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Never Lose! Smart Phone based Personal Tracking via Bluetooth

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Abstract

In this paper, we highlight the efficacy and usability of smartphone based tracking through Bluetooth. The studies show that misplaced items adversely impact our lives, whereas tracking technologies are still maturing. Our survey in China, USA and UK reveals that 95% users are ignorant while 94% are in demand to smartphone trackers. An in-depth analysis of tracking schemes formulates the Bluetooth based location estimator to be the optimal candidate. We comprehend a trade-off between 'platform-independence', and, a 'location accurate', 'budget-friendly and 'energy-efficient' solution. A user can launch the smartphone application which provides the initial crude tracking of a tagged item / personnel, whereas, the exact localization can be assisted by audio-visual aids in close proximity. We foresee our study to invoke public awareness about availability of such facility as well as to work as roadmap for cellular companies to facilitate their users while incorporating such application in their smartphones.

Keywords
Tracking via Bluetooth, Personal Tracking, Smartphone Apps, Misplaced Items, Indoor / Outdoor Tracking.

Introduction

In this paper, we try to efficiently address the problem of misplaced items for common public through smartphones. The tracking of lost and misplaced valuables is a common problem and a lot of research has been carried out in this regard, like tracking of elderly, patients, kids and pets as well as of parked vehicles, files, wallets, keys and other items at home and workplaces. According to a survey conducted at UK in early 2012, the numbers of items lost by the British adults seem to be 200,000 in their entire life time （Ensure Home Insurance Study, 2012). The survey that top lost items are the most usable and dependent parts of our daily life, like mobile phones, house and car keys, document folders, sunglasses, wallets, etc.

On the other hand, we observe that smartphones have made a major impact in our daily lives. Initially devised to replace wired telephones into cordless handsets, today, the dummy cellphones have been transformed to interactive smartphones. Today the smartphones are shaping our everyday life – adding more and more facilities in terms of entertainment, information media, healthcare, sports, finance, data storage, utility payments, and else. The smartphone industry is boosting day by day to the extent that number of smartphones are estimated to exceed human population in 2014 (Smith A, 2012). The recent statistics show that smartphone users in China are leading with a total of 256 million users, the US being second with 230 million users (Flurry Analytics Report, 2013). In US alone, the smartphone users have increased by 11% just in the year 2012 (Sticknfind Technologies 2013). On the other hand, it is estimated that there are around 1 million smartphone software applications available today (Cisco Systems, Inc., 2013), a large majority of which can easily be accessed from internet.

As smartphones become our virtual facilitators and resource managers, we observe them to be a viable candidate for tracking needs. We conduct a survey and find out a huge demand for any tracking facility based upon smartphone. Our results show that 92% of smartphone users would like to have tracking system in their phones, amongst them 38% individuals are even willing to change their smartphones, and amongst others, 61% are willing to pay an average monthly cost of 3 USD (around 18 RMB) to avail any such service.

We also observe that a variety of devices exist in market for tracking solutions which utilize diverse technologies depending upon the application and usability, like GPS, Wi-Fi, GSM etc. However, these technologies are not widely practiced because of twofold reasons: 1) These tracking solutions depend heavily on additional infrastructure (like satellites, cellular towers, WIFI Access Points, crickets etc.).Such a dependency makes these schemes as platform-dependent, budget-hungry and energy-starved solutions as far resourced of a common user are concerned; 2) Though commercial tracking devices provide good tracking resolution but majority of people are either ignorant to availability of such technologies or are reluctant to use them because of reason stipulated before. There hence, the choice of smartphone as tracking devices gives us the most feasible solution available for every common user. Our model is based upon a scheme whereby the lost item is tagged with a tracking Bluetooth tag and user tracks its location while running a Bluetooth based application on the smartphone. In addition, we also comprehend the salient requirements for any tracking facility from a user's perspective. A user wants such application to be host

independent (GPS, WIFI routers, GSM towers etc.), capable of working indoors and outdoors, to be budget friendly and energy efficient for his smartphone. In line with this, we formulate Bluetooth based location estimator to be the optimal candidate being a technologically-proven, platform-independent, budget-efficient and energy friendly solution. However, we observe that there is a tradeoff between 'tracking accuracy' and costs borne by the user in shape of budget, device energy, computation and host-independence. Later we explore that an analogy to such an application exists in practice by iPhone. The iPhone provides a Bluetooth based tracking application (nLocator) in from of third party software plugin, namely Navior. The 'nLocator' functions the same way as anticipated by us. To illustrate the public awareness, our survey reveals that a large majority of smartphone users are ignorant and only 5 % know about the existence of facility provided by iPhone.

In the upcoming paragraphs, we first give an overview of various surveys to highlight the extent of underlying problem. Later, we provide a technological insight into existing tracking technologies and devices available in the market. Though not the main core of this paper, still, we give an in-depth analysis about the benefits and drawbacks of the existing technologies. We then list down the requirements of a viable tracking technology keeping only a smartphone in front. Lastly, we highlight the results of our survey carried out in three different countries (USA, Europe and China) regarding use of a smartphone based technology for tracking of the lost items. Based upon the technological comparison, available resources within a smartphone and survey results, we conclude the Bluetooth based location estimator to be the most suitable option and give recommendations towards the end.

Problem scenario: Misplaced and lost things – how serious?

