QiLoc: A Qi-Wireless Based Platform for Robust User-Initiated Indoor Location Services

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ABSTRACT

We present the design and implementation of a novel user-initiated indoor location system called QiLoc. QiLoc is a simple yet effective way to accurately locate and identify occupants inside buildings. QiLoc is composed of QiLoc Stations and QiLoc Server. QiLoc Stations are embedded inside or under desks/tables. By utilizing the Qi wireless charging protocol, a QiLoc Station is able to extract the unique IDs from phones placed on the desk, and therefore locating the user. QiLoc Server communicates with QiLoc Stations, maintains location information of occupants, and provides a set of APIs via standard web services. These services include location, ad hoc group membership, and authentication. Using these primitives, QiLoc enables a wide range of smart-building applications and we have implemented a number of applications.

Keywords

localization, user-initiative, authentication

Categories and Subject Descriptors

H.5.m. [**Information Interfaces and Presentation (e.g. HCI)**]: Miscellaneous

1. INTRODUCTION

A plethora of smart-building and intelligent-space scenarios have been envisioned by researchers and industry over the past twenty years. In social networking, strangers close-by or in the same physical space can discover and interact with each other; in workspace, colleagues sitting in the same meeting room can easily form ad-hoc groups and share documents; at home, our rooms can know where and who we are and automatically adjust lighting and temperature conditions to our preferences; and in commercial spaces, stores can detect our location and identity, and push targeted advertisements to us. Unfortunately, while some of these scenarios have been realized in demos, most of them are still restricted to academic exercises and proof-of-concepts. We have yet to see these applications in our everyday lives. This is largely because of the lack of a robust, accurate, and scalable indoor location primitive that is also privacy preserving. There is a huge amount of research in recent year on indoor-localization and occupant identification. However, all of them have their short-comings.

In QiLoc, we explore the use of the Qi wireless charging protocol for precise desk-level indoor location and identification.

Figure 1: QiLoc Station, embedded inside QiLoc desk.

Qi is a widely adopted wireless charging standard, which is based on electromagnetic induction for wireless power transfer. A standard Qi wireless charging system comprises of a power transmitting pad and a Qi-compatible mobile phone. In the Qi specification, an unique ID is embedded in the charge controller of the phone and is transmitted to the charger upon insertion. We can extract this unique ID using a custom-designed charging board. Current, there are around 62 Qi-compatible smartphones; many new smartphones coming out will also be compatible. Phones that are not directly compatible with Qi can be easily fitted with adapters/cases, including iPhone. As Qi is becoming more mainstream, many Qi hot spots are starting to appear in public, such as coffee shops and airports. Our approach is not restricted to the Qi Wireless standard, but general to all wireless charging protocols including Qi's competitor PMA (Power Matters Alliance).

The key idea of QiLoc is that occupants can actively share their exact location when they sit down and put their phone on the table, as depicted in Figure 3. This is a behavior that most people are already used to. The smartphone is charged at the same time that the building learns about the location of the occupant. This approach does not need any additional actions from the user such as opening an app or enabling some function on the phone. Building on this primitive, we build a number of smart-phone applications and show that they are effective in improving our everyday lives.

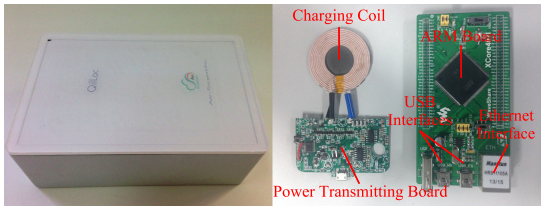

Figure 2: A prototype of QiLoc Station and its internal components.

2. SYSTEM DESCRIPTION

QiLoc consists of *QiLoc Station*s and *QiLoc Server*. QiLoc Stations can be embedded inside or under desks and tables. Each QiLoc Station has a sensing area outlined by its charging board. When a user charges her phone on a QiLoc Station, the station will extract the unique ID of the phone from wireless power signal by utilizing the Qi wireless charging protocol, thus accurately locating the user. On the cloud side, a QiLoc Server is designed to communicate with QiLoc Stations in real-time, maintain the location information of occupants, and provide a set of APIs via standard web services. Different from existing indoor localization systems that focus on positioning accuracy, QiLoc takes accurate indoor location as a primitive and enables a wide range of smart-building applications on top of it. Therefore, QiLoc represents an unprecedented user-initiated indoor location system.

2.1 QiLoc Station

We first present the design of QiLoc Station. Figure 2 shows a prototype of QiLoc Station and its internal components. When a phone is placed on a QiLoc-enabled desk, a QiLoc Station will not only charge the phone automatically, but also retrieve information from the phone, thus supporting the upper-layer applications. Specifically, a QiLoc Station consists of the following modules. The sensing module, a specially designed wireless charging board, extracts the unique ID from a charging phone by utilizing the Qi wireless charging protocol. Specifically, the power transmitter communicates with the power receiver using backscatter modulated power signal. In particular, the unique ID of a phone is encapsulated in the packet with the header of 0x71. We have designed a special charging circuit board which extracts the phone's ID through the aforementioned process. The obtained information, including the phone's ID, user's location, and associated timestamp, is uploaded to the cloud via the network module. QiLoc Station can use a wide range of wireless protocols such as Ethernet, WiFi, cellular (3G/4G). The network module mainly contains a micro-controller unit and TCP/IP protocol stack. In particular, we adopt an ARM Cortex-M4 for raw data processing and communication.

2.2 QiLoc Server

On the cloud side, we use a QiLoc Server for data storage and real-time communication with QiLoc Stations. The server mainly consists of a *data storage module* and a *service module*. The data storage module maintains the location information of all QiLoc users. In particular, we adopt the NoSQL database for data stream achieving, thus enabling efficient saving and searching of time series data. Specifically, the location-based service responds the location queries such as the user's present location and locations of people of interest. Therefore, third-party developers can easily integrate QiLoc with their own applications to enrich functionality. iLoc can be and has been deployed in a wide range of scenarios, providing rich location information. Such information, available at the QiLoc Server through standard APIs, can be leveraged to build or integrated with various applications. We will show the applications based on QiLoc in Section 3.

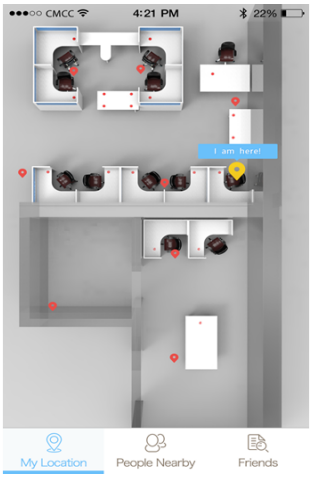

Figure 3: User's Location.

3. DEMO

In the Demo, we deployed several QiLoc Stations and some of them are embedded inside or under desks/tables and show several smart-building applications that we have implemented based on QiLoc. Figure 3 shows a straightforward application which is to provide location service for smartphone-based platform. It enables users to know their real-time locations. Another interesting usage is to learn the positions of certain people of interest. For instance, a user may want to be reminded of the identities of people that are sitting besides her during a conference, and tell if her colleagues have spent too much time in the rest area. These applications will enhance human interaction and productivity by integrating precise and live location information.

4. REFERENCES

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