



Development of An Android Application for Viewing Covid-19 Containment Zones and Monitoring Violators Who are Trespassing into It Using Firebase and Geofencing

Ranajoy Mallik¹ · Amlan Protim Hazarika¹ · Sudarshana Ghosh Dastidar¹ · Dilip Sing¹ · Rajib Bandyopadhyay¹

Received: 29 April 2020 / Revised: 13 June 2020 / Accepted: 18 June 2020 / Published online: 1 July 2020
© Indian National Academy of Engineering 2020

Abstract

The World Health Organization has declared the outbreak of the novel coronavirus, Covid-19 as pandemic across the world. With its alarming surge of affected cases throughout the world, lockdown, and awareness (social distancing, use of masks etc.) among people are found to be the only means for restricting the community transmission. In a densely populated country like India, it is very difficult to prevent the community transmission even during lockdown without social awareness and precautionary measures taken by the people. Recently, several containment zones had been identified throughout the country and divided into red, orange and green zones, respectively. The red zones indicate the infection hotspots, orange zones denote some infection and green zones indicate an area with no infection. This paper mainly focuses on development of an Android application which can inform people of the Covid-19 containment zones and prevent trespassing into these zones. This Android application updates the locations of the areas in a Google map which are identified to be the containment zones. The application also notifies the users if they have entered a containment zone and uploads the user's IMEI number to the online database. To achieve all these functionalities, many tools, and APIs from Google like Firebase and Geofencing API are used in this application. Therefore, this application can be used as a tool for creating further social awareness about the arising need of precautionary measures to be taken by the people of India.

Keywords Covid-19 · Android · Geo-fencing · Firebase · Location tracking · Notification · IMEI number

Introduction

Currently there are several research works undergoing in the country to prevent Covid-19 cases from rising. Previously our country was importing medical kits like PPE (Personal Protection Kits), mask from outside, but now it has been successful in developing these kits. Along with taking initiatives to fight this disease, our country has also taken steps to make people aware of the disease. The news and media have a great part in creating this awareness by informing the public about the preventive measures that can keep them away from infection. Awareness among the people to carry out all the preventive measures can immensely help to reduce

spread of the virus. The country has created containment zones throughout the cities wherever Covid-19 cases have been reported to prevent further spread of the virus. These containment zones have been kept isolated from the outside public to ensure no contamination occurs outside.

After more than 2 months of the lockdown, the government has relaxed some of the lockdown rules and has permitted reopening of government offices, bus and other road transportation facilities and shopping markets. People can move inside the city for work and other purposes. But the containment zones are still being kept isolated, and new containment zones are being formed wherever Covid-19 cases have been reported. These zones are highly contagious as droplets with virus coughed out from an unscreened asymptomatic patient can travel up to 8 m (Bahl et al. 2020). Though these containment zones are guarded by policemen, still there remains a chance that people might unknowingly step into them. In this situation where people can move in the city, these containment zones pose a risk of infection to these city dwellers. Therefore, informing people about the

✉ Ranajoy Mallik
wranajoy@gmail.com

¹ Department of Instrumentation and Electronics Engineering, Jadavpur University, Salt Lake Campus, Kolkata 700 098, India

location of the containment zones can help them bypass and avoid these zones and thereby reduce the chance of community transmission.

In this paper, we focus on developing a mobile based application to provide information regarding the Covid-19 containment zones in West Bengal. The application further tracks the user's location and provides notification alert if the user has entered a containment zone. The application also provides daily Covid-19 case statistics to the users to keep them updated. The application is developed on Android SDK and uses Firebase Cloud Firestore to store the location data. Android's geofencing client is used to create geofences around the containment zones and notification manager is used to provide notifications. The application also uses RESTful web services to show the Covid-19 cases in West Bengal.

We have tested our application with different users in different locations across West Bengal and it works efficiently and is able to attain our target.

Existing Apps in Google Playstore Related to Covid-19

We have conducted a brief survey on the existing apps published in Google playstore which are related to Covid-19. Efforts have been made to include most of the apps in the survey. The summary of the survey is given in Table 1 which includes the name of the apps, the description of the apps given in Google Playstore by their developers and our comments on the apps after using them.

The survey shows that there are several apps developed in the country to fight and contain COVID-19. Most of the states of our country have their own apps with specific features and functionality to help their citizens to stop COVID-19 spread, get medical assistance during a crisis, create awareness, and understand safety precautions. The study also shows that there are a limited number of apps which show the COVID-19 containment zones in the country or state and out of these none has the functionality of notifying and alerting the user when they have entered a containment zone. Therefore, no app in the Google Playstore is comparable with our proposed application because the idea behind the development of the proposed app is different. This highlights the novelty of the proposed app.

Proposed Work

The Android application shows the location of the containment zones to the users. It also notifies the user when he or she trespasses the boundary of a containment zone or stays in the containment zones (Fig. 1).

Application Design

There are mainly three activities in the application. The first activity consists of a welcome screen which is designed with images and information. Next activity is a screen displaying the instructions to operate the application and a disclaimer (Figs. 2, 3). The third activity is a maps activity which shows all the containment zones in a google map (Fig. 4). This activity also has a bottom sheet which can be pulled up to show the real time Covid-19 statistic of West Bengal.

Firestore Cloud Firestore

The application uses Firestore which is a flexible and scalable database for mobile, web and server developments from Firebase and Google cloud platform (Cloud Firestore 2020). In Cloud Firestore, the mobile application supports serverless app architecture where the application connects to the Cloud Firestore database directly without any intermediate servers in between (Cloud Firestore SDKs and client libraries 2020). The application receives data from the database using WebSocket. The Web Socket transfers data at a higher speed than HTTP. The database transfers new data to the user as soon as it is updated. When changes are saved in the database then all connected clients receive the updated data almost instantly. The Cloud Firestore does not always fetch data from the database unless the data has been changed, it gathers previous data from the cache memory which also enables its offline functioning.

The Cloud Firestore features a NoSQL, document-oriented database (Cloud Firestore Data model 2020) and the data is stored in a JavaScript Object Notation (JSON) format. The location data are stored in documents, which are organized into collections. All the containment zones are stored in a collection in which each containment zone is represented as an individual document. Each document has four fields namely "Lat", "Long", "locationName" and "radius" for storing latitudes, longitudes, location names and radius respectively. Figure 5 shows the document-oriented Cloud Firestore database with data of few containment zones. The "radius" field in each document is used to indicate the radius of the containment zone. In the development stage, the billing plan for the database used here is the firebase spark plan which is the free plan provided by Firebase. This plan has few limitations like 50,000 and 20,000 reads and writes per day. These usage limits can be resolved by choosing a different paid plan from Firebase according to requirement.

