COVID-19 Tracer : Towards Low-cost Passive Close-contacts Searching

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二等奖

Abstract

COVID-19 outbreaks rapidly around the world, which is the enemy faced by all humankind. Since COVID-19 is mainly spread through close personal contact, searching close-contacts is key to controlling this virus's spread. This paper designs COVID-19 Tracer, a novel low-cost passive system for searching COVID-19 patients' close-contacts. Utilizing ubiquitous Wi-Fi probe requests, COVID19 Tracer can quickly determine whether a person stays in one small space with a COVID-19 patient in the same period. Furthermore, it seeks to find out a close-contact with a novel rang-free judgment algorithm for location similarity. Finally, extensive experiments conducted in a school office building show our system's good performance, and the accuracy in finding out close-contacts is more than 98%.

SYSTEM DESIGN

1. Overview

This paper designs COVID-19 Tracer - a new low-cost passive system of searching COVID-19 patients' close-contacts based on ubiquitous Wi-Fi probe requests. Compared to other approaches, the probe approach requires neither high deployment cost (e.g., deploy cameras) nor user intervention (e.g., carry wearable devices or install mobile applications). Our key insight is that Wi-Fi probes are broadcast by smartphones to seek nearby access points (APs) requests, and they can be detected without users connecting to Wi-Fi devices, which in turn provides a non-intrusive way to determine whether two people are close contacted. It can tell that a person had stayed in a mall or office building with the COVID19 patient in the same period if one AP had received the Wi-Fi probes from these two people. This coarse-grained information has been beneficial to control the virus's spread, but we want to utilize received signal strength indicator (RSSI) in probes to obtain further fine-grained information, i.e., who is a close-contact of COVID-19 patient. To address this challenge, we propose a novel rang-free judgment scheme to define how far a person is from another based location similarity, which helps to rate the degree of proximity and finally determine the close-contact.

2. Workflow

COVID-19 Tracer consists of three innovative components:

(1) Data collection.

Smartphones frequently send wireless probe requests to discover APs that are obtainable in their environs. The probe requests sent can be obtained by an AP far away from a smartphone (even 100maway). Generally, there are many APs in an office building so that multiple APs can obtain the probe requests sent by one smartphone, including the MAC address and RSSI of this smartphone. By integrating the collected data, we can derive one sorting sequence for each smartphone, as shown in Fig. 1, where the elements are ordered by descending RSSI values.

(2) Proximity calculation.

We design two indicators to judge the localization similarity: *location similarity coefficient and close contact distance.* The location similarity coefficient. RSSI cannot be used to accurately calculate the absolute due to its environmental vulnerability, but can reflect the distance relationship between the smartphone and AP as RSSI weakens approximately monotonically with increasing physical distance. Given the sorting sequences of two smartphones, the location similarity coefficient is defined as the polynomial formula of the number of pairs in the same order in both sequences. The larger the number of the pairs in the same order, the closer the two smartphones are, and the more similar the locations of the smartphones are.

close contact distance. The accuracy of the location similarity coefficient may decline as the deduction of sequence length, i.e., the number of APs. As a supplementary indicator, the close contact distance is calculated by two APs closest to two smartphones.

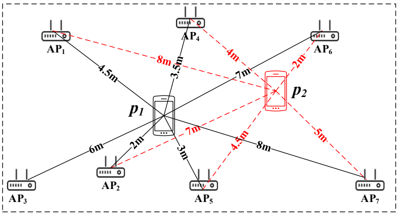

Fig1. Schematic diagram of prob collection

Fig2. Prototype System

EVALUATION

1. Experimental Setup

Six volunteers are recruited to conduct extensive experiments in a school office building (as shown in Fig.3), including four office rooms and two utility rooms for two weeks. We utilize 5 Aps (AR9341 WLAN chip) to collect the Wi-Fi probes. The majority of experiments is more than 1 h. We mainly use the following metrics to evaluate the performance of our system: (1) True Positive Rate(TP): the fraction of cases where two people are close-contacts is correctly detected; (2) False Positive Rate(FP): the ration of cases where two people are not close-contacts is wrongly detected.

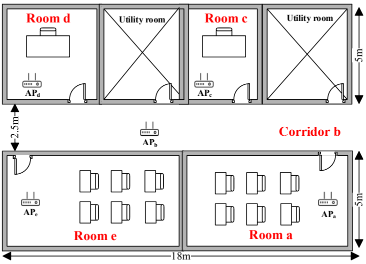

Fig3. Experiment scenario

2. Experimental results

We test the overall performance of COVID-19 Tracer every day and continuously collect Wi-Fi data for two weeks. During the evaluation process, two volunteers carrying smartphone $p1$ and $p2$ are required to move freely in Room e. A volunteer carrying a smartphone $p3$ is ordered to move freely in other rooms (Room a, Corridor b, Room c, and Room d) for 30 minutes in each room. Therefore, users of smartphone $p1$ and $p2$ are always close-contacts, and users of smartphone $p3$ and the others are non-close-contacts. Result show that the location similarity coefficient between smartphone $p1$ and $p2$ is always more than 0.5, and the close contact distance of smartphone $p1$ and $p2$ is always less than other cases. Fig. 4 shows that the average FP is less than 25%, and the average TP is more than 98%. Thus, we can claim that COVID-19 Tracer has good performance.

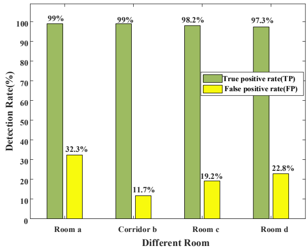

Fig4. Experiment scenario

CONCLUSION

This paper designs a new low-cost passive detection system for searching close-contacts of COVID-19 with ubiquitous Wi-Fi probes. Our system proposes a novel rang-free judgment algorithm for location similarity, which includes two judgment indicators that are location similarity coefficient and close contact distance. We conduct extensive experiments in a school office building. The experimental results show that our system, the accuracy rate of our system in judging close -contacts, is more than 98%. To the best of our knowledge, this is the first solution that searches close-contacts of COVID-19 patients using ubiquitous Wi-Fi probe technology. We believe that this low-cost passive detection scheme can help prevent the spread of the virus.

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