplies or medicines.

Using the mobile interface, a field worker can send and receive stock updates over SMS messages, over an offline phone application, using a smartphone application, or using a web interface. Location metadata is stored to

updates when possible.

The web interface of CommTrack can be used to visualize stock data and field worker activity through reports, graphs and map visualizations. If location metadata is included in data sent from the field, stock data can be visualized in real-time over a map layer.

CommTrack gives both field workers and managers real-time information on supply and demand indicators of supplies tracked. This makes streamlining requisitions and delivery possible, and thus can speed the supply chain.

Data collected by CommTrack can be shared between different applications via an open API. New applications can also be built, to contribute relevant information to CommTrack’s database. The information is generally stored to Dimagi’s cloud service, but it is possible to install CommTrack to a completely independent server environment. Dimagi offers different “services” and “plans” for user organizations, ranging from free solutions to tailored enterprise options.

CommTrack is currently used, for example, in Tanzania, Ghana, Malawi and Uganda. In Tanzania

IN THEIR OWN WORDS

DIMAGI

“Dimagi is a privately held social enterprise founded in 2002 with its headquarters in Cambridge, Massachusetts, USA.

“We deliver open and innovative technology to help underserved communities everywhere.

“At Dimagi, we believe that many of the world’s problems can be assuaged with low-cost technological solutions.

“The developing world stands to massively benefit from the technological advances that have been made in recent years, and Dimagi wants to bring those benefits to fruition.”

alone, CommTrack technology is used in over 2,300 facilities.

Dimagi CommCare

Dimagi's CommCare solution is an open source platform which Dimagi describes as a "job-aid for mobile workforces," a "tool for supervision and evidence-based change," and a "way to capture data in an electronic repository that otherwise sits in thousands of paper notebooks" (Dimagi 2014).

The goals of CommCare are 1) to enable data-driven management with visibility into performance, and 2) to improve access, quality, experience, and accountability of services.

CommCare consists of two technology components: CommCare Mobile and CommCareHQ. CommCare Mobile can be used by field workers to

- » gather survey data, such as health-related information (images, videos, text responses, bar codes, etc.) about patients or other subjects,
- » record images and videos to add extra content to the data collected,
- » add GPS coordinates to the data collected, and
- » educate by showing video, audio, and image prompts and guides for health services or other services provided.

The mobile application sends information to and synchronizes itself with cloud-based database application CommCareHQ. It is used by a compatible web browser to, for example,

- » analyze information collected using CommCare Mobile (and web forms),
- » visualize and display information, also using map layers to provide locational information,
- » build surveys and other methods for collecting data with the mobile application, and
- » manage field workers and their user permits, as well as other data relevant to the mobile application.

CommCareHQ analyzes data uploaded from a mobile application in real-time. CommCareHQ then synchronizes data with mobile clients when a network connection is available.

CommCare Mobile is a cross-platform product with support for low-end Java and Android phones and tablets.

As with CommTrack, Dimagi offers various plans for using CommCare, ranging from small-scale, cost-free options to solutions offered for major corporations or governmental partners.

Currently CommCare is actively used in 180 projects across 40 countries. Over 6 million forms have been submitted using CommCare.

4.3.2 DIMAGI USE CASES

Dimagi CommTrack: cStock—supply chains for community case management, Malawi

CommTrack technology was used in Malawi in a large project called cStock, a collaboration between JSI Research & Training Institute, the Bill & Melinda Gates Foundation, and the Malawi Ministry of Health.

Health Surveillance Assistants (HSAs) in Malawi carry and prescribe a predefined list of medicines such as antibiotics and anti-malarials. cStock software, based on Dimagi's CommTrack, was used to help with medicine distribution and management.

The goals of cStock were to:

- » improve the resupply process of medication carried and prescribed by HSAs;
- » provide a mechanism for health centers and district managers to troubleshoot and prioritize product availability. This was done by automatically providing them with sufficient information on medicine carried and prescribed by HSAs.

HSAs used their personal mobile phones to send geotagged SMS messages on stock information to the cStock database on the medicine they prescribed and carried.

The cStock system automatically calculated the need for medicines in the HSA's work and reported stock levels of each HSA automatically to the correspondent health center. This made it possible for the staff of the health center to pre-pack the supplies needed before a HSA arrived. This helped to reduce the wasted trips done by HSAs, since before the implementation of cStock system, health centers often ran out of stock in medicine before the HSAs arrived.

For higher-level staff, the amount of medicine

supplied provided a possibility for real-time identification of problem areas. The locational data provided from the stock data of HSAs and health centers opened up the possibility of monitoring the overall performance of the supply chain in a given area.

cStock has been a success; it has been deployed to over 1,500 HSAs in Malawi.

Key outcomes and results

Dimagi reports many positive outcomes and results for cStock projects. According to Dimagi’s study, the application:

- » Helped community health workers save time: some 99 percent of health workers reported that cStock saved them significant time, especially since fruitless trips to health centers were eliminated.
- » Helped to more than double product availability after the implementation of cStock.
- » Improved the health/medicine reporting rates to

above 80 percent in all districts where cStock was used.

CommCare Tanzania

According to Dimagi, CommCare is being actively used in 40 countries in over 180 projects. Key organizations which have used it include World Vision, World Health Organization, Public Health Foundation of India, and Save the Children.

One of the first projects to deploy CommCare successfully was CommCare Tanzania, which started in 2010 and is still ongoing. The project is carried out in cooperation with D-Tree International and Pathfinder International, both of which have a large network of home-based care providers (HBCPs). They have a roster of clients within Tanzania, whom HBCPs visit at least once a month. The HBCPs provide social support for their clients and do screening for clinical symptoms, such as drug-related issues or other problems requiring care.



Figure 4.5. Dimagi’s CommCare open source tool allows individuals and organizations to collect field data using mobile phones. Source: Dimagi.

HBCPs collect data using CommCare Mobile. The data collection tool is a mobile application, which prompts the HBCPs to 1) ask predetermined questions from the clients they are visiting and 2) record the answers given by the patients.

The data collection tool also collects other relevant data of the clients, such as basic patient information, and can be used to track GPS coordinates and save images and videos if the device capabilities allow.

After collecting the data from patients, HBCPs upload the data collected to the CommCareHQ Pathfinder and the Tanzanian government use it to build monthly health reports. They also plan their follow-up actions according to data gathered by HBCPs.

Key outcomes and results

While proper research of CommCare Tanzania outcomes is yet to be carried out, some results have been published. For example, according to Dimagi’s case study on CommCare Tanzania (2012),

- » after CommCare Tanzania’s mobile platform implemented an SMS reminder system, the timeliness of the scheduled visits of HBCPs improved by 85 percent.
- » Currently, over 150 HBCPs use CommCare regularly. HBCPs are trained and monitored by D-Tree staff located on-site in Tanzania.

In addition, constant tracking of client cases provided both NGOs and the Tanzanian government information and tools for managing future aid processes.

4.4 TAARIFA

4.4.1 OVERVIEW

Taarifa is an open source application for information collection, visualization, and interactive mapping. The platform is maintained by the Taarifa community—a group of volunteers interested in developing the application—but is said to be moving toward a more formal structure.

