Alternative

Contact Tracing

Group 09-18

Xiao Jing Da (Leader) | 3A3-30

Seow Chee Heng | 3A3-22

Alrik Koh | 3A3-07

Tang Xuyuan | 3A2-24

Abstract

The Covid-19 pandemic has changed every aspect of our lives over the past year. In such public health crises, it is imperative that we take advantage of all available technologies. In the situation with Covid-19, a highly transmissible disease, an efficient and effective contact tracing system is necessary to slow down and stop its advance and mitigate the massive risk to public health and reduce the already numerous human toll. Naturally, such pandemics must be stopped as quickly and with as little impact as possible on the livelihoods of people. In addition, the social distancing and quarantine measures that are necessary to prevent the spread of pandemics can and have caused massive economic challenges, furthering the need for systems that most effectively combat its spread and impact. Along with other measures, contract tracing systems play the vital role of identifying people who are at risk and adequately warning them and allowing them to quarantine themselves and reduce the risk of further spread. However, the effectiveness and efficiency of such systems are restricted by various inefficiencies and oversights. The objective of our project is to tackle one of those blind spots and propose an alternative contact tracing system. We have created a system to serve that function, complete with client application and other back-end systems.

Contents

Introduction

This project was started as an alternative solution to existing contact tracing, in order to provide a more accurate and efficient system, especially applicable in current times.

The Problem

As bluetooth is only able to capture immediate contact and can only record contact if 2 people are together at the same time, missing out the 72 hour period in which the Covid-19 pathogen can survive on surfaces *(Covid-19 Pandemic - let's not forget about surfaces, 2019)*. With our system, this loophole is eliminated.

Our primary goals were to balance the accuracy of the contact tracing with the observable impact on performance and battery life of the user, as well as the impact on personal privacy.

Our Solution

Bluetooth utilises radio waves in order to transmit data wirelessly. In a crowded and concrete-filled place like Singapore, this can become quite unreliable, giving incorrect distance readings or just simply not connecting (The Inventors of Bluetooth Say There Could Be Problems Using Their Tech for Coronavirus Contact Tracing, 2020). In contrast, GPS utilises the time differential between a satellite and a phone to determine a position, thus being far less susceptible to signal interference from the high density of bluetooth signals or the blocking of signals by indoor fixtures. As a result, GPS is a better solution to determine potential contact between people.

GPS locations can also be recorded and stored, so indirect contact within 72 hours can be found by simply finding people at the same location but within 72 hours. Hence, this system records the locations a person has visited and finds indirect contact via surfaces such as doors, tables etc.

Desired Outcome

We hope that with this alternative contact tracing solution, contact tracing would be made more efficient and accurate to the public, allowing for a person's potential contact with a confirmed case to be more accurately identified, keeping the community safe by reducing potential spread of the virus.

Target audience

It is targeted as a general alternative for the public for the current contact tracing solutions. We intend for this product to be able to reach the masses eventually to provide them with another potential source of contact tracing.

Literature review

Pre-existing Contact Tracing Solutions

At the time of conception of this project, Singapore relied on a SafeEntry system combined with a bluetooth TraceTogether system to track the places a person had visited. This required a person to scan a QR code to check in and out of a place, a process which was highly inconvenient and often resulted in people neglecting to check-in, or more commonly, check-out. In addition, the existing contact tracing system was unable to spot non-simultaneous contact, such as when bodily fluids (such as sweat) are left on door knobs or railings, and picked up by others, resulting in an untraceable virus transmission.

The system also had the flaws of using bluetooth as the method of tracking. As the majority of bluetooth based systems rely on the strength of the received signals for contact tracing, physical obstacles can result in a reduction in accuracy of the contact tracing. Thus, the mostly concrete walls and ceilings that are prevalent in the indoor environment where most Singaporeans interact with each other, would introduce an element of unreliability into the tracing abilities of the system.

Our Alternative Solution

These problems would be largely reduced in a system utilising GPS. As GPS location tracing is time-independent, contact could be traced within the 72 hours that Covid-19 pathogens can survive on surfaces

Methodology

Needs Analysis

We knew these systems were particularly in high demand as of recent times with the ongoing pandemic and the need for such contact tracing systems to reduce the spread of the Covid-19 virus.