In early 2012, a survey at UK reveals the extent of lost items for a British national. According to this survey, number of items lost by the British adults seems to be 200,000 in their life time (Ensure Home Insurance Study, 2012). People belonging to different professions face different problems regarding the misplacement of valuables but the majority of people lose their things at home, workplace or in cars. The survey also reports that items like Mobile phone, Car keys, Paperwork/ documents, Purse/ wallet, Bank card, Laptop and House keys are amongst the most common misplaced items (Ensure Home Insurance Study, 2012).Resultantly, these misplaced things not only consume time and efforts for their search but they are also cause of money wastage. Another survey in USA determines that how the wasting time can cost similar to wasting money (Newswire PR, 2013). The survey results show that about 177 billion dollars are wasted annually in searching the misplaced items in offices and workplaces. It was also found that people consume about 30 minutes of their work time in a week looking for the misplaced items. The survey also reveals that about 37 % people face the problem of being unprepared and lose their concentration due to misplaced things (Newswire PR, 2013).

Availability and efficacy of tracking devices

As highlighted in last section, the tracking of misplaced item is a serious issue that needs to be addressed. But at the same time, we observe that 'Personnel Tracking' is not a new term. The tracking devices are readily available in the market which offer different tracking accuracy with variable price ranges (Amazon online store), (Taobao online store). Most of these devices use the technologies like Wi-Fi, GSM and GPS. However as we will discuss later in great depth, these products are not widely adopted in general public because they are either host-

dependent (require dedicated hardware and stations) and/or budget-hungry solutions. A breakthrough in this regard has been the introduction of a smartphone based personnel tracking system named (Navior Co., Ltd. 'nLocator' by iPhone in 2011) which is based upon the Bluetooth technology within a user's smartphone. The nLocator gives a crude tracking information (in meters) and depends solely on smartphone resources. But, as per our survey, nearly negligible numbers of smartphone users are aware of any such utility offered by the iPhone.

In this paper, we first draw a global picture of indoor-outdoor location schemes. We briefly highlight the strengths and weaknesses of existing tracking technologies in lieu with user's resources and user's requirements. By user's resources, we mean the resources equipped within a generic smartphone. By user's requirements, we aim for a 'wish-list' or the extent of facilitation, e.g., the tracking service should work both indoors and outdoors (unlike GPS), it should not be depend upon base-stations (unlike WIFI and GSM) and should not utilized costly hardware and computational software resources. With this goal at front, we technically model our requirements in line with practical constraints and formulate it into most feasible solution, i.e. a tracking system based upon Personal Area Network (PAN) that offers no liability to host networks or resources, and gives a reasonable accuracy. Lastly, we explore that such a technology exists in practice, like Bluetooth based tracking application on a smartphone as offered by iPhone, which gives coarse but valuable tracking information within available resources and independent of host platform. However, a large majority of smartphone users are unaware about such facility by iPhone.

Wish list of available tracking solution with a mere smartphone in hand

In this section, we target common public - a person who lost his valuable item at any indoor/outdoor place and he/she only has his/her smartphone in hand. This wish-list is not referenced from any material and is solely made by the authors keeping in view the problem scenario.

(a) *Coverage*. Scheme should be best suited for indoor as well as outdoor environment.

(b) A *low-budget* solution.

(c) *Platform Independence*. Should not be dependent upon host infrastructure, like Access Points (GSM, GPRS and WIFI) or Satellites (GPS).

(d) *Accuracy*. can be coarse as far as it meets the localization goals. We foresee that an accuracy of meters is sufficient to estimate the location of the subject/ object, like, a person only need to know he has forgot his item on sofa or table, the nursing staff needs to know whether a critical patient is within prescribed area, the driver needs to know where the vehicle is parked? The coarse accuracy can be augmented with audio-visual aids for further navigation (detailed in paper).

(e) *Resource conformance*. Should conform within available specifications of in-hand smartphone, both hardware and software inclusive (like computational power and battery etc.).

(f) *Resource constraints*. Should not drive onboard resources beyond prescribed limitations. A user should be able to launch tracking application and in-parallel, could use the phone for other calls, web and other purposes.

After highlighting the wish-list of a common smartphone user, we give a brief overview of existing tracking technologies to see which solution is optimal in line with our tabulated requirements.

Salient overview of existing tracking technologies

In this section, we give a brief overview of tracking technologies and later sketch out a comparison between them. For reader's ease, we classify these technologies into outdoor/indoor tracking and behavioral sensing technologies. These schemes are further elaborated in great detail at Appendix-A.

The *Outdoor Tracking* solutions are mainly based upon GPS, GSM and WiFi, or combination of these. They are mainly limited by their coverage area and require availability of host services, hardware and software resources, pre-mapped host station coordinates and multiple sensors or antennas at user's end. Either way, it makes localization host dependent, costly and resource constraint.

The *Indoor Tracking* technologies can be classified into Active and Passive Techniques. The Active RF Tracking is a high-budget solution that makes use of sophisticated hardware installed in the surroundings of user and can only work at pre-installed locations. In Passive RF Tracking, the existing RF signals (like WiFi, GSM) are measured in great accuracy to make a 'digital map' of any specific area to estimate location. This scheme is resource heavy and limited by the fact that it only works at pre-mapped areas.

The *Active/Passive Behavior Sensing* can be thought of an assisted source of localization, like, taking the pictures of surroundings and matching with previously stored database. It is quite obvious that such schemes can only augment the location information in certain scenarios, and cannot work as sole source of localization.

Next, we summarize the contexts of each tracking technology at broader terms and list down their limitations in Table-1. We realize that there has to be a compromise between 'location accuracy' and other parameters for a host-independent, energy efficient, computationally feasible and budget-friendly solution. In next section, we discuss the Bluetooth based tracking technology in detail and show that why it can be deemed an optimal choice as a viable smartphone based tracking scheme.