Taarifa is derived from the Ushahidi project, presented earlier in this chapter. The project started at the World Bank’s Water Hackathon in London in 2012, as a solution to help deliver clean water and clean up contaminated water safely. Taarifa’s main extension to

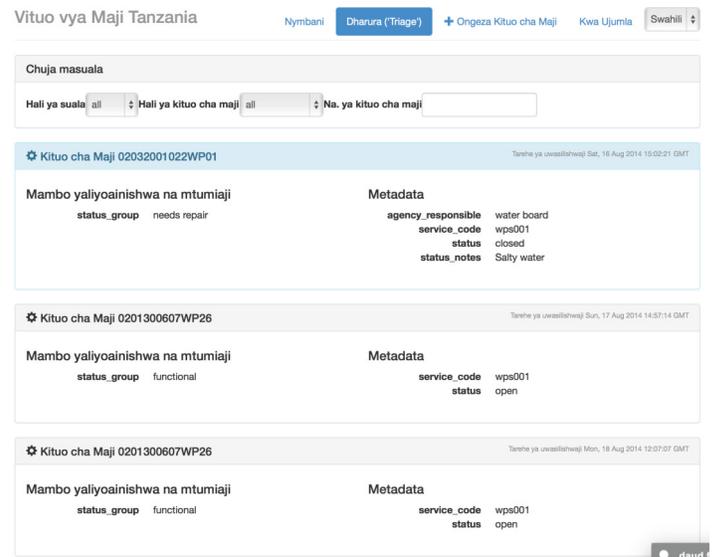


Figure 4.6. Taarifa triage screen. Source: <http://www.taarifa.org>

Ushahidi was adding problem reporting functionality to the Taarifa client (for example, a picture and description of an issue on a mobile phone) and a triaging system to the web application (a report goes through several stages before being marked as “resolved”) (Appcircus: Taarifa, 2014).

Taarifa won the first prize at the London hackathon, and has since been developed into a platform that allows all kinds of issue reporting, visualizing, and resolving.

Taarifa is primarily designed to “close citizen feedback loops.” This is done by:

- » collecting information, especially issue reports from the field, using SMS, HTML5-based web forms, emails and tweets;
- » visualizing and publishing the gathered information using simple map interfaces, and
- » sending the collected information—the issue reports—to officials.

By using the web application of the platform, the reports filed can be followed up and acted upon. For example:

1. A citizen can use his or her smartphone to fill the web form in a service using Taarifa, to report an unlicensed junkyard that has been observed. Locational data is included in the issue report, as well as a photo from the site.
2. The information on the junkyard is displayed on

IN THEIR OWN WORDS

TAARIFA

“Taarifa’s community is diverse and scattered across the world.

“They are brought together by the ideals of Taarifa in collaborating and building tools which help to shape the world.”

the web service’s map visualization.

3. Information on the issue is automatically sent to officials, who act to close and clean the illegal junkyard.
4. Officials update the web application and report the issue once resolved. This information is, again, saved to the issue report visualized on the map.
5. Citizens can see on the map that the problem has been resolved.

Taarifa helps to engage citizens and broader communities especially in the developing world: Taarifa connects the citizens who send issue reports with officials, who have the ability to fix the reported issues.

Taarifa says that it gives citizens “the power to report and address the problems around them” by using spatial information. The issue reports sent using Taarifa contain locational metadata, which is used to place the issue report to a map. With map visualizations, both the citizens and the officials can follow the sent reports, as well as the follow-up actions the reports have generated.

The Taarifa platform is built by an active community that believes in the ideals of Taarifa in collaborating and building technological solutions to help communities. Therefore the design emphasis of Taarifa has been in building a tool for activating citizens to take interest in local issues by using spatial information and map-based visualizations.

As Taarifa is an open source API and not a web service as such, a somewhat high level of expertise is needed to install, configure, and manage the service. The system requirements of Taarifa are somewhat similar to Ushahidi’s: the installation can be done on a dedicated server or to a cloud service. A MySQL database is needed. The development process is actively followed in Taarifa’s blog site at <http://taarifa.wordpress.com>, and new developers are actively encouraged to participate in building Taarifa.

4.4.2 TAARIFA USE CASES

Uganda pilot project for school construction

After winning the Water Hackathon competition, Taarifa was used in a pilot project with the Ugandan Ministry of Local Government and the Africa Urban and Water sector of the World Bank. In the pilot project the Ministry wished “to monitor local government projects based around improving community cohesion, public services and enterprise.”

The pilot project was carried out as a part of the Ministry’s “Improving Systems for the Urban Poor” program and its two sub-programs “Community Driven Development” (CDD) and “Local Government Management and Service Delivery” (LGMSD). CDD is a match-funding program, while LGMSD is a program for constructing buildings such as schools.

Traditionally the CDD and LGMSD reporting systems were paper-based. The paper forms were filled by pen, then mailed to central offices in Kampala, Uganda. The drawbacks of this system were the unreliability of the mail, the slow speed of the paper-based system, and the workload placed on the reporters. This was something that the Ministry wanted to change. (Ilffe, 2012).

In the Taarifa-based pilot program, civil servants were trained to use low-end smartphones equipped with Taarifa to upload the forms automatically to the Taarifa application. The intent was to speed up the process, make the process more reliable and decrease the workload of the field workers.

Key outcomes and results

The pilot was deemed successful by the Ugandan government. During and after the pilot:

- » Taarifa was rolled out to 111 districts in Uganda,

- » trained field workers managed to collect CDD and LGMSD information by using the smartphones provided, and
- » Taarifa was thoroughly tested in day-to-day field use, resulting in improvements to the Taarifa platform.

During the pilot, it was observed that custom forms built for smartphones worked well initially, but when field workers ventured into more distant districts, some problems with the offline mode of Taarifa were discovered. For example, it was not possible to switch between different survey forms when in offline mode. This problem was later addressed and served as a good example of connectivity problems in rural Africa and a demonstration of the flexibility of the Taarifa platform community.

4.5 COMPARING THE APPLICATIONS

The applications presented above—PoiMapper, Ushahidi, CommTrack, CommCare, and Taarifa—have successfully been used in a number of real-world cases. While all these applications can be said to enhance the delivery of development aid, at least in some way, the applications, their uses and target groups differ somewhat. From the stakeholders’ perspective, it is essential to select the right application for the right need.

Table 4.1 presents a functional analysis of the usage of the applications, while their technical similarities and differences are presented in table 4.2.