Table 1 Summary of existing apps in google playstore related to Covid-19

Serial no	Application name	Details from playstore	Comments
1	Aarogya Setu	Aarogya Setu is a mobile application developed by the Government of India to connect essential health services with the people of India in our combined fight against COVID-19. The app is aimed at augmenting the initiatives of the Government of India, particularly the Department of Health, in proactively reaching out to and informing the users of the app regarding risks, best practices and relevant advisories pertaining to the containment of COVID-19 (Aarogya Setu 2020)	The application is developed by the government of India. It uses contact tracing technology with the help of bluetooth to check if a user comes near a Covid-19 patient
2	Bihar Saathi	Bihar Saathi app by iBihar.org to aid the people in Bihar on health issues. It captures details of the person raising the SOS along with their geo-coordinates, that is their exact location, and shares it with the relevant government department for redressal'. Additionally, the app provides information about various initiatives and schemes by the government that raises awareness about the various health issues including outbreak (Bihar Saathi 2020)	The application contains safety and preventive information regarding Covid-19, an option for submitting suspected patient information who are not diagnosed to a database and links for making donations
3	CG Covid-19 ePass	The Government of Chhattisgarh has launched this app to issue Interstate and Intra-State e-Pass for vehicular movement during the lock-down period to enable migrants/stranded people to reach their homes and join with their families. It would also facilitate people to undertake travel in case of personal emergency like Medical treatment or Death in the Family. This app would also allow seamless transportation of essential commodities within the State of Chhattisgarh. The applicant can obtain an e-Pass by submitting a photograph, Id Proof and valid proof for travel. The Applicant will be able to select the travel date, time and destination (CG Covid-19 ePass 2020)	The application helps in issuing e-passes in Chhattisgarh for interstate and intrastate vehicular movement and in case of emergency travel, for people during lockdown period
4	CoBuddy-Covid19 tool	CoBuddy-Covid 19 Coronavirus Help Tool-to help stop the spread of Covid 19, get info and help from the Government. The app makes sure that the people quarantined are within their location, communicate directly with them, provide information, and receive alerts if the quarantined are in need of any help. Location tracking and user verification with heat-maps, communication management, notifications and alerts, health tracking and feedback, essential operations management (CoBuddy-Covid19 tool 2020)	The application keeps track of the home quarantined Covid-19 patients and their needs by the concerned authorities
5	Odisha COVID dashboard	Odisha COVID dashboard has been developed by the Government of Odisha for citizens and officers (Odisha COVID dashboard 2020)	The application provides Covid-19 statistics of Odisha, self-assessment test for Covid-19, provides health advisories, list of hospitals and regular updates about Covid-19 for people of Odisha
6	Corona Mukht Himachal	The app helps to lock one's quarantine location with the help of the assigned Health Care Worker. People should ensure that they are in their home while locking the location. Standing just outside will ensure high accuracy of GPS data (Corona Mukht Himachal 2020)	The application is limited to the people of Himachal Pradesh. It provides a catalogue of Covid-19 patients and people who are in home quarantine

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
7	Corona watch	This app is for showing the locations of Corona Affected Patients and their movement history of 14 days. General Public can use this to identify their movements in those areas. If found to be in such locations, they are requested to call help line numbers 104, 080-46848600, 080 66692000. The app also facilitates citizens to identify the nearest hospitals which can treat for coronavirus including the sample collection centres and testing labs, please visit: https://kgis.krsrac.in/covid/ for other information (Corona watch 2020)	The application presents the locations of Covid-19 active and cured cases of Karnataka in a map, emergency helpline numbers, helps in locating medicinal facilities, home quarantined locations and spots visited by Covid-19 positive patients in the last 14 days
8	CORONTINE	This app is designed to help organisations (including the Government of Meghalaya) to maintain accountability and responsibility towards members and society. The app accomplishes this by monitoring the geographical movements of members and ensuring they are following proper work from home protocol and social distancing policies set by the organisation. Data will not be used for any purpose other than the safety of the members. Members have the right to activate/inactivate location as per their discretion. This app sends coordinates to the server if the user activates location. Users can check in at their home location and will be alerted if they leave the region around home location. Administrator/sup-port cell will also get the list of users who are within the circle or outside the circle. Only authorized admin can access the backend services for the purpose of safety of registered users. App provides an option for the user to recheck in at a new location with the approval from administrator/Unit manager via OTP. App provides more information like emergency con-tact numbers and similar important information for the users to access in a short time at the hour of need (CORONTINE 2020)	The application provides questionnaire based self-diagnosis, general symptoms and precautionary tips related to Covid-19. It sends alerts to the concerned authorities if the person under home quarantine leaves the location around their home
9	COVA Punjab	COVA Punjab (Corona Virus Alert) app has been developed by the Govern-ment of Punjab to provide citizens with preventive care information and other government advisories. The app has the following main sections for citizens: (1) real time dashboard for Punjab, India and global stats. (2) To check for symptoms of Corona and have a quick self-screening. (3) Corona Awareness. (4) Traveling instructions. (5) Prevention Products. (6) Corona Hospitals, Punjab. (7) FAQ. (8) Call Support-The users will receive updates from government, advisories, and instructions from time to time via PUSH notification on the app. This app will provide quick information and help. The people should definitely visit the nearest hospital/doctor in-case they develop Covid-19 symptoms (COVA Punjab 2020)	The application provides Covid-19 statistics of Punjab, questionnaire based self-assessment tools, donation link to CM Relief fund, find-ing nearby Covid-19 hospitals and helps in requesting groceries and essentials for people in Punjab
10	COVID CARE	COVID CARE-Quarantine and Contact Health Tracing for Covid Suspects in Arunachal Pradesh (COVID CARE 2020)	The application provides means of self-updating body temperature and Covid-19 symptoms by people of Arunachal Pradesh, thereby helping to monitor them remotely

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
11	COVID Care Kerala	This mobile app is an initiative of District Collector, Kannur. The application is designed and developed by the Mobile APP Development Competence Center, Kerala of National Informatics Centre. Major Features includes Counselling Service for the Quarantined persons or Covid 19 Affected patients, food and grocery supply contacts for the Migrant Workers, Geotagging of Quarantined persons (COVID Care Kerala 2020)	The application provides news updates regarding Covid-19, counselling for people in self-isolation, home delivery of essential goods and lists community kitchens for people of Kerala
12	COVID Ebazaar	The mobile application is developed to provide a platform to make a bridge between the citizen and prospective sellers for essential items (COVID Ebazaar 2020)	The application provides requests for delivery of essential groceries, fruits, vegetables, medicines to people in Rajasthan
13	COVID-19 Odisha	COVID ODISHA is a risk-management application of the Government of Odisha to coordinate preventive measures against COVID-19 pandemic. It helps citizens understand the spread of the virus and helps them connect with checking centres and hospitals. It helps the Government recognise possible cases of COVID-afflicted individuals and coordinate responses involving the administration, medical and paramedical professionals. It enables access to authenticated information from the Govt, cutting down spread of misinformation and helps people to report incidences of mass gatherings, violation of social distancing norms (COVID-19 Odisha 2020)	The application provides questionnaire based self-assessment tests and helps people in Orissa to connect with nearest hospitals and centres
14	COVID-19 Care Tamil Nadu-(Official)	COVID-19 Care is a mobile application developed by Bhisma Technology Private Limited for the Government of Tamil Nadu to connect essential health services with the people of Tamil Nadu in our combined fight against COVID-19. This app is aimed to reach out to people informing about the best practices and official updates pertaining to the containment of COVID-19 (COVID-19 Care Tamil Nadu-(Official) 2020)	The application shows the district wise COVID-19 cases in Tamil Nadu. It also shows the containment zones of the state. It provides help line numbers and bed availability of Covid-19 hospitals in all the districts
15	COVID-19 West Bengal	This is an official app of the West Bengal Government to monitor and control coronavirus in the state of West Bengal. The app helps to monitor the people in home isolation and people in quarantine (COVID-19 West Bengal 2020)	The application could not be operated
16	COVID 19 feedback	This app has been made in public interest to give information and capture feedback on any treatment undergone by individuals. The data will be used to highlight efficiencies, issues and process related changes that need to be undertaken (COVID 19 feedback 2020)	The application provides a platform for getting feedback regarding Covid-19 tests and medical treatment from people who have undergone it
17	COVID 19 connect	This app is developed as part of ongoing research on COVID-19. This app aims to provide relevant information on accessible resources for patient care. This app does not provide any clinical assistance (COVID19 Connect 2020)	The application gives users the total Covid-19 case statistics of India, tips, helpline numbers, testing centres and government updates