Bluetooth based tracking: Exploring the existing technology

In this section, we critically investigate the Bluetooth technology in relation to accuracy, range, and power requirements. Since this is not a technical paper, so we highlight the chief parameters for understanding purposes and keep our focus on its utility.

Table-1 : A brief comparison of various tracking schemes vs proposed Bluetooth based scheme

	Coverage	**Accuracy**	**Host Dependent**	**Battery / Power Efficient**	**Processing**	**Cost for Tracking?**	**Main Limitation**

Outdoor Tracking	**GPS**	Outdoors	meters	Satellites	No	Computational	No	Only outdoors
	GSM	Outdoors/ Indoors	meters	Base Stations	Yes	Computational	Yes	Requires GSM Coverage
	WiFi	Outdoors/ Indoors	meters	WiFi Routers	Yes	Computational	Yes	Requires WiFi Coverage
Indoor Tracking	**Active RF**	Indoor (limited area)	cm	Pre-installed hardware / RF Fingerprinting	No	Computational	Yes	Requires pre-conFigured infrastructure/ measurements
	Passive RF	Indoor (limited area)	cm	Pre-installed hardware / RF Fingerprinting	No	Computational	Yes	Requires pre-conFigured infrastructure/ measurements
Behavioral Sensing		Outdoors/ Indoors	Cannot be used as sole localization source					Highly dependent upon surroundings and pre-mapped data
Bluetooth (via smartphone)		Outdoors / Indoors	meters	No	Yes	No	No	Only requires a Bluetooth based smartphone and tagged valuables

Bluetooth - A brief Technical Insight

We give an outlook of Bluetooth technology to see why we consider it to be an optimal choice for tracking services at a personal level. The Bluetooth is a universal communications protocol which is designed for Personal Area Network (PAN). It means that this communication media can work standalone and does not dependent upon any host (like satellites in GPS, towers in GSM, Access Points in Wi-Fi) or any services (like internet).

Majority of common users are acquainted with Bluetooth as a personal media for file and data transfer in device-to-device data communication (like smartphone to smartphone or laptop etc) or for control communications (like wireless mouse, keyboards etc). It provides an adequate range (max 100m for high-power Bluetooth Class-1). As a generic guideline, Bluetooth devices can communicate within 300ft in non-line-of-sight. The operational frequency band of Bluetooth is 2.4GHz. Since, there is a risk of frequency interference from WiFi and Microwave Ovens at same frequency so, Bluetooth technology adopts an intelligent technique called Adaptive Frequency Hopping for interference immunity (Shoemake MB, 2013), (Bluetooth SIG Inc., 2013), (Bekkelien A, 2012).

The advent of Bluetooth Low Energy (BLE) has opened avenues for long battery life of Bluetooth devices, a BLE commercial beacon can last a year just on a coin cell (Casio Electronics Co, Bluetooth Watch, 2013), (Amazon online store). So, in nutshell, we see that a tracking scheme based upon Bluetooth technology is the most appealing choice. Out main parameters for its selection include its long range, inherent interference cancellation, power efficiency, platform independence and being readily available almost in all smartphones today.

Bluetooth based tracking – is it something new?

It is worthwhile to mention that 'Tracking via Bluetooth' is not a new idea; rather we term it to be unknown from common public. A large variety of commercial applications exist today that utilize the Bluetooth technology for coarse localization. Some of these applications claim to locate objects up to150 feet (Kickstarter, Inc. New York, Hone for iPhone 4S, 2013), (Amazon online store) using Bluetooth tags, and up to 0.5 miles using Bluetooth and GPS (Sticknfind Technologies, Bluetooth locater, 2013). However till recent past, the Bluetooth tracking devices were mostly offered as a standalone solution. The Bluetooth tracking has been offered in smartphone in 2011 by iPhone, nLocator being the most famous third party software application (Navior Co., Ltd. nLocator 2013).

Currently researched Bluetooth tracking schemes

Apart from commercial Bluetooth tracking devices and nLocation facility from iPhone, other Bluetooth tracking schemes have been prototyped and demonstrated in academia (Cheung KC, Intille SS and Larson K, 2006), (Fernandes T, 2013), some of them providing an indoor accuracy of 1.5m (Bekkelien A, 2012). One of the Bluetooth localization techniques encompasses the Bluetooth-WiFi conjunction used in Proximity Marketing or Location Based Mobile Marketing (Ace Marketing & Promotions, Mobiquity Networks 2013), where customers are popped up commercial ads or information related to their proximity to a mall or shop. Recently, Nokia Research is aiming to incorporate indoor localization through Bluetooth technology (Deng Z, Xue T, Cao H, 2008) with an aimed accuracy of 0.3m (Belloni F, 2010). Furthermore, the market giants are in collaboration for a standardized protocol for a WiFi-Bluetooth scheme for indoor localization (Perry T, 2012). As said before, all these schemes required dedicated and pre-installed hardware and/or wireless fingerprinting of the area.

Working Principle of Smartphone based Bluetooth Tracking

For tracking via Bluetooth through a smartphone, we require specific Bluetooth tags which are attached to valuables (like hearing impairments, elderly, kids) or objects (such as keys, wallets, purses, remote controls, umbrellas).Once the Bluetooth service is activated on smartphone, the tracking information is shown on the device to coarse locate the lost items. Once the user reaches in vicinity of the lost item, the tag can assist in localization by beeps and flashes or similarly by audio-visual aids for user. In essence, the Bluetooth application on smartphone or the user-device establishes a wireless link to the tag and navigates the user by means of onscreen indication while giving a sense of distance between user and the lost object.

Why Bluetooth Tracking is optimal Solution

Here we broadly enlist salient advantages of Bluetooth based tracking scheme to be optimal and most appropriate for a smartphone tracking solution.