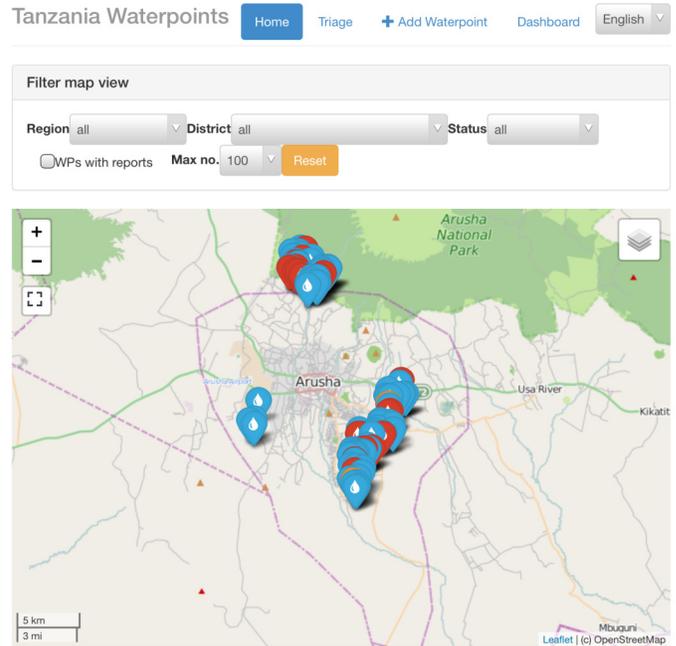


Figure 4.7. Map of waterpoints in Tanzania. Source: <http://www.taarifa.org>

4.6 USING BIG DATA TO ENHANCE THE SCIENCE OF DELIVERY

In addition to the applications and case studies presented earlier in this chapter, locational data can also be collected passively in the form of so-called “Big Data”. This can be defined as very large, complex datasets, which can be researched and, for example, visualized using

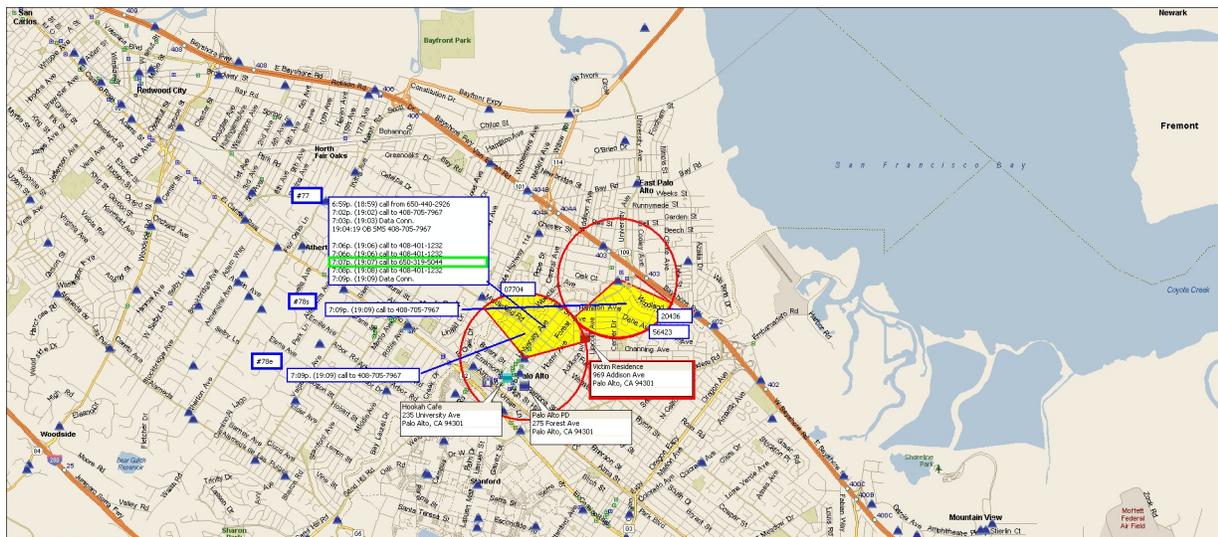


Figure 4.8. Example of localized CDR data from Microsoft Lync. Used with permission from Microsoft.

TABLE 4.1. A FUNCTIONAL ANALYSIS OF THE LOCATIONAL DATA APPLICATIONS

	Poimapper	Ushahidi	CommTrack	CommCare	Taarifa
What is it?	Application for collecting, editing, analyzing, and visualizing point-of-interest data.	A platform to collect, edit, and visualize crowdsourced data on a map.	An application for tracking inventory and the logistics of supply and demand.	An application to gather survey data, such as images, GPS coordinates, text, barcodes, videos, etc.	An application for reporting location-based issues and to track their resolution.
Typical use example	User defines what data to collect (e.g. text, photos, videos, etc.), gathers data using a mobile app, and visualizes it from the web interface.	User contributes to a crowdsourcing project by adding incident reports to a map which can then be analyzed to show the spatial build-up of incidents over time.	A field worker reports information on stock usage, on-site, using a mobile device. An office-based employee can track real-time inventory and act accordingly.	A field user records survey data to a mobile device. Data can be visualized and analyzed from the web interface.	User reports an issue that needs resolving using a mobile phone. The issue is then visualized on a map and public officials can take action.
Typical targeted users	Field workers and volunteers in NGOs and government.	Crowdsourcing volunteers and activists.	Field workers and volunteers in NGOs and governments and their managers.	Field workers and volunteers in NGOs and governments and their managers.	Citizens reporting a local issue, and officials with a responsibility to fix it.
Design features	Usability: robust and simple to use.	Adaptability: can be tailored for use in many scenarios.	Simplicity: automated SMSs assist with logistics management.	Adaptability: can be adjusted to collect many kinds of data.	Simplicity: citizen reporting made as easy as possible.
Key benefits (selected)	Can be used in “tough” environments running on various platforms.	Highly flexible and can run on various platforms.	Cost effectiveness: can reduce unnecessary work and trips.	Open source flexibility: can be adapted for multiple uses.	Workflow-based: issue reports can be tracked and resolved.
Use cases profiled	Tuberculosis monitoring in Thailand; oral cancer screening in India.	Mapping of wildfires in Russia; monitoring Kenyan referendum.	Stock control for community health workers in Malawi.	Communication with, and tracking of, home-based care providers in Tanzania.	Tracking school construction and maintenance in Uganda.
Comments	Location information is the “base metadata” collected.	Open source and widely used for a variety of different purposes.	Usage focused on aid and healthcare logistics.	Can be used as a teaching aid with multimedia capabilities.	Developed out of a hackathon and subsequently volunteer driven.

Source: Authors, adapted from websites and case examples.

appropriate research tools. The results of the research processes can be, in turn, used in both policy-making and development aid projects.

Big Data can be a powerful research tool, and it can provide an interesting perspective to development aid projects. A good example of the use possibilities of Big Data was demonstrated by Google in predicting flu spread patterns from flu-related search queries. This showed that

Big Data, which can be seen as byproduct of citizens’ everyday activities, can be harnessed for making powerful predictions. This, in turn, can steer policy-makers’ and citizens’ behavior (Philip, Schuler-Brown and Way, 2013). However, issues such as security or privacy should be considered thoroughly.