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
18	Driver Seva	The app allows truck drivers on highways to locate facilities including water, food and parking across PAN India. The initiative is supported by Bharat Petroleum Corp Ltd, and powered by highway delite and Locus (Startups working towards digital highway services and supply chain respectively). They are looking to add more partners—transport hubs, truck service centers, etc. in the network so that stranded drivers can get food, water and safe parking (Driver Seva 2020)	The application helps in locating the basic necessities like food, water and parking details for drivers on Highways across PAN India
19	Fight COVID	The app has been developed in continuation to initiative taken by the Maharashtra government to reduce exposure of COVID-19, that the suspected should undergo home quarantine for a few weeks. These home quarantined people are supposed to stay at home/hospital. Unfortunately, many of them are not following these guidelines. To stop people doing this, a technological solution (android application and website) has been developed to monitor home quarantined people with a GPS system from the corporation office itself. Alongside tracking, different reports can be generated which they need to share with health officials every day (Fight COVID 2020)	The application helps in tracking the home quarantined Covid-19 infected people by GPS and selfie. It also provides Covid-19 statistics, notifications and news updates related to Covid-19 and precautionary measures that need to be adopted by people while going outside
20	GCC-Corona monitoring	GCC-Corona Monitoring is the official app for collecting data to curb the spread of COVID-19 by the Greater Chennai Corporation (GCC-Corona monitoring 2020)	The application is limited to the people of Chennai, it can't be opened by people outside Chennai. It provides information regarding Covid-19 containment zones and isolation areas in Chennai
21	GoK Direct-Kerala	The app offers exclusive updates from GoK-Direct Kerala, where a user can download and install the app for free to use the service. Sign-up and registration are not required for the user to use this app. Welcome Screen-GoK-Direct Kerala. 2. Queue, the Timeline-Latest notification is shown as feeds from GoK-Direct Kerala (GoK Direct-Kerala 2020)	The application provides notifications related to general awareness, quarantine protocols and various such information on Covid-19 in multiple languages
22	Haryana Sahayak	Haryana Sahayak is a one-stop help app for all the citizens of Haryana. It helps people to battle the present Coronavirus outbreak by providing the following help to citizens around Covid-19: Helps citizens to provide Haryana Covid-19 Dashboard (State/District) level, locate confirmed cases near their location. The app also helps citizens to Locate Nearest Designated Hospitals Helps citizens to do a quick health test based on WHO guidelines, access to latest advisories and guidelines from Govt, thereby cutting down spread of misinformation. The app further helps citizens to locate essential commodities shop approved by Govt, get the movement pass, helps citizens to register as volunteers to provide assistance to people in need and also helps citizens for making donation to Haryana Corona Relief Fund Bilingual Support (English/Hind) SMS based OTP verification (Haryana Sahayak 2020)	The application has been developed for the state of Haryana. It provides questionnaire based health check-up, latest advisories and guidelines regarding Covid-19. It also provides information regarding nearest Covid-19 confirmed cases, nearest Covid-19 hospitals and helps in locating essential commodities

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
23	Kavach	Kavach app has been developed by the Government of Chhattisgarh to provide preventive care information and other government advisories. The app has the following main sections: (1) near real time Covid-19 dashboard for Chhattisgarh, India, and global stats. (2) To check for symptoms of Corona and have a quick self-screening. (3) Corona awareness. (4) Traveling instructions. (5) Corona Hospitals in Chhattisgarh (Kavach 2020)	The application provides Covid-19 statistics of Chhattisgarh, India and the world. It also provides questionnaire based Covid-19 check-up, various precautionary tips for creating awareness and lists the fake news regarding Covid-19
24	Mahakavach	Mahakavach is a digital contact tracing app for Covid-19. This app helps citizens to contribute and assist in tracing the contacts with potential risk of COVID-19 by helping Health administration. This app is to be used by individual(s) as directed by their doctor(s) or medical worker(s). The app also encourages updating the quarantine status to better adherence (Mahakavach 2020)	Only citizens permitted by the Health department are allowed to use this application
25	mCOVID-19	Official Covid-19 related guidelines and information from the Government of Mizoram (mCOVID-19 2020)	The application gives the statistics of Covid-19 cases in Mizoram and provides some Covid related guidelines. This application also monitors the patient under quarantine
26	MP COVID response app	National Health Mission (MP) has released MP COVID RESPONSE app to fight the spread of coronavirus. In case if the individuals feel the symptoms of COVID-19, they can report a case using this application after which they will be contacted by the nearest health centre. Latest guidelines related to COVID-19 released by the Govt. of Madhya Pradesh can also be obtained through this application (MP COVID response app 2020)	The application presents the number of Covid-19 cases in Madhya Pradesh and India, donation link to Emergency Relief Fund and helps in reporting Covid-19 cases through the application if people feel the symptoms and after which the person will be contacted by the nearest health centre
27	nCOVID-19 Nagaland	This application allows visitors (as users) to fill and declare their nCOVID status and travel history. The app also has DoHFW approved key information regarding nCOVID and Helpline numbers which can be used to reach in case of any further query regarding the same. The application is developed with the support of Nagaland Health Project (nCOVID-19 Nagaland 2020)	The application developed for the people of Nagaland gets input from users about their Covid-19 status and travel history. It also contains helpline numbers and users can also report about a Covid-19 affected person or an area through it
28	Niramaya	Niramaya app is an integrated solution to zero down COVID-19 spread in India. The app helps to get alerts about nearby outbreaks and request a COVID-19 test if the user has the symptoms. There is a COVID-19 self-test on the app to check if the user is safe. The app also provides verified information from your government and World news (Niramaya 2020)	The application provides the symptoms of Covid-19 and provides a request call for Covid-19 test
29	NMC COVID-19	This app provides an option to users to support the government to take immediate measures against COVID-19 by providing information regarding people suspected to be affected by COVID-19 near their vicinity (NMC COVID-19 2020)	The application provides contact numbers of Covid-19 hospitals, doctors, ambulance services, shelter centres and essential food item stores for people in Nashik. It also presents tips regarding Covid-19 control, prevention and people can also report about Covid-19 affected suspects near their location to the concerned authority through the application
30	Quarantine watch	The application helps in self-reporting by the home quarantine persons and families. Stay home stay safe (Quarantine watch 2020)	The application contains Karnataka health helpline numbers and helps in self-reporting by home quarantined people