Tools Utilised (Platform, sites, programs)

- Android Studio as mobile client platform
- Java-based network interface integrated with Socket.io framework
- MongoDB database
- C++ based server-side program to analyse and identify contact

Project Timeline

Figure 1: Project Timeline by month

Project Overview

Client-side

The client side application that runs on the android operating system collects GPS data using the device's inbuilt sensors every 60 seconds, then processing and saving the data locally. Every night at approximately 1 AM, the GPS data collected during the day, along with the corresponding timestamps and the user's identifier, is transmitted to the server for further analysis.

In the client UI, a map of location history is available to the user, based on the data collected prior. The client-side application will also provide warning alerts if/when potential contact is found with confirmed Covid-19 cases.

Server-side

The server analyses received location data, storing it for up to 14 days before deletion. Upon receiving notice that a user has tested positive, the server will gather the location data of the user over the previous 14 days, and should the server find that any of the user's location datasets fulfils the criteria for potential contact mentioned above, a notice will be sent to the respective users to quarantine themselves and take any other measures to prevent any further potential spread of the virus.

Overview on Project Modules

Network Interface

- Utilises Java and Socket.io to transmit the data
- Provides transmission of location/time data from client to server as well as warning notices from server to client
- On the server-side, it does pre-processing, filtering out unnecessary data and adding it to a MongoDB server for further analysis

Client

- Utilises android's inbuilt location services to find and record client locations
- Displays warnings for potential contact
- Displays client location history in map form
- Utilises the interface mentioned above to transmit data for analysis

Server

- Utilises C++ and MongoDB
- Utilises data provided by the client in the MongoDB instance to find potential Covid-19 contact and returns any matches to the client as warnings.

