KASBIT Business Journal, *14*(1), 60-69, March 2021

Smart Phone based Personal Assets Tracking under Internet of Things

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Abstract

The advent of personal connectivity, ubiquitous computing, and sensing capabilities in present-day smartphones makes them an appealing candidate for the evolving concept of Internet-of-Things (IoT). As IoT transforms human-to-human communication to autonomous device-to-device communication within a network, smartphones are conceived as its backbone. This paper proposes a Personal Tracking Model under the realm of IoT and utilizes smartphones as a key element. We articulate the feasibility of a Personal Asset Tracking scheme that can be realized under the umbrella of IoT using a smartphone and the tagged valuables. This is realized utilizing a hybrid Bluetooth/Wi-Fi-based communication topology with two employment concepts. At a lower level, a user solely uses the Bluetooth in his smartphone to track the lost or misplaced item which is tagged with a Bluetooth token. At a higher level, the object is tagged with a hybrid Bluetooth and Wi-Fi token. The Wi-Fi token provides an IoT connectivity which results in coarse localization information while the fine-grained tracking information can be achieved through Bluetooth tracking, as in the first case. We also present a technical overview and comparison of our proposed scheme with the existing tracking solution.

Keywords: *Internet-of-Things, Bluetooth, Wi-Fi, Asset tracking, Smartphone*

1. Introduction

The emergence of computing technology has led to capabilities never experienced before. Today, it is possible for people to remotely monitor activities like the movements of assets through real-time tracking systems. However, in a conventional computer network, users are required to be wired, which may be ineffective and inefficient in some cases. A good example is personal tracking that requires a lot of mobility as opposed to restricted location monitoring systems. However, the emergence of mobile communication devices has the potential of improving personal tracking in many ways. These mobile devices are fitted with different sensors able to communicate with conventional computer systems via wireless networks (Besada et al., 2007).

A personal asset tracking system can, therefore, be developed by anchoring mobile telecommunication sensors in smartphones. One main advantage of smartphones is that they are highly accessible and cheap to maintain as opposed to other tracking devices. A good personal tracking system should also provide location-based information, a functionality that smartphones are capable of providing (Zhuang et al., 2010). However, to ensure that personal tracking is viable, an issue of privacy, costs, and security are paramount. A hybrid system that utilizes the Internet of things (IoT) model has been proposed in this paper. Moreover, this hybrid system combines different components of wireless sensor networks (WSNs) that can transmit information from different points to a central place for decision making.

Globalization has led to increased mobility of people who at the same time need to monitor their assets as well as their loved ones. For instance, parents who have children at home may worry about their safety. Given that they cannot rely on calling them frequently or observing their movement using remote cameras while they have other tasks to perform, tracking seems convenient (Talukder et al., 2007). However, identifying the best tracking system is an issue for many individuals. Currently, there are many personal tracking models proposed under wireless sensor frameworks. WSNs are highly popular because of their ability to incorporate other applications that are location-dependent (Yahya and Iskandarani, 2006). However, for any tracking model to be considered applicable for a given task, cost and scope of hardware used are two main issues that must be considered.

In most cases, available WSN communication gadgets like GPS are quite expensive when they are used for low-value asset tracking or personal tracking. Such gadgets also have other limitations based on nodal communication. These gadgets can only transmit data to certain distances on a point-to-point basis (Shang et al., 2009). Another issue arises in the technicality of installation, use, and maintenance. As a result, traditional WSNs are increasingly becoming unreliable and costly even with the increased innovations in wireless controlled network technologies. Internet of things (IoT) is an increasingly popular model for point-to-point communication between two devices (Monares et al., 2014). Internet of things is a break from the traditional communication systems that rely on a human to human contact. It allows the connection of devices or assets in the same way individuals can form social networks through the traditional Internet concept.

This paper is, therefore, concerned with the development of a personal tracking model that effectively anchors IoT capabilities for smartphones. Smartphones are arguably one of the most accessible and widely used single pieces of communications technology in the world today. However, there are many limitations to the adoption of this model. This paper, therefore, focuses on how a hybrid model for personal tracking can be developed to overcome existing challenges and improve usage in useful activities like asset location, disaster response, and search and rescue missions among others. In this regard, the current study has the following objectives.

- To develop a hybrid model for smartphone-based personal tracking under IoT context
- To investigate the limitations of this model and how they can be mitigated
- To explore the shortcomings of other communication technologies currently used in personal asset tracking
- To review the available literature on personal asset tracking models and identify research gaps based on the IoT context

2. Research background

This section looks at previous works touching on the main concepts of this paper that include the Internet of things (IoT), use of smartphones as research tools, existing personal tracking models, and their shortcomings and justifications for this paper.