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
31	RajCovidInfo	RajCovidInfo is a citizen centric app, intended to provide its users with Covid-19 government guidelines and health advisory issued from time to time. The app also provides Rajasthan specific statistics of Covid-19 pandemic. Citizen specific features include, location based push alerts, list of hospitals for check-ups, Do's and Don'ts during Covid-19, helpline and emergency numbers. This app is being updated regularly with new updates and functionality and thus the users are requested to keep the latest version of the app installed in their mobile phones (RajCovidInfo 2020)	The application contains statistics of Covid-19 cases in Rajasthan and through this application the user can view the Covid Hotspots in Rajasthan and Covid-19 statistics. The application also provides updated information regarding Covid-19
32	SAIYAM-track and trace together	With the help of Saiyam we can together create an environment of safety and security (SAIYAM-track and trace together 2020)	This application is not directly related to Covid-19. It provides self-restraint to the user during lockdown
33	SMC COVID-19 Tracker	The brief about the functioning of the application is given below: (1) SMC has published a Self-Declaration Form on website www.suratmunicipal.gov.in where individuals can submit their details including their abroad or interstate travel history and if they have come in contact with any positive COVID-19 individual. Upon submission of details, an SMC is sent to individuals with a unique Traveller ID and are asked to download SMC COVID-19 Tracker Mobile Application. (2) SMC has also started a helpline number 1-800-123-8000 where a citizen can share details about travellers or suspects. The details are verified by the SMC team including health officials. A field team visits the location and if the details provided on the helpline is verified, the individual is asked to stay in home quarantine and they are also assigned a unique Traveller ID and are asked to download SMC COVID-19 Tracker Mobile. (3) Individuals must fill questionnaires twice a day (Morning 10 AM and Evening 9 PM) through SMC COVID-19 Tracker app regarding their health. After due consultation of health officials, we have prepared three questions in the questionnaire viz., if a person has fever, cough or difficulty in breathing. With this questionnaire, individuals have to also send their selfie (Photo). If any individual mentions an issue in the questionnaire regarding their health, initial follow up is done over the phone and if required, individuals are asked to visit nearby health facilities for necessary check-up and treatment. (4) After successful installation of the app, individuals have to send their location every hour to confirm that they are following home quarantine on a regular basis. The SMC team monitors the location history of individuals if any individual is found not following the home quarantine guidelines, strict actions are taken against such individuals. (5) For every individual asked to stay in home quarantine, daily house to house follow-up is also done by the SMC. Team. Follow up done by the SMC team is also captured through the system. (6) If any individual has developed symptoms during home quarantine and has been shifted to hospital, individuals who have come in contact with suspects are entered in the system under contact history so that they can be linked to understand the contact tracing. If the person admitted to hospital is found positive, the contacts are asked to follow quarantine (SMC COVID-19 tracker 2020)	The application has been developed for monitoring home quarantined people in Surat. Every hour the user must send their location through the application to the concerned authorities. Also, there are two sets of questionnaires one at 10am and another at 9 pm during which the user has to enter their symptoms and upload their selfie

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
34	Delhi Corona	Delhi Corona plans to provide a single avenue to cater to all the needs and issues of the Delhi populace during these tough times. It contains a self-assessment tool, guidelines, and important helplines to ensure wellbeing of the users. The app also allows the user to view all COVID centres and access lockdown services like ration, e-pass and hunger/shelter relief centres (Delhi Corona 2020)	The application provides details of the beds and ventilators available in each hospital in Delhi. It also provides Covid-19 statistics of India and Delhi, Delhi government Covid-19 helpline numbers and pdf of Delhi health bulletin. It provides a list of Covid-19 health services, lists the containment zones in Delhi and a questionnaire based self-assessment test for Covid-19. It redirects to a site which shows government orders for Covid-19 on a day to day basis. It also provides lockdown services (list of shelters, ration and hunger relief centres and helps in getting an e-pass for mobility for those who are engaged in providing essential services like manufacturing, transport, storage and shops but does not have a government or private id). It also provides a platform for donation to the Relief Fund
35	Covid locator	Covid locator app helps the Government of Goa track home quarantined citizens within the State of Goa. The app also helps the public with preventive guidelines and information about hospitals within the State of Goa that are authorised to treat COVID-19. Covid locator app has been developed by the Government of Goa to provide the public with preventive guidelines and helpline information. The app also provides a heat map of home quarantined citizens within the State of Goa (Covid locator 2020)	The application provides Covid-19 statistics, helpline numbers for emergency, government issued information for preventive care and advisories. It also provides a list of hospitals enabled to treat Covid-19 in Goa and tracks home quarantined people of Goa by their location and thereby provides a heat map of home quarantined citizens
36	Chikitsa Setu	Chikitsa Setu is a mobile application endorsed by the Department of Medical Education, Government of Uttar Pradesh, India. It provides official training content to doctors, paramedical staff and other “Corona Warriors” in the form of short videos. It is developed by Prashant Sharma, IAS in collaboration with King George Medical University, Lucknow and National Institute of Smart Governance, Hyderabad (Chikitsa Setu 2020)	The application provides helpline numbers of different states, several videos demonstrating how to take precautionary measures against Covid-19 and several do’s and don’ts, and webinars for making people socially aware regarding Covid-19. It also provides videos to train the concerned persons of the procedure of taking Covid-19 samples for conducting tests
37	BSafe tracking	BSafe tracking application has been developed for quarantine tracking in Kerala. The application has been developed and managed by Kerala Police Cyberdome. This application is strictly restricted to those who are quarantined in Kerala due to COVID-19 (BSafe tracking 2020)	The application is strictly restricted to those who are being quarantined in Kerala
38	Dasoha 2020 food delivery	The Government of Karnataka has partnered with citizens named Dasoha 2020, non-governmental, community and private institutions to ensure that no distressed person, especially migrant labourers, has to struggle for food during this time. The individuals who can take some time to deliver cooked meals and ration packets to the needy in their area can join as volunteers through this application. They can download the app, become a Corona Sainka, and deliver food to the poor and serve the society (Dasoha 2020 food delivery 2020)	Dashoda is an application developed for Karnataka by which people can join as volunteers and deliver cooked meals and ration packets to the people in need in their area

Table 1 (continued)

Serial no	Application name	Details from playstore	Comments
39	Prayagraj COVID19 hotspots	With the approval of administration, the COVID19 hotspots data are being collected to serve the community. An initiative from Data Live Technology. Only the app is published by Facewhiz Technologies (Prayagraj COVID19 hotspots 2020)	The application could not be operated
40	Telangana Covid19 tracker	Application developed by Telangana government to monitor and track home quarantine people for the wellbeing of society (Telangana Covid19 tracker 2020)	The application monitors the home quarantined people of Telangana by selecting a set of symptoms