- The major advantage of Bluetooth based tracking is that Bluetooth is a Personal Area Network (PAN) technology, which leverages the freedom from host networks like access points (WiFi), satellites (GPS) and cellular towers (GPRS) already installed infrastructure.
- It is also a budget friendly solution as user only needs to buy the Bluetooth tags and install the software application in his smartphone.
- Bluetooth based tracking is an energy efficient solution especially with the advent of Bluetooth-Low-Energy (BLE) whereby the products have been claimed to last more than a year's on a single coin cell.
- As regards the tracking accuracy, we foresee that even an indication in meters towards the specific area of misplaced items is enough for tracking the items, rather than to have exact localization in cm. We realize that there has to be a trade-off between aforementioned advantages of a tracking facility, and the tracking resolution. Moreover, many intelligent solutions can be incorporated in these Bluetooth tags and/or in smartphone application for facilitating the users for exactly location-finding the valuables, like the tag beeps and flashes to draw attention as the user reaches in certain vicinity. Working this way, user gets the crude location estimation through his smartphone based tracking application, and gets a pointed location of the source by audio-visual aids.

Limitations of Bluetooth based tracking scheme

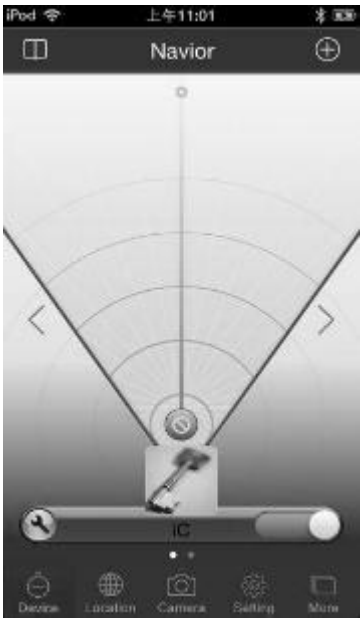
As pertains the provision of tracking facility from a single and stand-alone smartphone, the only limitation that we foresee is the 'coarse accuracy', i.e., the proposed technology cannot provide tracking accuracy in cm and can only pinpoint location of objects within meters. The reason is obvious; the system uses only a single tracker (the smartphone in our case) to perform the localization. As discussed in Appendix-A in detail, for an accurate tracking, we either need multiple host stations or pre-mapped RF-Fingerprint of the area, both of which limit the tracking to a limited area.

As highlighted earlier, the solution to such a 'coarse tracking' scheme is two folds : First, we envision that a tracking accuracy within meters can serve well enough for finding a specific car parked in whole parking place, or for finding keys placed on a table and else. To illustrate the efficacy of such a scheme, we show the snapshot of nLocator in Figure-1 (a) (Navior Co. Ltd. nLocator,2013). This Figureure shows the tracker view on iPhone, the green spot is the tagged valuable which we want to find. The tracking accuracy can further be enhanced in coupled with GPS for accurate positing, if required as shown in Figure-1 (b).

Secondly and most importantly, the tracking can be aided by audio-visual aids, like the Bluetooth tag on the misplaced valuable would blink and give audio beeps once the tracking person come into a close vicinity of the item.

Figure-1(b) : nLocator assisted by GPS **Figure-1(a): Snapshot of nLocator**

Figure-1 : Snapshots of nLocator by iPad. In Figure-1(a), the misplaced valuable is dhown by **a green dot and user can easily navigate his way towards the key. In Figure-1(b), the user can also switch-on his GPS to find the exact location of his misplaced valuables with assistance of GPS.**



During the course of survey, we also interacted with some clients who had practically used the Bluetooth based trackers (nLocator and else). These users pointed out two main short-comings of such trackers. Firstly, the connectivity of smartphone with tag (misplaced item) was not so 'fluent' as it is observed in the case of smartphones during file sharing on Bluetooth. The second observation related to bigger size of the tags. We foresee the second observation to be related to the balance between miniaturization and cost factor, and it differs from product to product. Referenced in earlier sections, we observe that there are many miniaturized Bluetooth tags readily available in market, especially one like in (Amazon online store) in which the tag is in-fact about the size of a quarter, i.e., in shape of a circular sticker with dimensions as small as 24mm (dia) x 4mm (thickness) and weighs just 4.5 grams.

Here, our main focus lies on Bluetooth-to-Tag connectivity issue which can better be explained from technical aspect. In case of two smartphones sharing the data, both the devices are normally in electronic Line-of-Sight, whereas, a lost item can be placed anywhere. Same is the case with nLocator and other such trackers. While trying to track an item, initially, we get low or intermittent connectivity because the smartphone is not in direct line-of-sight to the tagged item. But, once a user follows the on-screen indications and moves towards the tag, the Bluetooth connectivity improves. Underlying technical answer is that the signal strength improves more and more once distance is reduced and a direct line-of-sight is established. Here, we also wish to mention that there will always remain an adequate difference between a GPS and a Bluetooth tracker - the function of GPS is to pinpoint the exact location in-a-go, whereas, a Bluetooth based tracker is mainly aimed for coarse tracking which is further assisted by human-intelligence and audio-visual aids.

Smartphone user based Survey– research methodology

We carry out a prior interview-based survey followed by a detailed survey to underline the extent of consumer demand for a smartphone based tracking facility. The initial interview-based survey was conducted in Chengdu, China that involved 100 adult smartphone users, including both Chinese and foreign nationals. The participants were questioned on their approach in finding the misplaced or lost items, their reviews about any feasible tracking technology and extent to which they use Bluetooth, GPS and WiFi in their smartphones. They were specifically questioned about any in-use tracking facilities, desired tracking accuracy and cost effects of any such facility. This interview-based prior survey was followed by a detailed survey that comprised of 1000 participants from university and professional workers in USA, UK and China. The sample size for the participants was 1000 in total with 800 from China and100 each from USA and UK. The feedbacks of roughly 200 participants were discarded because of partial feedback (half-filled survey) and new participants were included to complete the population size of 1000.