2.1 Role of information technology connections

Traditional systems usually rely on human beings to coordinate communications and even facilitate information flow (Gubbi et al., 2013). For instance, in an emergency response situation, the first response is a factor of the time those available within the incident's location can relay the same information to responsible authorities. In addition, even when such information is relayed, issues of accuracy and clarity may provide challenges for those charged with responding. On the other hand, the responders may also have challenges in mobilizing the required resources as promptly as they may be needed.

IoT-based solutions are mainly built to take care of such limitations. This is because the communication between devices without human intervention helps in increasing speed, accuracy, and dependency of information flow for first response situations (Kortuem et al., 2010). IoT communications, therefore, eliminate the human element, which is susceptible to compromises and affected by attitudes, emotions, and nature of incidences that need to be monitored (Kopetz, 2011). On the receiver side, IoT connections also facilitate quick response by eliminating similar human factors (Yang et al., 2012). For tracking-based solutions, IoT, therefore, helps to eliminate an element of compromise (Weber, 2010). The reason is that devices cannot be compromised through corruption or distractions. When programmed to relay information on changing locations, they do so seamlessly without the intervention of any user and without relying on other external conditions like the immediate environmental factors (Chui, Löffler, and Roberts, 2010).

2.2 Emerging use of smartphones

To effectively function, IoT models heavily rely on the capabilities of participating devices. Smartphones have been picked for the project's tracking system because of their ever-expanding scope of use. Wendy and Stowers (2009) highlight the potential of smartphones as tools for discovery and information communications development. First, since the development of these gadgets, their adoption rates have been higher than that of any single piece of technology currently in use globally. Smartphones are also readily available to any user due to their user-friendly interfaces. As a result, they are the best candidates for tracking models in IoT-based solutions.

In addition, smartphones offer flexible advantages to users, which may also be of great importance to any tracking system on an IoT platform. Some of the technologies that have since been integrated into smartphone devices include GPS, digital cameras, sound recording, motion sensors, location sensors, and maps (Starkweather and Stowers, 2013). In addition, there are millions of smartphone applications being used today for different purposes, some of which might be helpful in tracking. For instance, smartphone cameras can scan barcodes and relay such information for analysis. This makes these devices unbeatable for personal tracking needs.

Moreover, smartphones are also cheap and easy to maintain (Murphy, 2010). For most functions, only a full battery and an Internet connection are needed. However, when an IoT framework is used, the costs of running tracking operations are likely to drop even lower.

2.3 Personal asset tracking communication channels

Even for the proposed smartphone tracking-based service under IoT, the choice of communication is a priority. Five potential modes have been identified, given their capabilities of facilitating information flow and relay to the user or between two devices. They include RFID, GPS, GSM, WIFI, and Bluetooth technologies (Roggen et al., 2013).

Radio Frequency Identification (RFID) is a communication technology channel based on-chip and antenna relays. The chip, just like a bar code, contains information on a particular asset or individual and the antenna can relay that information through radio signals. An RFID device must, therefore, be scanned to relay the information required. In the case of tracking, RFID devices can transmit signals regarding asset location and details. A major limitation of this communication technology is that it may only be able to transmit information within a smaller geographical area.

Secondly, the global positioning system (GPS) utilizes satellites to determine the precise location of a given asset or individual. Using this location, the geographical position of a given asset can, therefore, be located on a map, with a margin of error. Most smartphones already have GPS trackers pre-installed on them which make them potential GPS units when deployed in an IoT context. On the other hand, WIFI is a localized wireless technology that mostly uses the Internet or radio waves to transmit data and receive information from connected devices within the system. A WIFI connection is limited to a given area and may present security issues if not well monitored or secured.

On the other hand, the global system for mobile communications (GSM) is a standard channel of communication used by cellular devices. Through this information in a form of voice and text can be transmitted from one device to another simultaneously. Today, GSM is one of the most widespread networks for mobile communications in the world. However, there are numerous challenges for establishing GSM connections in remote locations (Weiss, 2003). Lastly, there is Bluetooth technology, which is used in personal area networks to transmit data radio and ISM bands. Bluetooth is reliable and cost-effective for personal information management in comparison to other technologies discussed in this section.