Some examples of using Big Data in development aid projects are published in the United Nations Global

TABLE 4.2. A TECHNICAL ANALYSIS OF THE LOCATIONAL DATA APPLICATIONS

	Poimapper	Ushahidi	CommTrack	CommCare	Taarifa
Developer	Pajat Inc., Finland.	Ushahidi volunteer community.	Dimagi, US-based social enterprise.	Dimagi, US-based social enterprise.	Taarifa community.
Mobile platforms*	Android, iOS, J2EE.	J2EE phones, with apps for Android, iOS.	Offline solution for Nokia phones. Apps for Android, iOS.	J2EE phones and Android.	Any SMS-capable phone. HTML5 interface, apps for smartphones.
License	Proprietary (software as a service).	Open source. Licensed as GNU Lesser General Public License.	Open source, and software as a service.	Open source, and software as a service.	Open source.
User competence required	Easy and simple to use and administer.	Good admin and installation skills required, but data reporting easy for users.	Mobile app easy to use but web application requires experience.	Mobile app easy to use but web application requires experience.	Good admin and installation skills required, but data reporting easy for users.
Acquisition of locational data	Locational data saved automatically and can be edited. Points of interest shown on map.	Locational data saved automatically and can be edited. Points of interest shown on map.	Locational data can be saved when required.	Locational data can be saved when required.	Locational data saved automatically and used in report visualization and issue tracking.
Website	poimapper.com	ushahidi.com	commtrack.org	commcare.org	taarifa.org

*Note: Each application also has a web interface for admin and management.

Source: Authors, adapted from websites and case examples.

Pulse “Mobile Phone Network Data for Development” primer (2013). The primer explains how analysis of large quantities of call data records (CDRs, sometimes called Call Detail Records), passively collected from mobile phones, can provide information for development purposes, and thus provides case examples of using one type of Big Data in development aid projects and research.

United Nations Global Pulse (2013) defines CDRs as follows:

“Whenever a mobile call or transaction is made, a call data record (CDR) is automatically created by a mobile network operator. CDRs are a digital collection of attributes of a certain instance of a telecommunication transaction, such as the start time or a duration of a call. ... An additional piece of information that gets recorded in CDRs by a mobile network operator is to which cell towers the caller and recipient’s phones were connected at the time of the call.”

The primer presents three types of indicators that can be extracted by analyzing the Big Data of call detail

records: the analysis of the mobility of people, the analysis of social interactions, and the analysis of economic activity. All of these are discussed below.

A somewhat different example of using Big Data in development aid research was a study conducted by a team of researchers from the Harvard School of Public Health and seven other organizations. The team used cell phone data to illustrate the spread of malaria and to show how human travel patterns contribute to its diffusion. This example is briefly discussed in section 4.6.3.

While connecting the frameworks presented in chapter 3 to Big Data research is difficult, at least some observations can be made by using the UHP review framework, where the factors of relevance, effectiveness, efficiency and sustainability are considered. This suggests that Big Data research has great potential in the science of development delivery, for the following reasons:

- » The availability of “Big” data sets, and the relevance of Big Data research, is increasing. Epidemiology studies, for instance, are impossible,

or at least extremely difficult, to produce without large datasets, and information collected from mobile phones is relatively inexpensive, and available in near real-time.

- » Big Data research can directly inform decisions made by policy-makers (evidence-based policy-making), especially the case of mobility analysis presented in section 4.6.1.
- » From the perspective of research, Big Data can add value to development projects, if only because the technique is still relatively new.
- » The Big Data approach is inductive, in the sense that researchers look for patterns in the data rather than presupposing, from theory, what they may find. Thus, there is scope for surprises.

4.6.1 USING BIG DATA TO ANALYZE THE MOBILITY OF PEOPLE

By researching call detail records, it is possible to analyze the movement of masses, since the route of calls and messages can be tracked (by “connecting the dots” between different cell towers).

This information can be used to analyze and visualize,

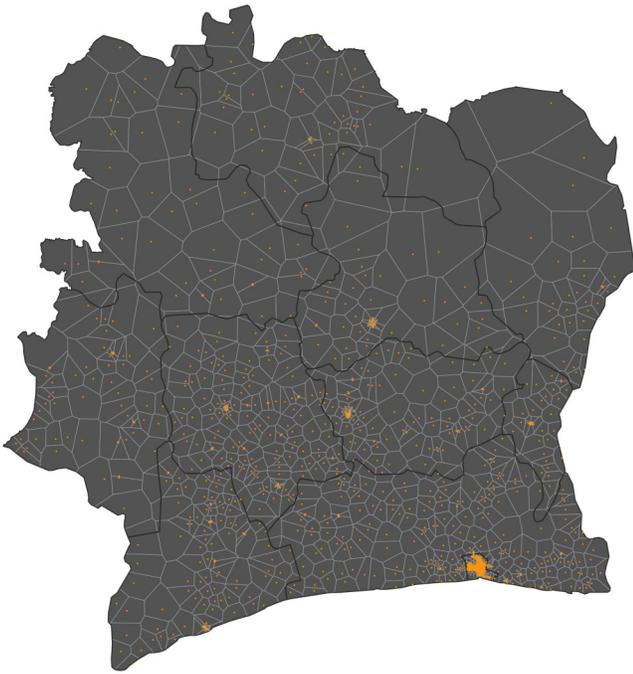


Figure 4.9. Poverty map of Côte d'Ivoire developed using call data records. Source: <http://dl.acm.org/citation.cfm?id=2557358>

for example, the daily rhythms of commuting of large quantities of people.

One example where CDRs were used to analyze and develop large movements of people was a program for optimizing transport networks in Côte d'Ivoire's largest city, Abidjan, conducted by IBM's AllAboard project's researchers. According to Mobile Phone Network Data for Development, “rabid urbanization in developing countries has increased pressure on infrastructure such as road networks. Roads and public transportation systems become saturated, and people lose a great deal of time traveling from home to work.”

This problem was addressed by analyzing 500,000 CDRs over a period of five months:

“Mobile phone location data is used to infer origin-destination flows in the city, which are then converted to ridership on the existing transit network. Sequential travel patterns from individual call location data is used to propose new candidate transit routes. An optimization model evaluates how to improve the existing transit network to increase ridership and user satisfaction, both in terms of travel and wait time” (IBM AllAboard 2013).

According to United Nations Global Pulse (2013), the research work resulted in a partial solution to the commuting problem: four new bus routes were added to Abidjan's commuting infrastructure, and one route was extended. This should reduce traveling time by 10 percent. United Nations Global Pulse sees such a provisioning use of CDRs as “useful for better urban planning and public transportation.”

4.6.2 USING BIG DATA TO ANALYZE SOCIAL INTERACTION AND ECONOMY

A second indicator, where CDRs are used to improve the science of delivery, is the analysis of social interaction. This can, in turn, be used to analyze other social patterns, such as poverty. The third indicator, economic development, can also be researched by analyzing CDRs.

According to United Nations Global Pulse (2013), the geographic distribution of social connections can be used to build demographic profiles of aggregated call traffic and to understand changes in behavior: “Studies have shown that men and women tend to use their phones differently, as do different age groups. Frequently making and receiving calls with contacts outside of one's

immediate community is correlated with a higher socioeconomic class.”

One of the interesting research cases, where CDRs and Big Data were used to understand social connections and the link between poverty and social interaction, is described in the paper “Ubiquitous Sensing for Mapping Poverty in Developing Countries” (2013) by Christopher Smith, Afra Mashhadi and Licia Capra.