A detailed questionnaire was prepared and opinions were obtained from the participants. The questionnaire was delivered to participants by hand and all the participants were briefed about the aim of the Survey. Furthermore, the Survey questions were printed both is English and Chinese languages for Chinese citizens. All the participants were elaborately explained about the aim of survey and the relevant questions were answered. For USA and UK, we determined the amount in Dollars and for Chinese participants, the currency was converted into Chinese Yuan (RMB). For academia in China, the survey was conducted in different university classes around Chengdu city. For academia in UK and USA, we also selected the universities but questioner was randomly distributed. For professional

candidates in China, the questioner was distributed in university office workers and different companies located in Chengdu.

Survey goal

The survey was aimed to estimate and evaluate the public view point for the demand for any smartphone based tracking application. The goal of the survey was fourfold:

- To check the awareness of smartphone users about the availability of tracking facility in their smartphones.
- To determine any in-practice technology used by smartphone users for locating and tracking their lost items.
- To examine the user's willingness to change their smartphones if new smartphone is equipped with a tracking facility.
- The users were also questioned for the amount of money they can spend per month in order to avail any such service.

Survey results

The survey results dictate that 69% of the targeted population doesn't know about the possibility of any tracking facility that can be offered by their smartphones. Within remaining 31% individuals who are acquainted with possibility of such a facility, only 4% exactly know about the actual services. In general, 92% of smartphone users would like to have personal tracking system for tracking of their valuables (keys, wallet, bags, books, pets and kids). Amongst them, 38% individuals showed their willingness to change their smartphone whereas the remaining 62% individuals don't want to change their smartphones but want to avail such a service at monthly payments. The 61% individuals were willing to pay an average monthly cost of 5 USD (around 30 RMB) to avail any such service. In survey, we found that 8% of the population showed no interest about using any such service. The detailed results have been presented in Figure-2

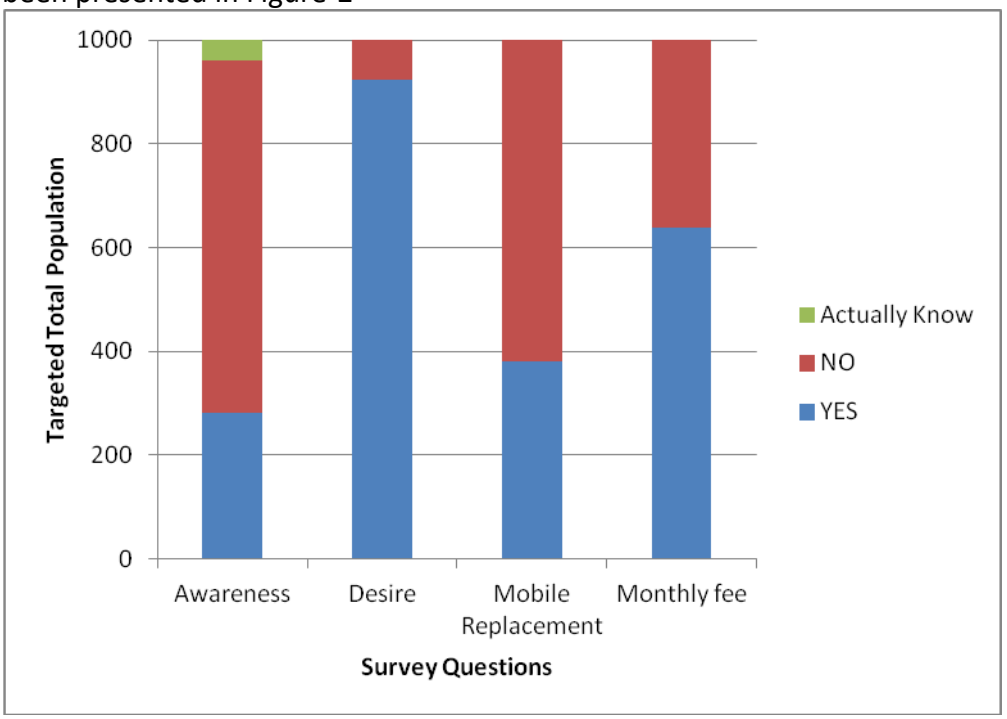


Figure-2: Survey results depicting the customer demand for Personal Tracking System

More in specific, we divide the survey results into three categories. The population of US and UK is divided in one group (size = 200). The remaining 800 individuals belong to China

and are further divided into two categories - Office Workers (400) and the University Students (400). The detailed results are shown in Table-2 for UK and US citizens, Chinese Office Workers and Chinese University Students.

