
A CONTACT-TRACING MOBILE PHONE APP FOR SARS-CoV-2 ERADICATION THAT MAINTAINS USER PRIVACY AND DATA PROTECTION **** DRAFT ****

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ABSTRACT

As of 2nd April a large proportion of the global population are living under social distancing measures in order to control the spread of COVID-19. If these measures are successful, in a few months the prevalence in many countries will again be low. At that stage, contact tracing is likely to be an important part of the response in order to prevent a resurgence of the disease but simulations show(Tang, 2020) that manual contact tracing will be too slow and inaccurate to be effective. Here we describe the design of a mobile phone app that is capable of automatically tracing close contacts of users without compromising privacy.

Keywords COVID-19, SARS-CoV-2

1 Introduction

Simulations show(Tang, 2020) that traditional methods of contact tracing are unlikely be fast or accurate enough for successful containment of SARS-CoV-2 due to its high R_0 , high proportion of asymptomatic carriers and significant pre-symptomatic transmission. There will be a better chance of containing the virus if technology is used to implement extremely fast and accurate tracing. Efforts in China have demonstrated that this can be achieved, but implementation in western countries is more challenging because user privacy and data protection must be preserved.

2 Design of a mobile phone app

We propose the use of a mobile phone app that broadcasts Bluetooth LE advertisement packets to locate potential close contacts. Each packet contains a randomly chosen UUID and a value that gives the tx signal strength². If another phone with the app installed comes within 2 meters for one minute, then each phone will locally store the random UUID of the other's along with it's own UUID. The UUID of each device will change every two minutes to a new, randomly chosen value.

As a person travels through the community, the app will collect the UUIDs of all encounters, along with its own UUIDs during those contacts. Because these are randomly generated they can't be used to identify anyone or track their movements. UUIDs are stored for 3 weeks, then deleted.

If a person tests positive, all the exchanged UUIDs of contacts stored on that person's phone are made public on the Internet. Since these are just random numbers, no sensitive information is disclosed. Every few hours, all apps will check the published UUIDs against their own locally stored values. If there is a match of 8 or more UUIDs, the user is notified that they are at risk and should self-isolate and be tested.

In this way, all close contacts of a newly confirmed case (as long as they are using the app) can immediately be informed that they are at risk. The only limitation being the proportion of people who install the app and the compliance of the

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²Spooing of the MAC address should also be used, this is available when Bluetooth LE Privacy is in use.

user with advice to self isolate. A recent survey(Abeler, 2020) shows that public support for an app is high in the UK and that around 74% of respondents would probably or definitely install a contact-tracing app.

3 Measuring distance

When a new Bluetooth device is detected, the received signal strength (RSSI) is used as a first approximation of the physical distance. If the received signal strength goes above a threshold an optional alarm is sounded³. The device whose name string has the lowest binary value sounds the alarm first. The alarm serves to alert the user that another person is too close, but also serves to calibrate the Bluetooth signal strength/distance relationship for the current pair of devices in the current surroundings. Encoded within the alarm sound is the UUID of the sender and that of the potential close contact (encoding could be done, for example, by using frequency shift keying and an error correcting code such as Reed Solomon). The close-by device listens for this alarm and has exactly one second to decode and process it. Once the alarm is recognised and the recipient name is matched, exactly one second after the receipt of the beginning of the alarm, a response alarm is sent back to the original sender. The original sender can now approximate the distance between devices as

$$d = \frac{(t_r - t_s - 1)c}{2}$$

where t_r is the time that the original alarm began, t_s is the time that the beginning of the response alarm was received and c is the speed of sound in air. Exactly one second later the original device sounds a second alarm in order to allow the other device to also calculate distance. If at any point the communication fails either of the devices can initiate a repeat alarm after waiting for an exponential backoff time.

Speed of sound in air is approximately 340 ms^{-1} , so in 1 microsecond sound would travel around 0.34mm. The timing of the alarms can be made accurate to a few tens of microseconds without any particular difficulty so the accuracy of this technique is adequate for the current purposes.

Once the actual distance is found, it can be used to calibrate the RSSI to distance model. It has been shown(Zhou & Pollard, 2006) that, for positive values of RSSI, distance can be approximated as

$$d = A10^{-\frac{R}{20}}$$

where d is the distance, R is the RSSI signal strength and A is the unknown we need to calibrate.

If calibration is not possible by this method, due to background noise or muffled/muted phone then calibration falls back to a standard value based on the make and model of the users phone and the value in the tx signal strength of the received advertisement packet. A community-generated database of these standard values for all phones could be made available online.

4 Aggregate contact monitoring through opt-in data gathering

If, as seems likely, the contact tracing is going on within a context of other social distancing measures, people could opt to allow the app to submit the number of close contacts they have each day along with (again optionally) information about the respondent. This would allow governments to closely monitor the effectiveness of different policy measures in reducing the aggregate daily number of contacts, and allow them to respond to local outbreaks effectively while minimising disruption to peoples lives.

5 Optional scientific research

The app could also be used to perform scientific research. The spread of a “virtual disease” could be studied by reserving one of the bits in the Bluetooth name and using it to denote infected or not infected with the virtual disease. It could then be observed how the virtual virus spreads between members of a set of volunteers.

6 Gamification

In order to encourage people to use the service and to encourage social distancing in public places, perhaps the app could be gamified. Perhaps there could be an in-app pet that the user must look after, and for every real-world close contact, there’s a chance that the in-app pet gets infected. The longer the user manages to keep the pet healthy, the more points awarded and the faster the pet will grow from a baby into a healthy adult.

³The following requires access to the devices microphone so the user can optionally deny this access

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