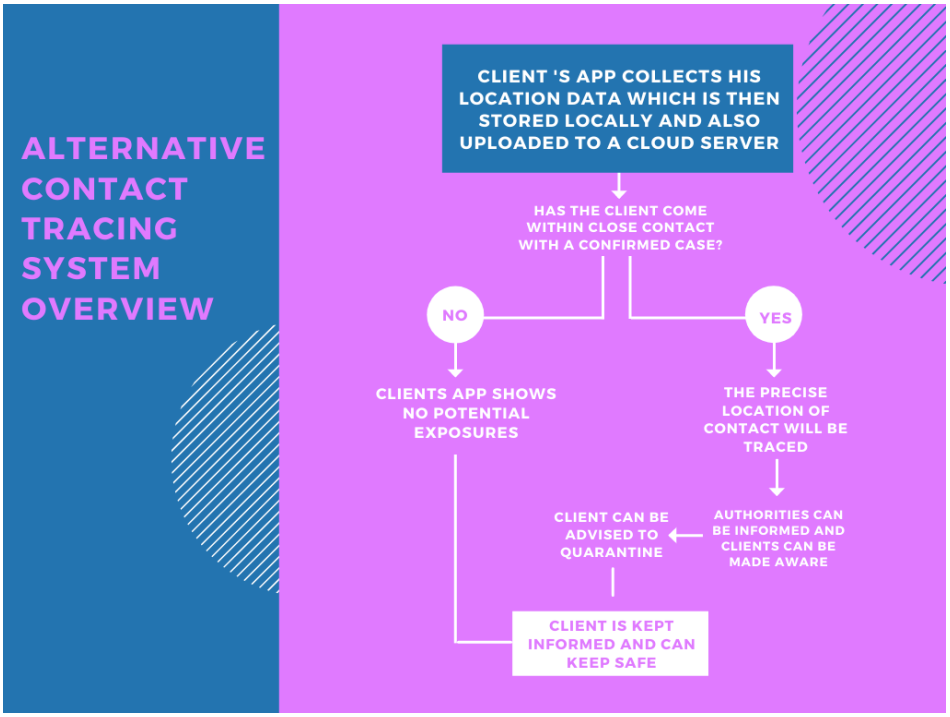

Figure 2: Project overview from client perspective

Client UI

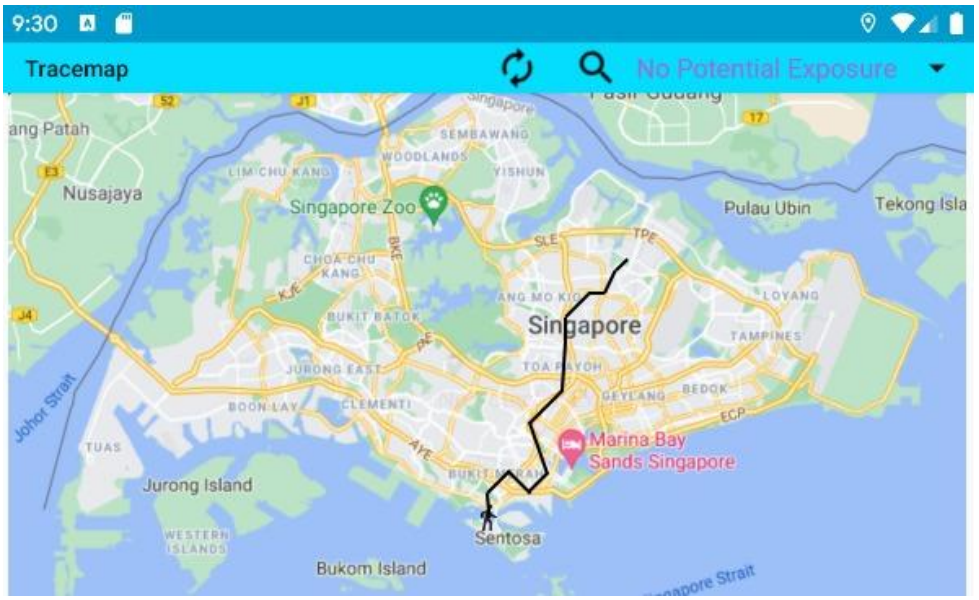

Figure 3: Client UI when there are no exposure alerts

When no exposure warnings are found, the map simply displays the client's current location, with the option to display the client's location history when the 'history' button is clicked, shown displayed above in Fig. 3

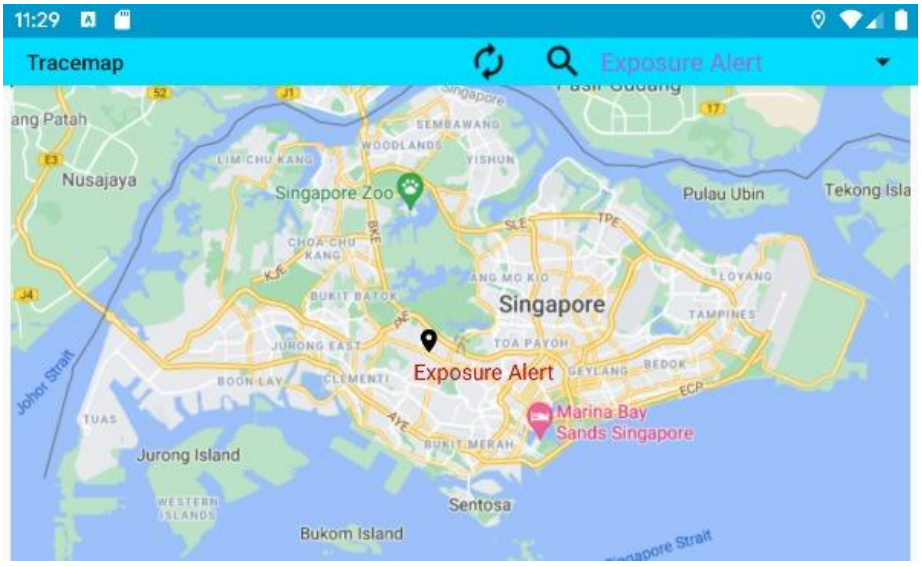

Figure 4: Client UI displaying Exposure Alert

When potential contact is found, a red alert will appear on the map at the location of contact, as well as an indicator in the top-right corner. In addition, a warning will be

displayed to the user as an OS-wide alert to notify them of the presence of an Exposure Alert.