2.4 Shortcomings of other communication technologies

For most outdoor location tracking systems, GPS is commonly used. However, the main challenge with GPS is that it may not work indoors or in areas where there are tall buildings and other obstacles such as trees. Secondly, GPS technology heavily relies on power and when used with smartphones, they drain battery power easily. This energy consumption constraint, therefore, makes them unreliable for personal asset tracking (Ahmad, 2014). On the other hand, WIFI systems require massive resources like antennas and other networking hardware for wide coverage. GSM-based systems also present challenges in terms of location information they provide. Below in Table 1: show the comparative model for personal tracking.

		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
	Wi-Fi	Outdoors/ Indoors	meters	Wi-Fi Routers	Yes	Computational	Yes	Requires Wi-Fi 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- pre-configured infrastructure/ measurements
Behavioral Sensing		Outdoors/ Indoors	Cannot be used as the 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

Source: (Ahmad et al., 2014)
Table 1

In most cases, GSM-based communication technologies arrive at locations based on estimations from different base stations (Besada and Bernados, 2007). Just like in WIFI technology, GSM operations also require massive installations (Spirito, 2001). These challenges have, however, led to the establishment of hybrid methods of tracking and location systems.

Communication Technologies	NFC	RFID	Bluetooth	Wi-Fi	ZigBee	GPRS	GSM	WiMAX
Network	PAN	PAN	PAN	LAN	LAN	WAN	WAN	MAN
Topology	P2P	P2P	STAR	STAR	Mesh, Star, Tree	STAR	Mesh	Mesh
Power	Very Low	Very Low	Very Low	Low-High	Very Low	Medium	High	High
Speed	400 Kbs	400 Kbs	1 Mbs	11-100 Mbs	250 Kbs	35-115 Kbs	1.8-7.2 Mbs	11-100 Mbs
Range	< 10 cm	< 3 cm	10-45 m	4-20 m	10-300 m	Cellular Network	Cellular Network	50 Km
Cost Adder	Low	Low	Low	Medium	Medium	High	High	High

Source: Freescale white paper "What the Internet of Things (IoT) Needs to Become a Reality"
Table 2

Table. 2 shows the comparison concerning Network, Topology, and Power consumption, Speed of service; Range, and Addition Cost. Peng et al. (2010) give an example of SMART, which integrates the use of WIFI systems with cameras, microphones, and accelerometers. In addition, other hybrid techniques utilize GPS and WIFI.

These hybrid models are meant to increase efficiency and reliability through the utilization of the complementing capabilities of the different devices. Further, Papandrea and Michela (2011) propose a combined GSM/GPS/WIFI model. However, any suitable model must consider resource availability, service requirements, data storage requirements, and their intended use.

3. Study justification and limitations

Personal asset tracking takes advantage of available technologies in the information and communications sector. However, the conventional transmission systems have their limitations are discussed in this section. As a result, the purpose of this study is to propose a new model under the IoT framework. Apart from overcoming the limitations of usual systems, the new model is supposed to eliminate human error, which is associated with conventional human-human communication systems (Abu-Elkheir et al., 2013). The findings and recommendations of this study will, therefore, be important in addressing existing gaps, especially in areas of testing and assessing developed IoT-based solutions before they are successfully implemented.

On the other hand, this study is mainly limited to personal asset tracking solutions. As such, it may not extensively look at other models meant for intensified tracking activities like for large commercial institutions like shipping or airline companies (Lee et al., 2013). However, the proposed model will be able to enlighten designers of tracking systems to improve their innovation in real-time location-based monitoring and control.

4. The proposed hybrid model

After a comprehensive comparison between Bluetooth with GSM, GPS, WIFI, and RFID we can conclude that Bluetooth is an optimal candidate for personal asset tracking. It is cheap and more effective. However, Bluetooth technologies have their limitations.

Bluetooth mainly has a limitation of Internet connectivity so under the IoT context we purpose a hybrid asset tracking system Bluetooth- WIFI (Chen et al., 2014). We compare all the combinations one by one in detail with Bluetooth. Like blue tooth with RFID, Bluetooth and GSM, Bluetooth and GPRS, and with other communication technologies, and we found Bluetooth- WIFI is the most effective hybrid personal tracking device. Here the question that also comes to our mind is if WIFI can help us with tracking and it is satisfying the IoT conditions as well then why we proposed a hybrid tracking system. Because WIFI has its limitations tracking by using WIFI is very costly and it is required at least four personal Antennas (Ahmad, 2014) so it is not feasible for a smartphone user to keep such expensive equipment to afford.