In their paper, Smith et al. research a large quantity of anonymized CDRs from Côte d’Ivoire. They research the correlation between the CDRs and poverty by combining the CDRs with a Multidimensional Poverty Index created by the University of Oxford, and find that there are “several features of communication patterns among mobile phone users in Côte d’Ivoire that track poverty of regions as defined by the Multidimensional Poverty Index.” Smith et al. see that these research findings have important implications for policy-makers and agencies working in societies where it is difficult manually to collect large quantities of socioeconomic data. They also claim that the analysis of CDRs “can be used to provide poverty estimates at a spatial resolution finer than previously available.” United Nations Global Pulse (2013) comment that Smith, Mashhadi and Capra in their research “validated the possibility of making poverty maps using call detail records.”

It is not a coincidence that both the commuting study and the poverty study use CDRs from the same country, Côte d’Ivoire. That’s because relatively few operators and relatively few developing countries are currently willing to release call data in the quantities needed to make such analyses work. But data release is becoming more common in developed countries, as the example profiled in figure 1.2 shows. Big Data approaches are, for the moment, much less developed than the mobile applications profiled in the first part of this chapter. In the longer term, however, the potential value of passively collected call data is much higher than actively collected survey data, if only because the unit costs are so much lower.

4.6.3 USING BIG DATA TO ANALYZE THE SPREAD OF MALARIA

In 2012, researchers at the Harvard School of Public Health (HSPH) and several other institutions published a research paper that combined anonymized phone data

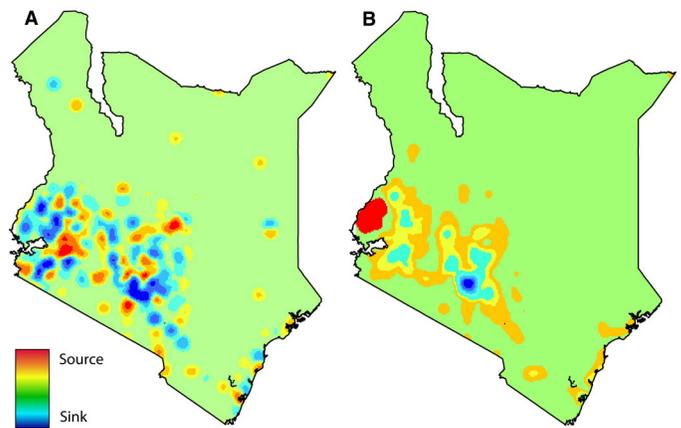


Figure 4.10. Examples of “sources” and “sinks” of malaria. Source: Wesolowski et al. (2012).

with information on the regional incidence of malaria in Kenya. The research showed on largest scale so far how human travel patterns contribute to the spread of malaria (HSPH News, 2012).

The study, by Amy Wesolowski and her team, published in the October 2012 issue of *Science*, presents results from a study where researchers mapped every call or SMS message made by over 14 million mobile phones in Kenya. According to Wesolowski et al. (2012), “Human movements contribute to the transmission of malaria on spatial scales that exceed the limits of mosquito dispersal.

Identifying the sources (where malaria comes from) and sinks (where malaria goes) of imported infections due to human travel and locating high-risk sites of parasite importation could greatly improve malaria control programs.”

Previous smaller-scale studies had used mobile phones to estimate importation rates of malaria, but lacked resolution on infection risk. In their study, Wesolowski et al. used a Big Data approach to identify networks of malaria parasite movements and pinpoint regions from where disease “sources” and to where it “sinks.”

By analyzing this huge dataset, the researchers came to observe that 1) it was possible to estimate the probability that a particular person is carrying malaria parasites, and 2) it was possible to build a map of parasite movements between areas that mostly emit diseases and areas that mostly receive diseases. The map not only predicted malaria movement, but also showed which locations could be targeted for malaria control and elimination (Medical News Today, 2012).

The research team found that a large part of malaria in Kenya comes from the Lake Victoria region and spreads east, mainly toward Nairobi, Kenya’s capital. Using this information, according to the research team, “would yield the biggest benefit nationally.” This is important research, since one million people die from malaria each year globally, and 90 percent of the deaths are children under five years, living in sub-Saharan Africa (Medical News Today, 2012).

While Wesolowski et al. see some limitations in their approach—the study can only measure mobility among phone owners and in regions where there are phone networks, and cannot showcase migration across borders (Wesolowski et al., 2012)—nevertheless the research is important and influential. It could be used, for example, by public health officials. They could send geographically targeted text message warnings to the phones of people traveling to high-risk malaria areas, suggesting they use a bednet, and thus help reduce the spread of malaria (HSPH News, 2012).

CHAPTER FIVE

CONCLUSIONS

5.1 USING LOCATIONAL DATA TO ENHANCE THE SCIENCE OF DELIVERY

This report has provided insights about the many features of a mobile phone, specifically the technologies which empower users to locate themselves in space and time, to collect and visualize locational data, and to interface with computer databases and maps in “the cloud.” Together, these capabilities serve to enhance the “science of delivery” when employed in a development context. Specifically, they assist in applying experimentation-based evidence to improve development aid process outcomes.

Chapter 2 of this report provides the technological underpinning to location tracking, based on three particular tracking technologies: cell tower triangulation, GPS (Global Positioning System) by satellite, and WPS (WiFi Positioning System). The selection of which technology to use for a particular application will depend on the availability of data, the degree of accuracy required, and the location of the user (e.g. indoors/outdoors, urban/rural, etc). It will further depend on the degree of sophistication of the mobile devices used.

In addition to the technical solutions which cell tower triangulation, GPS, and WPS can provide, simple innovations in mobile phone use can also be used to pinpoint locations. For example, SMS text messages sent by a user from a certain location can contain a code, or other piece of geo-specific information. This code can be tied to a certain known location—an election site, for example, as presented in Uchaguzi-Kenya referendum monitoring project presented in section 4.2.2.

Chapter 3 presented a methodological and conceptual framework for the benchmarking of specific cases carried out in Chapter 4. Several mobile applications and real-life use cases were highlighted that have recently been used to enhance the delivery of development assistance.

The applications presented were Poimapper, Ushahidi, CommTrack, CommCare, and Taarifa. The similarities and differences between the different applications are summarized in the benchmark crosstabs presented in section 4.5.

In addition to the five benchmarked applications, some potential uses of location-related Big Data—drawing upon very large samples sizes of data—were explored. Section 4.6 focused on three cases where Big Data was used in research related to

development interventions. In the first two cases, the analysis of call detail records (CDRs) from mobile phones was used in development projects and research. In a project carried out in Côte d'Ivoire, the analysis of CDRs led to improvements in public transport. In a research project case presented, it was shown how CDRs can be used to map poverty in developing countries. In addition to these cases, a research case was presented in which sources and sinks of malaria were mapped from analyzed phone data.

5.2 POTENTIAL USES OF LOCATIONAL DATA FOR ADDRESSING DEVELOPMENT CHALLENGES

This report has established that locational data applications can, and are, being used by development practitioners. Although their use is still largely small scale and experimental, and the technology continues to evolve, there is sufficient evidence of beneficial outcomes to move to deepen and broaden the experiment. In other words, pilot programs show sufficient potential for scaling up and extending to additional development challenges.