Client-server Interface

Network interface

The interface utilises the Java module of the Socket.io framework and Java's inbuilt network interface to transmit the data over a TCP connection encrypted with AES-256.

Server pre-processing *(Secondary Function)*

Upon receipt of the client's location data, the interface verifies the validity of the data, filtering out any coordinates that are outside Singapore (with a buffer space to account for GPS inaccuracy) and any timestamps which are not within a few days of the server's inbuilt time. Then, the GPS-time coordinates are entered into a MongoDB instance to be later retrieved and analysed.

After this, the interface finds any potential contact cases stored by the server regarding the connected client. If any are found, the server transmits back the GPS-time coordinates of the user during the potential contact case. If not, a null response is sent and the connection is closed.

Server-side Data Analysis

Whenever notice of a confirmed case is received, the server iterates through the recorded location-time data of that user over the last 14 days. Whenever another person is found to have been within the same 20 meters and the same 72 hours as the confirmed case, the server saves it into a list of potential contact cases. Then, finding any matches with the same user with a time gap of less than 20 minutes, it deletes all cases except the first one, presuming that the user has merely been at the location of the confirmed case for an extended period of time. After this filtering is complete, the server saves it into the

MongoDB instance as a potential contact case for the network interface (as mentioned above) to pick up and send back to the client.

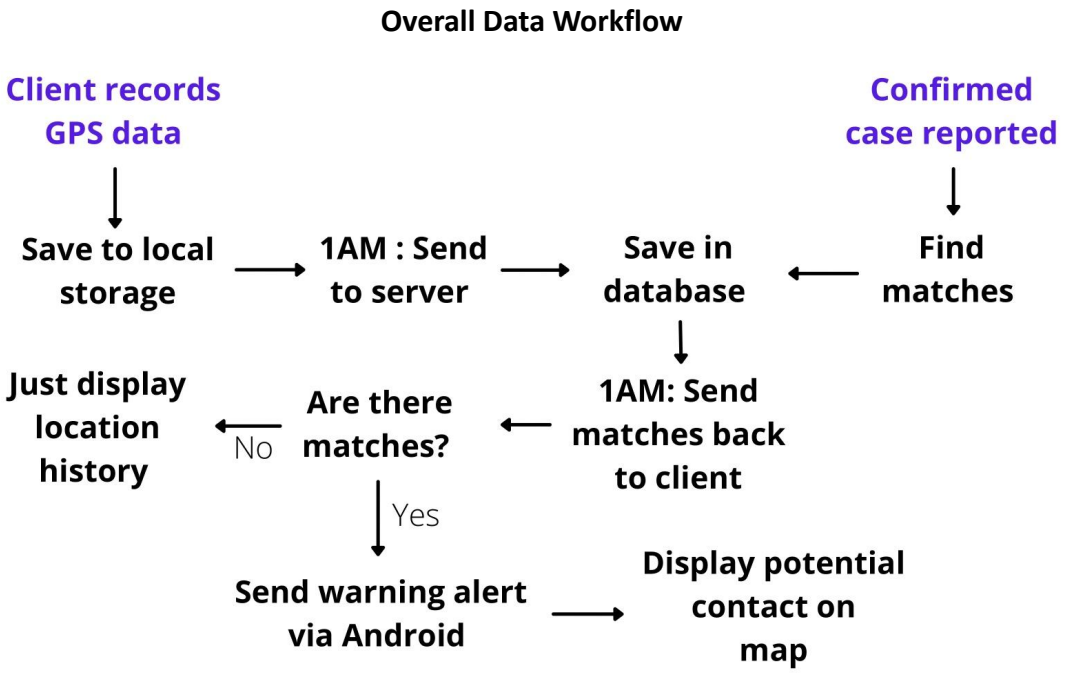

Figure 5: Data Workflow

Limitations and Recommendations

Limitations

- The constant location tracking can be a load on the user device's battery. However, this load would only noticeably impact older or smaller devices with less battery capacity, having little impact on the batteries of newer and larger devices.
- At the moment, the client application is only available for Android

Areas for improvements

- Our GUI for the client application could be better developed to be more consumer friendly and easier to navigate.
- Security could be improved.
    - On the client-side, more advanced encryption could be employed to ensure that a security breach of the client's device itself could not reveal the location data of the person
    - On the server-side, the database security could be improved (using an encrypted OpenVPN tunnel for developer testing, having some form of client authenticity verification etc), in order to protect the data security of the clients.
    - In addition, a hashing system could be used to protect data security. When the data is sent to the server, a hash of the coordinate could be used to match locations instead of sending the location data in actuality. Thus, the locations would never leave the client's device.