Fig. 1 Methodology of the application

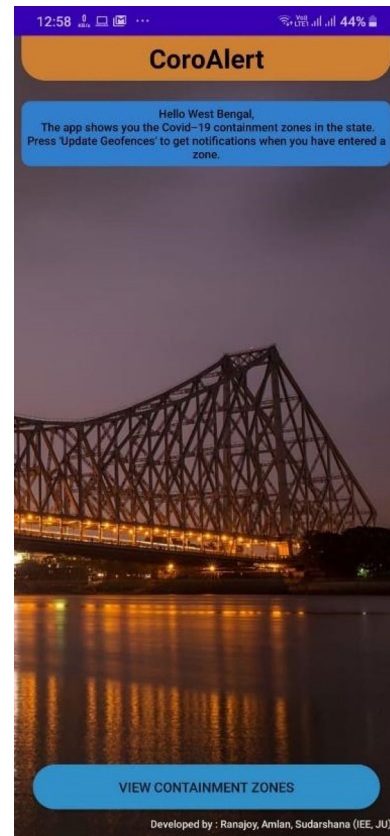


Fig. 2 Welcome screen



Fig. 3 Disclaimer screen

Geofencing

Geofencing API from Android is used to create virtual boundaries or fences around geographical locations (Create and monitor geofences 2020). The developers can add geofences at different locations by providing the latitudes and longitudes along with radius to define the virtual boundary at that location. Geofencing technology senses the user's current location and checks whether the location is inside any of the geofences created. A broadcast receiver receives intent contained in a pending intent (an android API) sent by the location services when the user has entered, dwelt, or exited a geofence as shown in Fig. 6 and can initiate a background work or send a notification. The geofence transitions events include enter, exit, and dwell and multiple transition events can be set for the geofences. In this application, the dwell transition is set for the containment zones with a loitering delay of 5 seconds and an expiration duration set to never expire. The broadcast receiver is set to initiate a notification by the notification manager upon receiving an intent. Once the

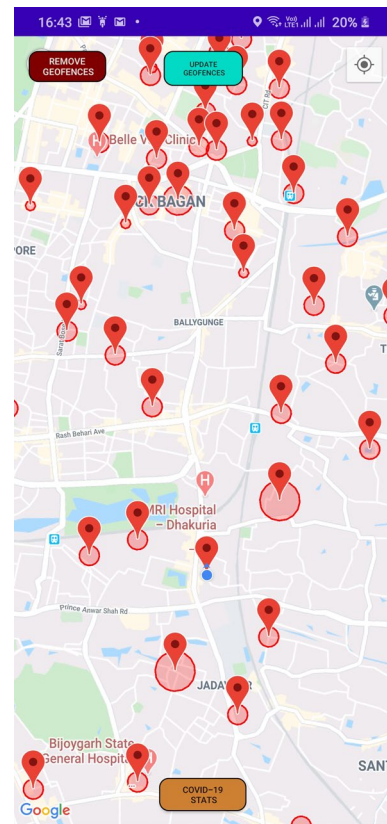


Fig. 4 Google map showing containment zones

geofences are set, the user would receive notification on entering and dwelling inside a containment zone.

RESTful API

Representational State Transfer (REST) API or RESTful web services are architectural styles for communications often used in web services development (RESTful API 2020). These APIs use less bandwidth than the Simple Object Access Protocol (SOAP) and hence they are useful for cloud applications. The RESTful API uses the HTTP methodologies which are defined by the RFC 2616 protocol. The information stored in a RESTful API are resources which can be read, updated, or deleted using resource methods like GET, POST or DELETE. The resources are accessed using Uniform Resource Identifiers (URIs). In this application, we have used a RESTful API from COVID19 India API (COVID19 India API 2020) and the resource that we have used is the Country and State wise data. We have used the GET method to receive the data of West Bengal as a JSON object in the application and show it in a bottom sheet (Fig. 7).

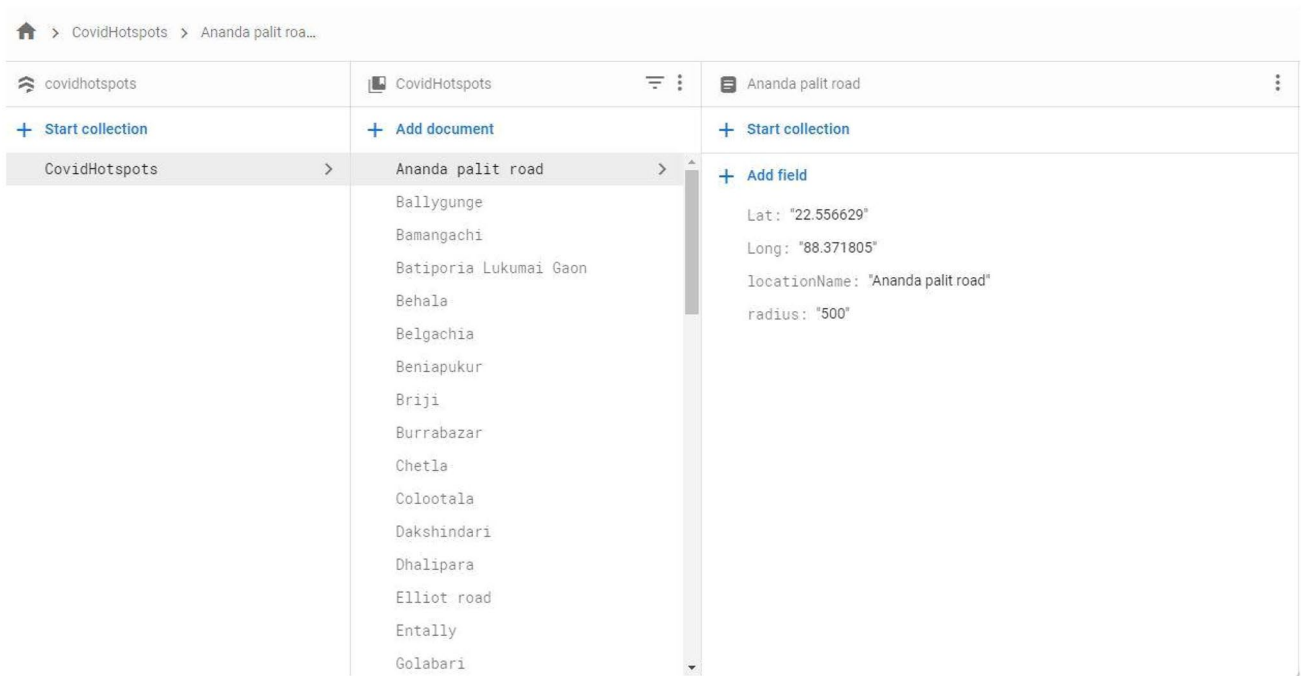


Fig. 5 Cloud Firestore database with location data of containment zones

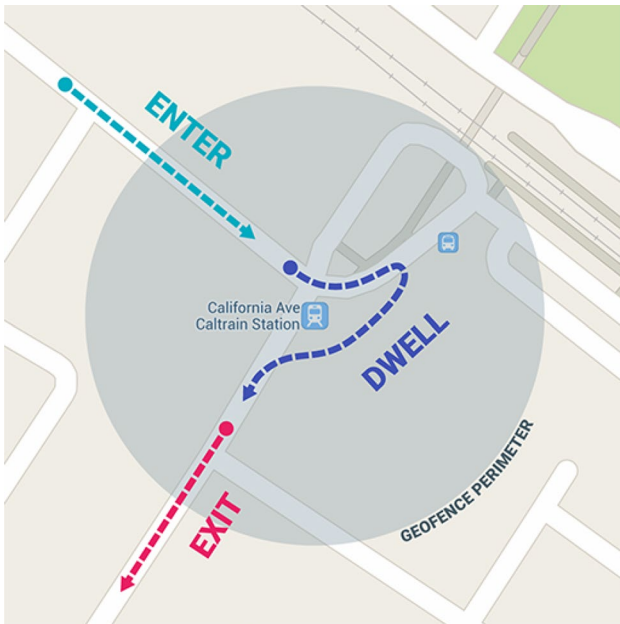


Fig. 6 Geofence trigger events

Working of the Application

The application gets data from the Cloud Firestore database. A collection is created in Cloud Firestore with containment zones as documents. Each document has four fields: latitude, longitude, location name and radius. Accordingly, a Java