One way of conceptualizing the potential of locational data is by examining, in broad terms, the development challenges facing today's world, and then considering how locational data could be used to respond to them. Table 5.1 presents a first attempt at this. The eight development challenges presented here are the Millennium Development Goals, as defined by the UN Millennium Summit in 2000.

In general, mobile survey data applications have the highest potential, notably for the development challenges relating to poverty and hunger (#1), education (#2), control of infectious diseases (#6), and environmental sustainability (#7). The applications of Big Data are less obvious, but perhaps that is constrained by data availability. Big Data has the most promise in carrying out rapid or real-time poverty assessments, particularly at times of stress, for instance associated with famine or civil unrest. Big Data approaches generally need to be combined with other data sources, for instance associated with satellite imagery, to be effective.

5.3 RECOMMENDATIONS TO DEVELOPMENT PRACTITIONERS AND POLICY-MAKERS

Some observations can be made on the uses of applications and Big Data.

First, all the applications presented in this report have been used to gather, edit, and display information that is relevant for development purposes. Although the types of information collected can vary—for instance, survey data, images, videos, or inventory status information—all the showcased applications have proven successful in enhancing the science of delivery.

Second, there is a wide variety of potential applications that respond to a range of different development challenges. The application chosen will vary according to the function of the end-user: for instance, field workers may be more likely to use a mobile device, while office-based staff may be more likely to use web-based applications.

Third, the design emphasis of the applications, their key benefits, and intended uses also vary. It is up to the project management and to those implementing the project to choose which platform or application is the best choice for a given situation or delivery outcome.

Fourth, in addition to the use of locational data for evidence-based policy-making, it can also be used to improve organizational efficiency, particularly for development functions that rely on timely updating of inventory (e.g. community health workers or emergency food supplies). The tools can also be used to improve project management and donor coordination, for instance through easy visualization of areas being targeted by different organizations.

Fifth, further research is required to address concerns over information security and privacy. In practice, these concerns appear to have been overstated in that it is relatively easy to anonymize data, for instance for call data records. Nevertheless, guidelines for best practice use should be set.

Sixth, policy-makers may need to take a lead in encouraging the release of call data records that privately-owned operators may consider too commercially confidential to release. Policy-makers can raise awareness

TABLE 5.1. EXAMPLES OF THE POTENTIAL USES OF LOCATIONAL DATA IN RESPONDING TO GLOBAL DEVELOPMENT CHALLENGES

Millennium Development Goal	Possible use of mobile survey data	Possible use of Big Data applications
1. Eradicate extreme poverty and hunger	Potential: High Mobile tablets can be used for conducting household surveys for poverty assessments. The World Bank has used mobile tablets, equipped with geotagging capabilities, to replace paper-based surveys for rapid assessments in South Sudan.	Potential: High Big Data from Mobile Call Records can be used as a back up, or sanity test, for other sources of data, for instance by showing the ratio of incoming to outgoing calls in different parts of a country (with a high ratio of incoming calls suggesting lower income levels).
2. Achieve universal primary education	Potential: High School teachers may submit attendance statistics for their classes, which can be geotagged and timestamped to identify regions where attendance is low, and can track trends over time.	Potential: Moderate Mobile call records from the phones of teachers could be used to track whether they are in the same location as their school, to track absentee or “ghost” teachers.
3. Promote gender equality and empower women	Potential: Moderate Data on school attendance (see above) can be tracked against geotagged photos on school maintenance, showing which schools have working toilets. Anecdotal evidence suggests girls’ participation in class is lower in schools that lack good sanitation facilities.	Potential: Low In general, anonymized call records do not allow to distinguish between male and female users. However, Big Data can be combined with survey data to track, for instance, the routes followed by women when gathering firewood or collecting water, typically female roles in many countries.
4. Reduce child mortality	Potential: Moderate Vaccination campaigns for infectious childhood diseases, such as measles, can be followed using geotagged and timestamped survey data, to ensure full coverage in a particular area.	Potential: Low In general, anonymized call records do not allow to distinguish between child and adult users. However, Big Data can be combined with survey data, for instance, to track children’s movements in areas close to landmines.
5. Improve maternal health	Potential: Moderate Doctors or midwives making home visits to expectant mothers could make geotagged emergency calls requesting urgent medical assistance.	Potential: Low SMS messages to expectant mothers with information on maternal healthcare can be targeted, using triangulation techniques, to cells where maternal mortality is high.
6. Combat HIV/AIDS, malaria, and other diseases	Potential: High Inventory tracking for community health workers allows more efficient restocking.	Potential: Moderate Tracking of mobile CDRs in an area around an outbreak of an infectious disease allows for estimations of risk of contagion and epidemiological modeling.
7. Ensure environmental sustainability	Potential: High Camera-equipped mobile phones can be used to track the state of coastal sea defences during high tide.	Potential: Moderate Call data records can be used to estimate the population density of rural areas, which can be meshed with satellite imagery, to better plan for anti-deforestation campaigns, for instance by providing alternative cooking fuel.
8. Develop a global partnership for development	Potential: Moderate Mapping of donor initiatives, for instance by geotagging field reports, can be used to better coordinate development interventions.	Potential: Low Sharing of call data records around the time of disaster events, such as earthquakes or tsunamis, can help in disaster risk planning.

Source: Authors.

by showing the beneficial outcomes from Big Data projects and by setting up neutral clearinghouses that will apply basic privacy and security standards.

5.4 FINAL REFLECTIONS

After presenting and comparing the technologies which underlie locational data, and having reviewed a series of mini case studies of applications and Big Data solutions, the following final reflections can be offered:

- » Locational data can be generated from three main sources: cell tower triangulation, GPS-equipped mobile devices, and WPS.
- » Locational data can be used to identify key waypoints (points of interests) for monitoring outcomes, tracking user movement, or displaying certain routes.
- » Locational data, when complemented with temporal data, can provide a measurable depiction of mobility and progress, for instance, in the case of geotagged and timestamped data such as SMS-survey responses, media files, or user-generated reports.
- » The technologies have limitations. Cell tower triangulation relies on the density of cell networks

and towers in a given geographical area. GPS is limited by dense foliage, crowded urban areas, and other signal-blocking inhibitors. WPS is entirely dependent on dense WiFi connectivity.

- » Locational data provided by mobile phones and applications related to them can be used—and are being used—to enhance the science of delivery.
- » Case examples presented in the report show that development interventions, such as providing healthcare in difficult environments or monitoring elections, can be made easier by using technologies and applications that generate, and make use of, location-based data.
- » The Big Data-related cases presented here show its potential in research and evidence-based policy-making.
- » Technologies and applications used to enhance the delivery of development aid vary. So do the uses, target groups, and properties of the applications and cases presented here. The applications do not directly compete with each other, but complement one another. Therefore, the appropriate application must be chosen for the specific development challenge.