Reflections

Xiao Jing Da

This project is definitely fun and challenging at the same time thus I find it very memorable. This project was inspired by the Covid-19 pandemic making such a project special. I learnt more about how Android Studios works as well as the languages gradle and java. By fixing the numerous bugs in the code, I have gained valuable experience which I feel are important and applicable for other coding related activities. Because we started late due to the safety measures to prevent the ongoing pandemic and I did not take into account the exam in term 3, my schedule became very tight and I hardly had enough time to revise for exams. From then I have now learnt to plan further ahead to take into account other possible problems that might occur and plan my time accordingly. I also have learnt the responsibilities of a leader and how important facilitating and helping every member finish their task at hand is.

Tang Xuyuan

This project was a challenging but rewarding experience for me. Our project was inspired by the challenges brought on by the recent Covid-19 pandemic. During this project, I developed my observation and critical thinking skills, learning to spot issues in our daily lives that we may otherwise miss out. As we were brainstorming solutions, we had to come out with ideas that targeted the core of the issue using the new technology available to us today. Undeniably, I honed my technical skills, such as my familiarity with networking and encryption, along with my knowledge regarding the usage and optimisation of database functions and data structures. However, I found that learning how to apply these skills flexibly to problems in real life was more important. Ultimately, this project helped me understand the impact of simple and elegant solutions to complex problems.

Seow Chee Heng

This project was overall rather memorable and a unique experience to have. From this project, I learnt how to work better with my project work members and got to know them much better. This was my first time developing an application on Android and in the process, I greatly improved on my coding skills and gained a deeper understanding of the android framework. One of the aspects that I feel we could have improved on would be the time management of the overall project. The main parts of this project was done during term 3, during which we all had a rather packed schedule with numerous tests during that semester. I believe that we would be able to further improve our product and make it even more optimised, even more streamlined.

Alrik Koh

I find doing this project very meaningful, since we are in the midst of the Covid-19 pandemic, and doing such a project may be of use to save lives. From the process of doing this project, I learnt how to code in C++ much better than before, such as knowing how to properly download relevant libraries to communicate with the MongoDB databases. Also, I learnt how to work together with my different project work group mates to synchronize the various backend programs, client programs, and servers. I also learnt that server security is important as in the midst of doing this project, our test data stored in the database was hacked and held ransom by an unknown person. This prompted us to improve security of the MongoDB server, even when development of the project was still in the early stages. Overall, it was a fun and enriching experience, and I would have never done it if not for the support of my teammates!

Bibliography

Biddle, S. (2020, May 5). *The Inventors of Bluetooth Say There Could Be Problems Using Their Tech for Coronavirus Contact Tracing.* The Intercept. https://theintercept.com/2020/05/05/coronavirus-bluetooth-contact-tracing/

Bluetooth contact tracing needs bigger, better data. (n.d.). MIT Technology Review. https://www.technologyreview.com/2020/04/22/1000353/bluetooth-contact-tracing-needs-bigger-better-data/

Newton, C. (2020, April 10). *Why Bluetooth apps are bad at discovering new cases of COVID-19*. The Verge. https://www.theverge.com/interface/2020/4/10/21215267/covid-19-contact-tracing-apps-bluetooth-coronavirus-flaws-public-health

Rawlinson, S., Ciric, L., & Cloutman-Green, E. *(2020, May 19). COVID-19 pandemic – let's not forget surfaces. Journal of Hospital Infection, 105(4), 790–791.* https://doi.org/10.1016/j.jhin.2020.05.022