We talked about the functionality of our proposed tracking devices explain through the instances if some works in the office and at home his/her pet walks away from the house, our important asset misplaces at absence by mistake through it out or theft. Thus, your pet valuable or not at predefine circle the early warning will be sent to your mobile via WIFI and also if you are valuable under the range of any other WIFI it will send you to massage the area of that WIFI but as we mention for navigation WIFI required personal equipment which is expensive so navigation will be done through Bluetooth.

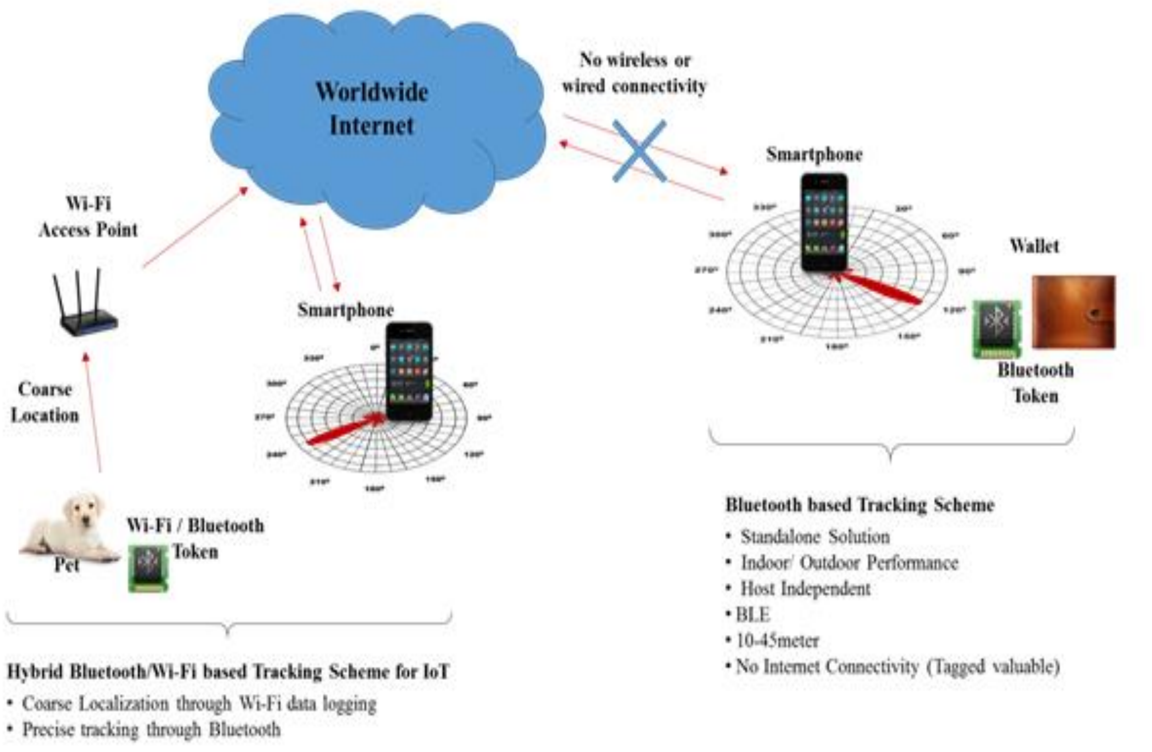

Figure-1

As shown in Figure 2, the usage of the hybrid model is quite simple. All assets are connected with hybrid Bluetooth/Wi-Fi tags and if any of the tagged subjects are out of predefined Area the Wi-Fi will instantly send a message on the smartphone as an early warning. As the tagged subject will move from one place to another place we can get information within the available Wi-Fi access point, and the précised tracking will be done with the Bluetooth.

Advantages

The advantages of use include:

1. Real-time tracking of assets (Mascolo et al., 2014).
2. An asset to asset communication, which ensures coordination in movement or location
3. Secured and multi-model (WIFI/Bluetooth) connectivity that is more effective and reliable
4. The high degree of expanding the network in case assets increase
5. Improved performance (Dyck et al., 2007).

5. Conclusions and recommendations

Hybrid systems are recommended because they can take care of issues of failure in communication to a given mode. An asset tracking system can, therefore, be developed by anchoring mobile telecommunication sensors in smartphones (Shamszaman et al., 2014), which have different communication capabilities. One main advantage of smartphones is that they are highly accessible and cheap to maintain as opposed to other tracking devices. A good personal tracking system should also provide location-based information, a functionality that smartphones are capable of providing. However, any suitable model must consider resource availability, service requirements, data storage requirements, and their intended use (Suhonen et al., 2009).

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