REFERENCES

Alexandrova, Alexandra (2014) “Bluetooth Low Energy Solution Released”, an Indoor published blog post, dated 27 November, 2013 and available at: <http://indoo.rs/bluetooth-low-energy-solution-released/> .

Anthony, Sebastian (2012) “Indoor Navigation on your Smartphone, using the Earth’s Magnetic Field – just like a pigeon”, an Extreme Tech digital news article dated 9 July, 2012, and published by Ziff Davis, LLC., available at: <http://www.extremetech.com/computing/132484-indoor-navigation-on-your-smartphone-using-the-earths-magnetic-field-just-like-a-homing-pigeon>

Anthony, Sebastian (2012) “Think GPS is cool? IPS will blow your mind”, an Extreme Tech digital news article dated 24 April, 2012, and published by Ziff Davis, LLC., available at: <http://www.extremetech.com/extreme/126843-think-gps-is-cool-ips-will-blow-your-mind/2> .

Appcircus: Taarifa (2014): Taarifa Description at Appcircus.

Broadcom.com (2014) “Broadcom Delivers First Global Location Chip for Wearables: Enables Consumers to More Accurately Manage Fitness Data On-the-Go”, press release dated 20 February, 2014, available at: <https://www.broadcom.com/press/release.php?id=s827044>

Burton, Marcus (2013) “Location-based Wi-Fi services can add immediate value to Wi-Fi deployments”, A web article dated 10 October 2013, available at: <http://www.networkworld.com/news/tech/2013/101013-wifi-location-services-274734.html>

Business Insider (2013) “Smartphone Market Forecast”, available at: <http://www.bullfax.com/?q=node-smartphone-market-forecast-how-price-sensitive-global-c>.

Cangeloso, Sal (2013) “Forget WiFiSlam – ByteLight uses LEDs for indoor positioning,” an Extreme Tech digital news article dated 25 March, 2013, and published by Ziff Davis, LLC., available at: <http://www.extremetech.com/extreme/151068-forget-wifislam->

bytelight-uses-leds-for-indoor-positioning

Carothers, Thomas (2010): The Elusive Synthesis. *Journal of Democracy* 21.4, pp. 12-26. ESRI (2014) "ArcGIS Online Features", a product description, available at: <http://www.esri.com/software/arcgis/arcgisonline/features/apps> .

Dimagi, Inc. (2014) CommCare Tool. Available at: <http://www.commcarehq.org/home/>

Dimagi, Inc (2014) CommTrack Tool. Available at: <http://www.comtrack.org/home/>

Evans, Annie (2013): The Top Ten Challenges of Implementing New Technology. Retrieved from <http://gettingsmart.com/2013/08/the-top-ten-challenges-of-implementing-new-technology/>

Fend, Jiangfan & Liu, Yanhong "Wifi-based Indoor Navigation with Mobile GIS and Speech Recognition", a journal article from *IJCSI International Journal of Computer Science Issues*, Vol. 9, Issue 6, No 2, dated November 2012, available at: <http://www.ijcsi.org/papers/IJCSI-9-6-2-256-263.pdf>

Gartner (2014) "Market share analysis: Mobile Phones worldwide, 4Q2013 and 2013", available in summary form at: <http://www.gartner.com/newsroom/id/2665715>.

Global Voices Online: Russia "Help Map" Wins Runet Award (2010): <http://globalvoicesonline.org/2010/12/03/russia-help-map-wins-runet-award/>

Guest, Greg; Macqueen, Kathleen M and Namey, Emily E (2012): *Applied Thematic Analysis*. SAGE.

Holmes, Chris (2014) "Distributed Versioning for Geospatial Data (Part 1): Distributed Versioning Implementation", A white paper available at: <http://boundlessgeo.com/whitepaper/new-approach-working-geospatial-data-part-1/> .

Hsieh, Edward F. (2005): Investigating Successful Implementation of Technologies in Developing Nations. Available at <http://dspace.mit.edu/bitstream/handle/1721.1/32887/62616466.pdf?sequence=1>.

HSPH News (2012): Using Cell Phone Data to Curb the Spread of Malaria. Available at <http://www.hsph.harvard.edu/news/press-releases/cell-phone-data-malaria/>.

IBM AllAboard (2013): Smarter Urban Dynamics. http://researcher.watson.ibm.com/researcher/view_group_subpage.php?id=4746

Iliffe, Mark (2012): Taarifa: Public Service Delivery. <http://www.agi.org.uk/storage/GeoCommunity/AGI12/Papers/MarkIliffe.pdf%20>

Insiteo (2014) "http://www.indoor-gps.com/joomla/index.php/en/latest-news/185-insiteo-first-to-announce-bluetooth-40-indoor-location-on-android-2

ISO/IEC 25010:2011 (2011): Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE) -- System and software quality models.

Kosack, Stephen (2002): Effective Aid: How Democracy Allows Development Aid to Improve the Quality of Life. *World Development* vol. 31 n:o 1, pp. 1-22.

Lepmets, Marion; Ras, Eric and Renault, Alain (2011): A Quality Measurement Framework for IT Services. Service Science and Innovation Public Research Centre Henri Tudor.

Lounamaa, Pertti (2012) "Poimapper: A Mobile GIS Cloud Service to improve field work efficiency, monitoring, and planning," A Pajat Solutions Ltd power point presentation given on 15 May 2012, available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&cad=rja&uact=8&ved=0CF8QFjAG&url=http%3A%2F%2Fwww.bond.org.uk%2Fdata%2Ffiles%2FEffectiveness_Programme%2FPoiMapper_BOND_100512.ppt&ei=DnNhU9DLGOKQyAHozYHQAw&usq=AFQjCNFlz3sTFcGvwICYQZZgVQbDEgIEGg&sig2=x5_pz0iBEeU5fjxWlwGJdw&bvm=bv.65636070,d.aWc

Medical News Today (2012) "Curbing Malaria Spread With Cell Phone Data". A news article available at <http://www.medicalnewstoday.com/articles/251425.php>.

Mora, Fernando (2011): Innovating in the Midst of Crisis. A Case Study of Ushahidi. http://www.researchgate.net/publication/231537244_Innovating_in_the_midst_of_crisis_A_case_study_of_Ushahidi

Morrow, Nathan; Mock, Nancy; Papendieck, Adam; Kocmich, Nicholas (2011): Independent Evaluation of the Ushahidi Haiti Project. Retrieved from <http://ggs684.pbworks.com/w/file/attach/60819963/1282.pdf>

Moss, Magdalene (2012) "Collecting and Utilizing Point-of-Interest (POI) Data Cost-Effectively with Mobile Technologies," Journal Article from Vol. 4 of the Sustainable Research and Innovation Conference Proceedings held May 3rd-4th at the African Institute for Capacity Development, available at: <http://elearning.jkuat.ac.ke/journals/ojs/index.php/sri/article/view/238>

Navizon|Accurate Positioning Anywhere (2014) "Applications in Health Care," Webpage available at: <http://www.navizon.com/health-care> .