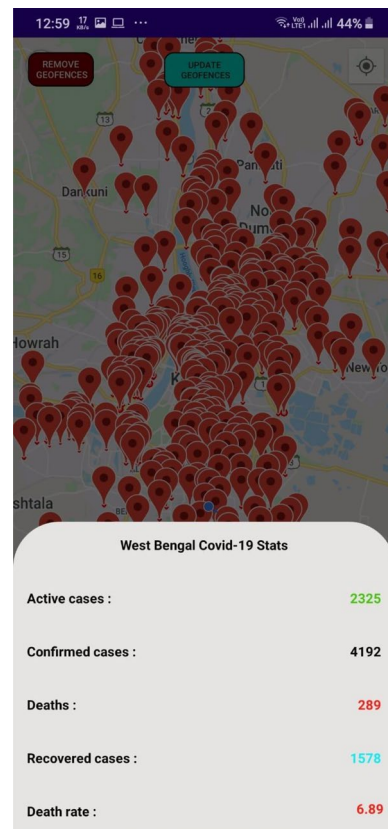


Fig. 7 Bottom sheet showing Covid-19 statistics of West Bengal

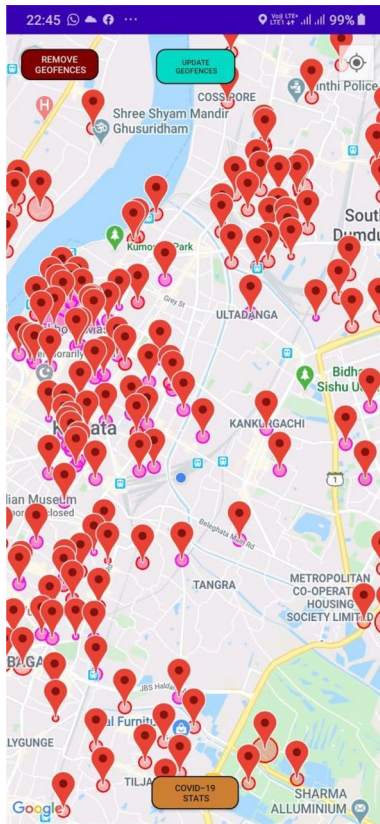


Fig. 8 Selection of closest containment zones for geofencing

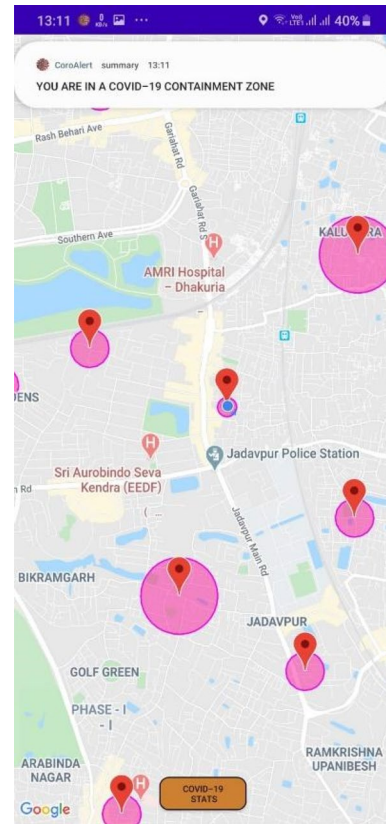
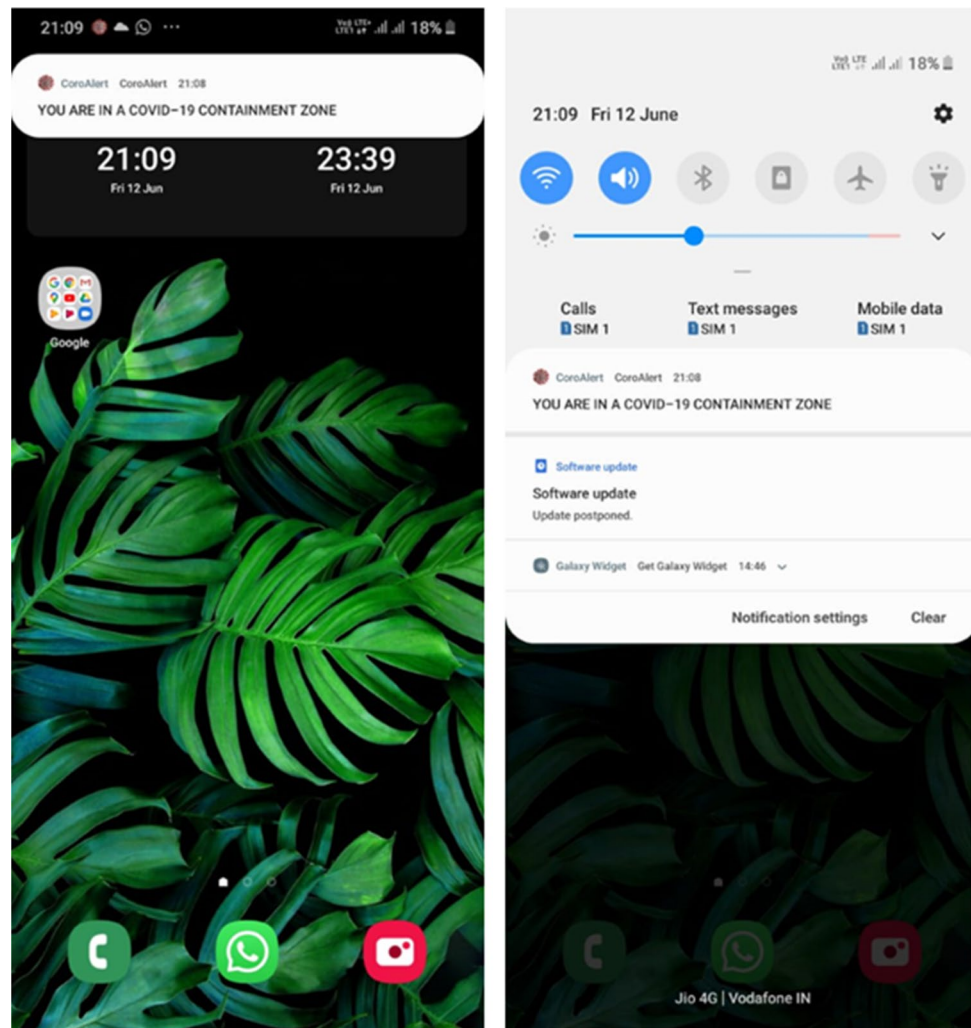