Conclusion and Recommendations

In this paper we explore a Bluetooth based tracking service that can be operated from any smartphone to locate the misplaced valuables, both indoors and outdoors. We carry out our study in multiple perspectives. From the technological aspects, we highlight the shortcomings of existing tracking solutions and outline the requirements from the view point of a common smartphone user. We observe a trade-off between tracking accuracy and user's facilitation, and

Table-2: Detailed Survey results

	Awareness	Desire	Mobile Replacement	Monthly fee	
Yes	52 (26%)	180 (90%)	94 (47%)	98 (49%)	**US and UK Citizens (200)**
No	138 (69%)	20 (10%)	106 (53%)	102 (51%)	
Actually know	10 (5%)				
Yes	123 (31%)	387 (97%)	179 (45%)	264 (66%)	**Chinese Office Workers (400)**
No	257 (64%)	13 (3%)	221 (55%)	136 (44%)	
Actually know	20 (5%)				
Yes	107 (27%)	356 (89%)	109 (28%)	277 (69%)	**Chinese University Students (400)**
No	284 (71%)	44 (11%)	291 (72%)	123 (31%)	
Actually know	9 (2%)				

as an optimal solution, we conclude Bluetooth technology to be the affordable candidate. Bluetooth is very common technology today used for data-sharing and is found almost in all smartphones. Using Bluetooth, we get the crude initial tracking information through smartphone tracking application, and final location estimation via audio-visual aids from the tagged valuable item. From the facilitation aspects, we note that Bluetooth tracking devices are energy efficient and budget friendly solutions. A smartphone based Bluetooth tracking system can locate objects absolutely free of cost with substantial battery saving. Such scheme will be solely based upon smartphone for deployment and operation, and will be independent of GPS, GSM and WiFi etc. From the user's aspect, consumers are willing to have a tradeoff between tracking accuracy for an autonomous and free-of-cost solution. The survey customers feel the importance and requirement of any such tracking facility for their lost and misplaced valuables. Furthermore, survey results depict that a large majority of smartphone users are ignorant to availability and usefulness of any such service. Even a similar Bluetooth tracking facility as offered by iPhone remains hidden from the public eye. Therefore, we suggest the availability of such service to be advertised on a massive scale. Since, the Bluetooth tracking facility would only require software plug-in at user's smartphone and a low-cost tag on the valuables, so, we recommend the cellular giants to facilitate their users

with a free software option for such a service and provision of some advertisement tags as the basic necessity in a phone package, like headphones and charger. Not the least, we foresee smartphone based tracking service to be a valuable, low-cost and in-demand necessity which remains obscure from public viewpoint, in general, and from manufacturer's focus, in particular.

Appendix - A

We divide the tracking technologies into three broader categories for easy understanding, namely outdoor localization, indoor localization and behavioral sensing.

A broader perspective of outdoor localization

The foremost scheme for outdoor-location includes the GPS. However, GPS does not work indoors or once surrounded by high walled architectures. The cold start-up time for GPS is another considerable factor which drains the battery of energy constraint devices for localization purposes (Bu˘si´c L, Filjar R, 2005). Systems based upon WIFI localization require a coverage area, multiple antennas, high processing and additional hardware (Subramanian AP, Deshpande P, 2008). The GSM-based localization techniques mainly assume that either the exact location of the Base Stations is known for signal strength measurements (Besada JA, Bernardos AM, 2007) or require multiple receivers/ antennas for multi-literation (Spirito MA, 2001). Other methods like SMART (Peng Z, Dan W, and Yi S, 2010) work upon WiFi along with onboard resources for localization like microphone, camera and accelerometer. Some hybrid methods have been devised which work with GPS and WIFI both (Pereira C, Guenda L and Carvalho NB, 2011). The multi-model solutions based upon GPS/ WIFI/ GSM have also been proposed (Papandrea and Michela, 2011). Other solutions based upon global internet architecture are proposed (Bayir, Ali M, 2009). Summarizing all such various techniques, the main caveat lies in dedicated hardware/ software resources, availability of services, pre-mapped war-sensed data (Access Points or Base Station coordinates) and multiple sensors or antennas at user's end. Either way, it makes localization host dependent, costly and resource constraint.

An insight to indoor localization

In recent decades, the indoor-localization has been greatly researched and a number of approaches have been proposed and prototyped, each with certain trade-offs. Here, we chiefly classify them as active and passive schemes, and illustrate a generic picture for clear understanding.

Active RF Localization

Active RF schemes refer to installation of specific hardware in the environment and to make high precision indoor localization, like, Cricket (Priyantha NB, 2005), Nokia's Bluetooth model, and Time-of Arrival (TOA) systems like PINPOINT (Youssef M, Youssef A, 2006). The Link Signature scheme can also be utilized for location estimation (Zhang J, Firooz MH, 2008) which detects the variations in link parameters through multiple sensors as the device moves in the network. However, all such active techniques are in fact high-budget applications, require pre-installed infrastructure and can only scale small areas.

Passive RF Localization

Such technologies sense the RF signals from surrounding environment through existing devices and require specific firmware/ software (Bahl P and Padmanabhan VN, 2000) and (Niculescu D and Nath B, 2004). In most of such schemes, a specific area is war-driven to make a 'Wireless Fingerprint Map', and then localization is carried out via sensing the real-time fingerprint on the target device. The salient examples are Place Lab (Chen Y, Chawathe Y, 2005) where signals are mapped from various WiFi and GSM base stations, and, RADAR (Bahl P and Padmanabhan VN, 2000) which outputs precise location based upon accurate WIFI fingerprints, but at cost of time and hardware resources. Some other techniques are variants to same idea, like Active Campus project (Griswold WG, Shanahan P, 2003) which works on known locations of WIFI Access Points. We conclude that passive RF localization is resource heavy and mainly requires pre-mapped wireless fingerprints of the area.

Active/Passive Behavior Sensing

Can be thought of assisted source of localization and circumvents the context-aware computing (Clarkson B, Mase K, 2000) and (Yiu C and Singh S, 2007) like Image Matching techniques (Elias R and Elnahas A, 2000). However, such schemes require the 'decision making object' (like furniture, floor style etc) to be long lived and stable. Other solutions have also been prototyped like in (Fitzpatrick P and Kemp C, 2003), cameras have been mounted on shoes to achieve a vision of the floor. However, it is very obvious that such schemes can only augment the location information in certain scenarios, and cannot work as sole source of localization.