INSITEO first to announce Bluetooth 4.0 indoor location on Android", a press release on Webpage available at: Online Dictionary of the Social Science (n.d.): Qualitative research. Retrieved from <http://bitbucket.icaap.org/dict.pl?alpha=Q>

OpenGeospatial.org (2014) "Compliant Products," A webpage offering information on the difference between OGC compliant and implementing technologies, available at: <http://www.opengeospatial.org/resource/products/compliant>

Pajat and Biocon (2013): Case Study on Oral Cancer Prevention

Pajat Solutions Ltd (2014) "Poimapper: Real-Time Field Data," case study available at: http://solutionscenter.nethope.org/case_studies/view/poimapper-real-time-field-data#

Pajat Solutions (2014). Tuberculosis Monitoring by Plan Thailand – An Abstract

Park, Will (2008) "Federal judge sets cellphone privacy precedent – Requires warrant for cellphone location

data", web article dated 13 September 2008 from intomobile.com via the Washington Post, available at: <http://www.intomobile.com/2008/09/13/federal-judge-sets-cellphone-privacy-precedent-requires-warrant-for-cellphone-location-data/>

Philip, Thomas M.; Schuler-Brown, Sarah; Way, Winmar (2013) "A Framework for Learning About Big Data with Mobile Technologies for Democratic Participation: Possibilities, Limitations, and Unanticipated Obstacles", available at Tech Know Learn 18:103-120

QGIS.org (2014) "QGIS as OGC Data Client," A chapter from the QGIS 2.0 guidebook, available at: https://www.qgis.org/en/docs/user_manual/working_with_ogc/ogc_client_support.html

QGIS.org (2014) "Supported Data Formats," A chapter from the QGIS 2.0 guidebook, available at: https://www.qgis.org/en/docs/user_manual/working_with_vector/supported_data.html

QGIS.org (2014) "Vector Data," A chapter from the QGIS 2.0 guidebook, available at: https://www.qgis.org/en/docs/gentle_gis_introduction/vector_data.html

Ratzer, Charles (2014) "BAE Systems Unveils Geospatial Intelligence Mobile App for Google Glass", A news article dated 15 April, 2014, available at: http://www.baesystems.com/article/BAES_166261/bae-systems-unveils-geospatial-intelligence-mobile-app-for-google-glass%E2%84%A2?_afrLoop=570592627905000&_afrWindowMode=0&_afrWindowId=null&baeSessionId=qRvhTz9b7RDDMnbvfVjfhKNkQJD9mXtnGj1PHdcXR16yLFQgc5TW!425070103#%40%3FbaeSessionId%3DqRvhTz9b7RDDMnbvfVjfhKNkQJD9mXtnGj1PHdcXR16yLFQgc5TW%2521425070103%26_afrWindowId%3Dnull%26_afrLoop%3D570592627905000%26_afrWindowMode%3D0%26_adf.ctrl-state%3D5an5qm1ff_4

Segan, Sascha (2011) "Smartphone GPS Just Got a Whole Lot Better, and Russian", A PCMag Digital news article dated 7 September, 2011 and published by Ziff Davis, available at: <http://www.pcmag.com/article2/0,2817,2392569,00.asp>

Shibasaki, R. (2014) “The flows in cities: Tracking movements of cell phone subscribers for infrastructure planning and disaster risk management”, Presentation based on written research available at: http://pflow.csis.u-tokyo.ac.jp/paper_e.html.

Smith, Christopher; Mashhadi, Afra; Capra, Licia (2013): Ubiquitous Sensing for Mapping Poverty in Developing Countries. <http://www0.cs.ucl.ac.uk/staff/l.capra/publications/d4d.pdf>

Spirent Communications (2014) “What is Wi-Fi Positioning” A webpage available at: http://www.spirent.com/Positioning-and-Navigation/What_is_Wi-Fi_Positioning

“The Evolution of Cell Phone Design Between 1983-2009”, A webdesignerdepot.com report dated May 22nd, 2009, available at: <http://www.webdesignerdepot.com/2009/05/the-evolution-of-cell-phone-design-between-1983-2009/>

TipSense, LLC (2014) “Poimapper”, An App Discovery Engine and Application review web page available at: <http://appcrawlr.com/android/poimapper>.

United Nations Global Pulse (2013): Mobile Phone Network Data for Development. <http://www.slideshare.net/unglobalpulse/mobile-data-for-development-primer-october-2013>

Ushahidi (2012) Uchaguzi – A Case Study: <http://blog.ushahidi.com/2012/10/24/ushahidi-kenya-evaluation-case-studies/>

Vicent, J. P. A (2013) “WIFI Indoor Positioning for Mobile Devices, An Application for the UJI Smart Campus” A Dissertation for the Degree of Master of Science in Geospatial Technologies at the Jaume-I University

dated March 2013, available at: <http://run.unl.pt/handle/10362/9193>

Walji, Aleem (2013) “What is science and what is delivery”, blog article, dated 19 May 2013, available at: <http://blogs.worldbank.org/voices/what-science-and-what-delivery>.

Wesolowski, Amy; Eagle, Nathan; Tatern, Andrew J; Smith, David L; Noor, Abdisalan M; Snow, Robert W; Buckee, Caroline O (2012): Quantifying the Impact of Human Mobility on Malaria. Author manuscript available at <http://europepmc.org/articles/PMC3675794>. Full article available at Science, Oct 2012.

Wikipedia (2014) “GPS Exchange Format”, last modified 30 April 2014, available at: http://en.wikipedia.org/wiki/GPS_eXchange_Format

Wikipedia (2014) “Keyhole Markup Language”, last modified 17 April 2014, available at: http://en.wikipedia.org/wiki/Keyhole_Markup_Language

Wikipedia (2014) “Shapefile”, last modified 27 March 2014, available at: <http://en.wikipedia.org/wiki/Shapefile>

Wilson, Tracy V. “How GPS Phones Work” 24 October 2005. HowStuffWorks.com article available at: <http://electronics.howstuffworks.com/gps-phone.htm>

The World Bank (2014) “Information and communication technology for Forest Law Enforcement and Governance; Lessons from a Two-Country project in LAO PDR and Moldova,” report.

The World Bank and Second Muse (2014) Big Data in Action for Development. World Bank, Washington DC, 68 pp. Available at: http://live.worldbank.org/sites/default/files/Big%20Data%20for%20Development%20Report_final%20version.pdf



This report looks at the different ways in which locational data from mobile devices can serve to enhance the science of development assistance. In particular, the report shows how locational technologies work and how they can be used for tracking users. The report looks at four different use cases of mobile survey data in detail—Poimapper, Ushahidi, Dimagi and Taarifa—and also examines a number of ways in which Big Data, notably mobile call data records, have been used for development purposes. The report provides an analytical framework, based on the Millennium Development Goals, to examine which global development challenges may be most amenable to a locational data approach.

The report has been prepared with generous funding by the Ministry for Foreign Affairs of Finland. It was written jointly by the Media Lab Helsinki at the Aalto University School of Arts, Design and Architecture and the World Bank Global Transport and ICT Global Practice. The Global Practice provides clients with infrastructure and policies to improve connectivity and competitiveness, link people to markets and social services to stimulate economic growth, increase climate resilience and reduce carbon footprint.



WORLD BANK GROUP