Fig. 9 Notifications from geofence broadcast

object is created which can get the data from the document. In the map's activity, the firebase Firestore instance and collection references are created to which a snapshot listener is attached. The snapshot listener retrieves the document snapshots which are then converted into the Java object mentioned earlier. With the help of getters each data from the document is retrieved and are converted to string. Markers and circles are set using the location coordinates and radius and tags are given by the location names. The google map gets populated with these markers surrounded by circles which represents the containment zones. A JSON request is made with the get method to the REST API URL which returns the West Bengal Covid-19 case data as a response. The response is converted to a JSON object and the information is extracted. The google map shows all the containment zones in West Bengal along with the location of the user using "set my location" enabled (Google map API). The Geofencing API can create up to 100 geofences per device and the number of containment zones are more than 1000 in West Bengal. The solution to this problem is to create

100 geofences on the 100 nearest containment zones. Once the map is loaded and populated with containment zones and user's location, the user can press a button to add the geofences on the closest 100 containment zones. The snapshot listener returns the documents containing the locations of the containment zones from Firestore which are not sorted according to the distance between the user and containment zone. The distance between the user and each containment zone is measured using distance between method of the location manager (Android developer-Locations 2020). This distance is then used as a key and is stored along with the document in a Tree map. Likewise, all the containment zones with their distance from the user get stored in the tree map and get sorted according to the distance or key. First 100 entries from the tree map are retrieved and geofences are created on these 100 containment zones as shown in Fig. 8. Once the geofences are set, the user can get notification on entering the containment zones as shown in Fig. 9. The geofences get triggered and notifications are sent even when the app is not running in background as shown in Fig. 10.

Fig. 10 Notifications without app running



It is advised to remove the geofences when the user is not moving outside his or her residence to conserve power. The workflow of the app is shown in Fig. 11.

The application further extracts the IMEI number of the trespasser and uploads it to the online database. The application prompts background location services permission and if granted the geofences get triggered even if the application is not open in foreground.

Results and Discussions

Tests have been carried out in various containment zones across West Bengal for the validation of the Android application. The identified containment zones chosen for the testing of the application were visited one by one. Table 2 shows various containment zones identified for conducting the test, the date, time of entry, time of receiving the notification

alerts upon entering. From Table 2, it is highlighted that the application sends notification alerts within 5–8 seconds on entering.

Memory Utilization

The memory profiler has been used to analyse the memory allocation of the application. It has been checked several times that the MapActivity is allocating around 150 MB in which graphics takes around 40 MB and Java 35 MB and the graph is flat as shown in Fig. 12. Heap dump is recorded several times and no memory leaks have been found.

Network Traffic

The Network traffic is analysed using Network profiler in Android profiler and programmatically with Traffic stats method. The application uses the network to load the Google



Fig. 11 Workflow of the application

maps, to retrieve containment zone data from the Firebase Cloud Firestore and to get Covid-19 statistics from a RESTful Api. Network usage spikes have been detected in Network profiler for MapsActivity and connections are attached from here. The receiving network bandwidth has been checked multiple times and is found to be around 1 MB/s. The getUIdRxBytes and getUIdTxBytes methods of TrafficStats have been also used to monitor how much data the application is sending and receiving. First the application

was installed on two devices and then 2 types of readings were taken. In the first reading shown in Table 3, the application was initiated several times without destroying the application process in the background. In the second reading, the application process was destroyed before taking each reading (Table 4).

It has been observed that the application receives around 23 KB of data during the start of the MapsActivity when the application is initiated and receives around 10 KB when it has been running in the background. This data includes both Firestore data and Google maps data.

Conclusion and Future Scopes

The application provides an efficient way of showing the identified Covid-19 containment zones to the users in a Google map. With the alarming increase of Covid-19 affected cases throughout the world, this developed application can be employed as a tool for creating further social awareness among the people. This application further tracks the user’s location and checks whether it is present in the list of identified containment zones. It sends separate notification alerts to the user on entering. The developed android application further extracts the IMEI Number of the trespasser in the containment zones which can be useful to the local police to track and identify people who are frequently trespassing the containment zones. Thereby this application identifies the containment zones and highlights the need for taking further precautionary measures for combating Covid-19. The application has been tested in various locations and has been found to yield accurate results.

The application can be further used for many purposes like maritime and forest safety to prevent users from entering restricted areas.

Table 2 Containment zones with the time of entry, the time of receiving notification alerts in the android application and the extracted IMEI number of the trespasser in the corresponding containment zones which is uploaded to the online database

Serial number	Name of the containment zone	Date of entry in the containment zone	Time of entry in the containment zone	Notification time	IMEI number
1	Bamangachi	21.04.2020	09:30:16	09:30:21	356129106619221
2	Belgachia	20.04.2020	09:45:50	09:45:55	356129106619221
3	Garden reach	22.04.2020	10:55:10	10:55:18	868134038083620
4	Garia	22.04.2020	11:52:19	11:52:25	356129106619221
5	Golabari	21.04.2020	11:20:50	11:20:59	356129106619221
6	Kaikhali	20.04.2020	10:42:12	10:42:25	868134038083612
7	Mudiali	23.04.2020	09:46:00	09:46:08	356129106619221
8	Nayabad	23.04.2020	10:58:21	10:58:28	356129106619221
9	Park circus	20.04.2020	11:35:12	11:35:17	868134038083612
10	Tikiapara	22.04.2020	09:35:23	09:35:30	868134038083612

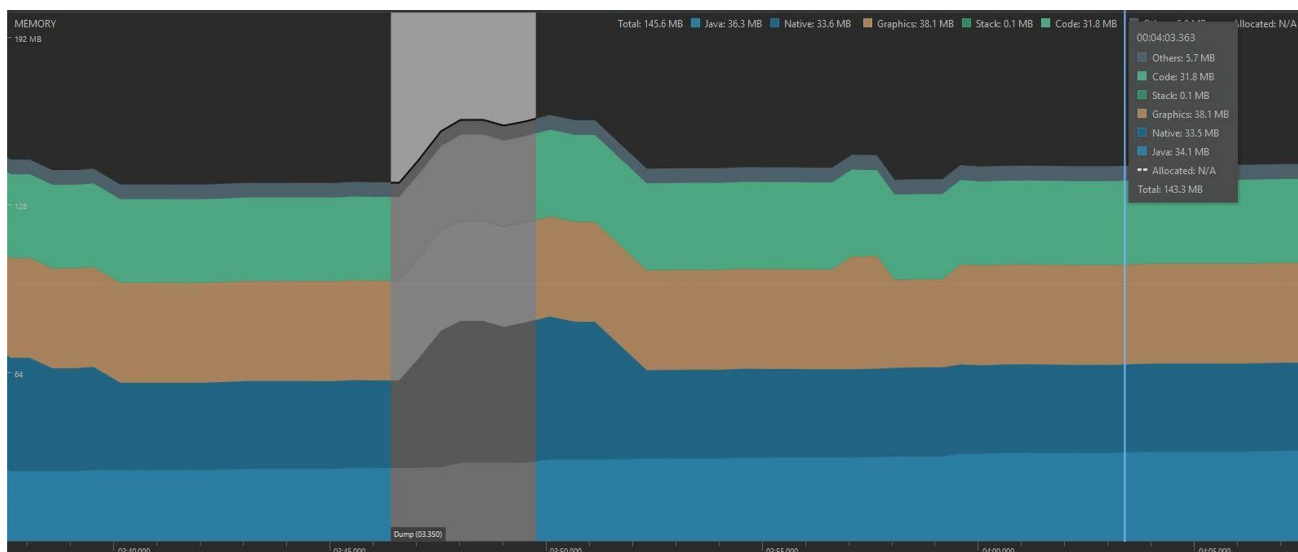


Fig. 12 Memory utilization

Table 3 Bytes received application initiating

Test no	Bytes received by device 1	Bytes received by Device 2
1	12,273	11,706
2	9413	10,476
3	9644	9908
4	7199	10,020
5	12,803	9909
6	10,693	10,019
7	10,112	9174
8	9399	9920
9	9497	9899
10	9499	9571

Table 4 Bytes received when app starts from background

Test no	Bytes received by device 1	Bytes received by device 2
1	22,644	25,787
2	22,634	22,130
3	22,184	21,321
4	27,604	21,363
5	22,317	23,397
6	23,234	23,779
7	22,307	24,739
8	22,030	23,110
9	24,993	22,529
10	22,342	22,915

Author Contributions All the authors have contributed in their respective parts.