In nutshell, each of Active, Passive or Behavioral localization schemes has certain tradeoffs chiefly in terms of hardware/software resources; accuracy, installation platform; energy consumption, computational complexity and most of them require the war-sensing of area or the coverage of base-stations.

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References

Flurry Analytics Report (Feb, 2013) China Now Leads the World in New iOS and Android Device Activations. Available at: http://blog.flurry.com/bid/83261/ China-Now-Leads-the-World-in-New-iOS-and-Android-Device-Activations (accessed 27 October, 2013).

Ensure Home Insurance Study (Mar, 2012) We're a bunch of losers. Available at : http://www.esure.com/media_centre/archive/wcmcap_100800.html (accessed 13 October, 2013).

Newswire PR (Aug, 2013) 'P-touch® Means Business' Survey Reveals Offices Waste More Than $177 Billion Per Year Looking for Lost Items. Available at: http://www.prnewswire.com/news-releases/p-touch-means-business-survey-reveals-offices-waste-more-than-177-billion-per-year-looking-for-lost-items-101465149.html (accessed 21 October, 2013).

Subramanian AP, Deshpande P, Jie G et al. (2008) Drive-by localization of roadside WiFi networks. In: *27th Conference on Computer Communications*, INFOCOM, Arizona, USA, 11-13 April 2008, pp. 718-725.

Besada JA, Bernardos AM, Tarrio P et al. (2007) Analysis of tracking methods for wireless indoor localization. In : *2nd International Symposium on Wireless Pervasive Computing*, ISWPC, Puerto Rico, USA, 5-7 February 2007.

Peng Z, Dan W, and Yi S (2010) SMART: Simultaneous indoor localization and map construction using smartphones. In : *International Joint Conference on Neural Networks*, IJCNN, Barcelona, Spain, 18-23 July 2010, pp. 1-8.

Pereira C, Guenda L and Carvalho NB (2011) A smart-phone indoor / outdoor localization system. In: *International Conference on Indoor Positioning and Indoor Navigation*, IPIN, Guimarães, Portugal, 21-23 September 2011.

Papandrea and Michela (2011) Multimodal ubiquitous localization : a GPS/WiFi/GSM-based lightweight solution. In : *World of Wireless, Mobile and Multimedia Networks & Workshops*, WoWMoM, Sydney, Australia, 16-19 June 2011.

Spirito MA (2001) On the accuracy of cellular mobile station location estimation. In : *IEEE Transactions on Vehicular Technology*, 2001, Vol. 50, No. 3, pp. 674–685.

Buˇsi´c L, Filjar R and Deˇsi´c S (2005) Assisted satellite positioning. In : *Proceedings of 47th International Symposium on Electronics in Marine*, ELMAR, Zadar, Croatia, 08-10 June 2005, pp. 263–267.

Bayir, Ali M (2009) Track me! A web based location tracking and analysis system for smart phone users. In : *Proceedings of 24th International Symposium on Computer and Information Sciences*, ISCIS, Guzelyurt, North Cyprus, 14-16 September 2009.

Youssef M, Youssef A, et al, (2006) Pinpoint: An asynchronous time-based location determination system. In : *Proceedings of ACM MobiSys*, 2006, Uppsala, Sweden, 19-22 June 2006.

Priyantha NB (2005) *The cricket indoor location system*. PhD thesis, Massachusetts Institute of Technology, USA.

Zhang J, Firooz MH, Patwari N et al. (2008) Advancing wireless link signatures for location distinction. In : *Proceedings of 14th Annual International Conference on Mobile Computing and Networking*, ACM MobiCom, San Francisco, USA, September 14-19, 2008.

Bahl P and Padmanabhan VN (2000) Radar: an in-building RF-based user location and tracking system. In : *Proceedings of 19th Annual Joint Conference of the IEEE Computer and Communications Societies*, *INFOCOM*, Tel Aviv, Israel, 26-30 March 2000.

Chen Y, Chawathe Y et al, (2005) Accuracy characterization for metropolitan-scale WiFi localization. In : *Proceedings of International Conference on Mobile Systems, Applications, and Services*, MobiSys, Seattle, , Washington, USA, 6-8 June 2005.

Niculescu D and Nath B (2004) VOR base stations for indoor 802.11 positioning. In : *Proceedings of International Conference on Mobile Computing and Networking*, ACM MobiCom, Philadelphia, USA, 26 Sep – 1 Oct 2004.

Griswold WG, Shanahan P at el (2003) ActiveCampus - experiments in community-oriented ubiquitous computing. *IEEE Computer Journal*. 37(10) : 73 - 81.

Clarkson B, Mase K and Pentland A (2000) Recognizing user context via wearable sensors. In : *Proceedings of 4th IEEE International Symposium on Wearable Computers*, 2000.

Elias R and Elnahas A (2000) An accurate indoor localization technique using image matching in intelligent environments. In : *Proceedings of 4th International Symposium on Wearable Computers*, Atlanta, GA, USA ,16-17 Oct. 2000.

Fitzpatrick P and Kemp C (2003) Shoes as a platform for vision. In : *Proceedings of 7th IEEE International Symposium on Wearable Computers*, New York, USA, 21-23 October 2003.

Yiu C and Singh S (2007) Tracking people in indoor environments. In : *Proceedings of 5th International Conference on Smart homes and health Telematics*, ICOST, Nara, Japan, 21-23 June 2007.