Funding Not applicable.

Availability of Data and Material Data and material available.

Compliance with ethical standards

Conflict of interest There are no conflicts of interest.

Code availability The Java code of the app is available.

References

Aarogya Setu (2020) <https://play.google.com/store/apps/details?id=nic.goi.aarogyasetu&hl=en>

Android developer-Locations (2020) [https://developer.android.com/reference/android/location/Location#distanceBetween\(double,%2520double,%2520double,%2520float\[\]\)](https://developer.android.com/reference/android/location/Location#distanceBetween(double,%2520double,%2520double,%2520float[]))

BSafe tracking (2020) <https://play.google.com/store/apps/details?id=com.cyberdome.bsaf&hl=en>

Bahl P, Doolan C, de Silva C, Chughtai AA, Bourouiba L, MacIntyre CR (2020) Airborne or droplet precautions for health workers treating Coronavirus disease 2019? J Infect Dis. <https://doi.org/10.1093/infdis/jiaa189>

Bihar Saathi (2020) <https://play.google.com/store/apps/details?id=com.ibihar.saathi&hl=en>

CG Covid-19 ePass (2020) <https://play.google.com/store/apps/details?id=com.allsoft.corona&hl=en>

Chikitsa Setu (2020) <https://play.google.com/store/apps/details?id=com.abhitech.chikitsasetu&hl=en>

Cloud Firestore Data model (2020) <https://firebase.google.com/docs/firestore/data-model>

Cloud Firestore (2020) <https://firebase.google.com/docs/Firestore>

- Cloud Firestore SDKs and client libraries (2020) <https://firebase.google.com/docs/Firestore/client/libraries>
- CoBuddy-Covid19 tool (2020) <https://play.google.com/store/apps/details?id=www.facetagr.com.cobuddy&hl=en>
- Corona Mukht Himachal (2020) <https://play.google.com/store/apps/details?id=com.developmentlogics.patientgeotracker&hl=en>
- Corona watch (2020) <https://play.google.com/store/apps/details?id=com.krsac.drawshapefile&hl=en>
- Covid locator (2020) <https://play.google.com/store/apps/details?id=com.intutrack.covidtrack&hl=en>
- CORONTINE (2020) <https://play.google.com/store/apps/details?id=com.itaakash.iitbc&hl=en>
- COVA Punjab (2020) <https://play.google.com/store/apps/details?id=in.gov.punjab.cova&hl=en>
- COVID-19 Odisha (2020) <https://play.google.com/store/apps/details?id=odisha.gov.covid19&hl=en>
- COVID-19 Care Tami Nadu-(Official) (2020) <https://play.google.com/store/apps/details?id=com.rvmatrix.corona&hl=en>
- COVID-19 West Bengal (2020) <https://play.google.com/store/apps/details?id=com.pixxonai.covid19wb&hl=en>
- COVID19 feedback (2020) <https://play.google.com/store/apps/details?id=com.NIC.covid19&hl=en>
- COVID19 Connect (2020) <https://play.google.com/store/apps/details?id=com.igib.COVID19Connect&hl=en>
- COVID19 India API (2020) <https://covid-19india-api.herokuapp.com/>
- COVID CARE (2020) <https://play.google.com/store/apps/details?id=app.igotit.covidcare&hl=en>
- COVID Care Kerala (2020) <https://play.google.com/store/apps/details?id=org.nic.covidcarekannur&hl=en>
- COVID Ebazaar (2020) <https://play.google.com/store/apps/details?id=gov.ebazaar.covid&hl=en>
- Create and monitor geofences (2020) <https://developer.android.com/training/location/geofencing.html#HandleGeofenceTransitions>
- Dasoha 2020 food delivery (2020) <https://play.google.com/store/apps/details?id=in.swiggy.covidvolunteer&hl=en>
- Delhi Corona (2020) <https://play.google.com/store/apps/details?id=com.delhi.covidcare&hl=en>
- Driver Seva (2020) <https://play.google.com/store/apps/details?id=com.hd.seva&hl=en>
- Fight COVID (2020) <https://play.google.com/store/apps/details?id=com.pratikthoratoronatracker&hl=en>
- GCC-Corona monitoring (2020) <https://play.google.com/store/apps/details?id=com.gcc.smartcity&hl=en>
- GoK Direct-Kerala (2020) <https://play.google.com/store/apps/details?id=com.qkopy.prdkerala&hl=en>
- Haryana Sahayak (2020) <https://play.google.com/store/apps/details?id=hr.gov.covid19.sahayak&hl=en>
- Kavach (2020) <https://play.google.com/store/apps/details?id=in.gov.chhattisgarh.cova&hl=en>
- Mahakavach (2020) <https://play.google.com/store/apps/details?id=com.mahakavach&hl=en>
- mCOVID-19 (2020) <https://play.google.com/store/apps/details?id=gov.mizoram.mccovid19&hl=en>
- MP COVID response app (2020) <https://play.google.com/store/apps/details?id=com.covidmp.coronago&hl=en>
- nCOVID-19 Nagaland (2020) <https://play.google.com/store/apps/details?id=com.tattvafoundation.ncovid&hl=en>
- Niramaya (2020) <https://play.google.com/store/apps/details?id=com.niramaya.people&hl=en>
- NMC COVID-19 (2020) https://play.google.com/store/apps/details?id=com.kodwell.nmccovid_19&hl=en
- Odisha COVID dashboard (2020) <https://play.google.com/store/apps/details?id=com.ocac.covidodisha&hl=en>
- Prayagraj COVID19 hotspots (2020) <https://play.google.com/store/apps/details?id=com.prayagraj.covid19.hotspots&hl=en>
- Quarantine watch (2020) <https://play.google.com/store/apps/details?id=com.bmc.qrtwatch&hl=en>
- RajCovidInfo (2020) https://play.google.com/store/apps/details?id=com.gismcg.covid19_rajasthan&hl=en
- RESTful API (2020) <https://searcharchitecture.techtarget.com/definition/RESTful-API#:~:text=A%2520RESTful%2520API%2520is%2520an,to%2520communicate%2520with%2520each%2520other>
- SAIYAM-track and trace together (2020) <https://play.google.com/store/apps/details?id=com.flowace.saiyam&hl=en>
- SMC COVID-19 tracker (2020) <https://play.google.com/store/apps/details?id=in.smc.covidout&hl=en>
- Telangana Covid19 tracker (2020) https://play.google.com/store/apps/details?id=com.corona.tscovid_19&hl=en

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.