Sticknfind Technologies. Ultra-Small Bluetooth GPS Locator, Available at : http://blutracker.com/ (accessed 21 October, 2013).
Kickstarter, Inc. New York, USA. Hone for iPhone 4S: Never Lose Your Keys Again, Available at: http://www.kickstarter.com/projects/690528216/hone-for-iphone-4s-never-lose-your-keys-again (accessed 21 October, 2013).
Casio Electronics Co., Ltd. GB-6900AA-2ER Bluetooth Watch. Available at : https://www.casioonline.co.uk/p/10308/gb-6900aa-2er (accessed 18 October, 2013).
Shoemake MB, Texas Instruments, White Paper, Wi-Fi (IEEE 802.11b) and Bluetooth Coexistence Issues and Solutions for the 2.4 GHz ISM Band. Available at : http://focus.ti.com/pdfs/vf/bband/coexistence.pdf (accessed 20 October, 2013).
Bluetooth SIG, Inc. A Look at the Basics of Bluetooth Wireless Technology, http://www.bluetooth.com/pages/Basics.aspx (accessed 20 October, 2013).
Bekkelien A (2012) *Bluetooth indoor positioning*, Master's Thesis, University of Geneva, Switzerland.
Cheung KC, Intille SS and Larson K (2006) An inexpensive bluetooth-based indoor positioning hack. In : *Proceedings of 8th International Conference of Ubiquitous Computing Ex-tended Abstracts*, UbiComp, California, USA, 17-21 September 2006.
Ace Marketing & Promotions, Inc., New York, USA. Mobiquity Networks. Available at : http://www.acemarketing.net/technology-platforms/mobiquity-networks.html (accessed 20 October, 2013).
Deng Z, Xue T, Cao H et al. (2008) Realization of A Bluetooth Network-Based Multi-Module System. In : *Proceedings of 12th World Multi-Conference on Systemics, Cybernetics and Informatics*, Florida, USA, 29 June - 2 July 2008.
Perry T (2012) Article title. In : The Indoor Navigation Battle Heats Up. Available at: http://spectrum.ieee.org/tech-talk/consumer-electronics/portable-devices/the-indoor-navigation-battle-heats-up (accessed 21 October, 2013).
Belloni F (2010), Article title. In : Bringing Navigation Indoors. Nokia Research Center Radio Systems Laboratory, Finland. Available at : http://geta.aalto.fi/en/courses/bringing_navigation_indoors.pdf (accessed 23 October, 2013).
Navior Co., Ltd. nLocator. Avaialable at : https://itunes.apple.com/us/app/nlocator/id483498248?mt=8 (accessed 23 October, 2013).
Fernandes T, Article title. In : Indoor Localization Using Bluetooth. Faculty of Engineering, University of Porto, Portugal. Available at http://paginas.fe.up.pt/~prodei/dsie11/images/pdfs/s5-4.pdf (accessed 21 October, 2013).
Venere E (2012), Article title. In : Free apps drain smartphone energy on 'advertising modules' . Purdue University News, 4 April 2012. Available at: http://www.purdue.edu/newsroom/research/2012/120404HuSmartphone.html (accessed 23 October, 2013).
Cisco Systems, Inc. (2013) Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2012–2017. Report. Available at : http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html (accessed 23 October, 2013).
Smith A (2012), Article title. In : 46% of American adults are smartphone owners. Pew Research Center's Internet & American Life Project. Available at: http://pewinternet.org/~/media/Files/Reports/2012/Smartphone%20ownership%202012.pdf (accessed 23 October, 2013).
Sticknfind Technologies, StickNFind Stickers. Available at : https://www.sticknfind.com/ (accessed 23 October, 2013).

Amazon online store, Loc8tor Pet - Ultimate Wireless Pet Locator. Available at : http://www.amazon.com/Loc8tor-Pet-Ultimate-Wireless-Locator/dp/B003WF0LDG/ref=sr_1 13? ie=UTF8&qid=1379 886136&sr=8-13&keywords=tracking+device (accessed 23 October, 2013).
Amazon online store, Pocket Finder Vehicle GPS Tracker Device. Available at : http://www.amazon.com/PocketFinder-Vehicle-GPS-Tracker-Device/dp/B00BJ1BNBO/ref=sr_1_14?ie=UTF8&qid=1379886136&sr=8-14&keywords=tracking+device (accessed 23 October, 2013).
Amazon online store, Bushnell BackTrack D-Tour Personal GPS Tracking Device. Available at : http://www.amazon.com/Bushnell-360310-D-Tour-Receiver-Green/dp/B004QHL944/ref=sr_1_ 15?ie=UTF8&qid=1379886136&sr=8-15&keywords=tracking+device (accessed 23 October, 2013).
Amazon online store, Mommy I'm Here cl-103br Child Locator. Available at : http://www.amazon.com/Mommy-Im-Here-cl-103br-Locator/dp/B0009PLRXK/ref= sr_1_17?ie=UTF8& qid=1379886167&sr=8-17&keywords=tracking+device (accessed 23 October, 2013).
Amazon online store, Click n Dig Key Finder Wireless RF Item Locator Remote Control, Pet, Wallet, Keyfinder. Available at : http://www.amazon.com/Click-Wireless-Locator-Keyfinder-Free-Batteries/dp/B001BK54RM/ref=sr_1_21?ie=UTF8&qid=1379886167&sr=8-21&keywords= tracking+device (accessed 23 October, 2013).
Amazon online store, Tagg-The Pet Tracker Master Kit. Available at : http://www.amazon. com /Tagg-The-Pet-Tracker-Master-White/dp/B0077I42S4/ref=sr_1_28?ie=UTF8&qid= 1379886167 &sr=8-28&keywords=tracking+device (accessed 23 October, 2013)