




Geo-Information Communication Technology (Geo-ICT) Framework to Prevent Spread of Corona Virus Disease (COVID-19)

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Abstract

Health is an important part of human life. The awareness about the quality health care plays a major role in the human life. The present Corona virus Disease (COVID-19) is infectious and fast spreading. In a country like India, prevention of the infection is still the best option. The use of Geo-Information Communication Technology (Geo-ICT) framework can help in the prevention of spread of the disease. The use of geo-spatial technologies simplifies the complex data to improve decision making. In this manuscript, an attempt is made to design a geo-spatial framework to capture data, store data in centralized geo-spatial data bank and use the data to alert the citizens in near real time for COVID-19 clusters using mobile map interface. The solution will support citizens in protecting themselves from infection. The paper also discusses the methods of data moderation and data dissemination to the mobile app users. We conclude that the present study is an effort towards enabling the information dissemination process for quick and reliable mitigation measures.

Keywords COVID-19 · Bhuvan geo-platform · Mobile app · Geo-spatial data · Cluster mapping · GPS

Introduction

Health is a basic need to lead a quality life, and the health care must be within the reach of every citizen. The health sector is very important which faces several challenges in extending the reach to the entire geographical extent of India. India is the second largest populated country in the world. It covers almost one-fifth of the world's population (Myers, 2020). The majority of the population is living in the towns which would make government departments more difficult to prevent the spread of infectious disease. The infectious communicable diseases occur through transmission of Prions, Viruses, Bacteria, Fungi, Protozoa or Multi cellular parasites, which contribute to many crises by means of indirect or direct morbidity and mortality (Checchi & WHO, 2009). In December 2019, a mysterious pneumonia type infection with symptoms such as fever, dry

cough, fatigue and occasional gastrointestinal problems in Wuhan, Hubei, China emerged which spread very rapidly in the city. Later the infection was identified as 2019 Novel Corona virus (COVID-19). By mid-January 2020, the infection spread to many big cities in China and 25 other countries (Wu et al., 2020). By December, 2020, many studies were being carried out to prevent the transmission of such infection or illness. The transmission of infection took place from person to person or animals to person. The transmission of COVID-19 like virus occurs by means of direct and indirect contact from infected person. The direct means is through droplet and human-to-human contact. The indirect means is by touching contaminated objects and airborne contamination (Liu et al., 2020; Govt. of Nunavut Canada, 2020). The World Health Organization (WHO) notified that the infection can spread most commonly via mouth, nose and eyes. The physical contact needs to be avoided, as virus can spread easily from person to person. Due to above said reasons,; infection may spread over a wide geographic area affecting large proportion of the population. On 11th March, 2020 the WHO declared Covid-19 infection as a pandemic (WHO, 2020). As per Aarogyasetu, a Govt. of India Portal for COVID-19 as on 21st Oct 2021, 341 lakh people got infected in India, making India the second largest infected country

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(Aarogyasetu, 2021). Since India is thickly populated in towns and cities, there is a need for the study representing geographical information system to avoid spread of infection to large number of people. The central and state governments have suggested people with infection should reside in home under quarantine. Even the smallest of precautions is the necessity (GOI, 2020). The use of geo-spatial technology to address health issues with respect to geographical area has become vital. The use of geographical information system in public healthcare studies helped in understanding the infection and its treatment with respect to geo-location (Fradelos et al., 2014). The public health surveillance is the process of data collection to understand the health condition of the population of an area. This enables to analyse the collected data and disseminate health report which is further used to monitor and improve the health of the people (Soucie, 2013; Bhuvan Document-2, 2021). The active surveillance is a system that employs staff regularly to get the state and status of the health condition of the people. It is also an accurate method of getting information in the system (Nsubuga et al., 2006). It is very difficult to maintain individual physical distance and avoid viral infection. Maintaining physical distance from the areas where infected persons are residing is recommended. At the same time, government must also ensure the availability of basic essential commodities required in the infected clusters. The current study focuses on the systematic data collection of COVID-19 patients. The use of geo-spatial technology which has proven in many such applications can be used. The healthcare sector poses many challenges to policy makers and policy enforcement agencies. The technology also helps business and academia in reducing the financial burden. GIS is an effective tool to support spatial decision-making in public health through applying the evolving analytical approaches to deal with healthcare planning issues. This requires the literature review before preparing relevant studies, particularly because of the continuous development of GIS technologies. By following the standards based on spatial planning, we can overcome the inequalities of spatially distributed healthcare services. (Khashoggi & Murad, 2020). With advent of communication technology, the portable handheld device containing GPS receiver, Camera, mobile data with internet connectivity and strong operating system enables developer to develop solution to cater to the needs of modern data collection and store information in centralized systems (Nowak et al., 2020; Ibrahim and Mohsen, 2014). The article showcases use of location based services integrated with GIS in the data collection system. The design of GIS-based framework for data collection, immediate upload, visualization, analysis and decision making is discussed. The article introduces a solution for users to add, remove

and review specific locations on the online map. Apart from the above-mentioned study, the current framework also introduces a methodology for GIS layers creation using tabular data in the mobile. It also reports information in near real time using decision making tools in GIS environment. The systematic data moderation and its tracking are also part of the web app solution.

Technical Requirements of the Framework Design

An application framework is designed to address the requirement of components, build procedure and workflow based on the resources available including human or material. The design needs to identify the technologies to build the solution and implementation (Aydin & Ucar, 2017). The envisaged framework must help government departments in preventing the spread of COVID-19 virus in its area of jurisdiction. The solution must communicate to the citizens with alert by locating COVID-19 patients in the neighbourhood. The alert cautions the citizens about entering the infected area which can result in minimising the spread. It becomes necessary for the government to facilitate the basic requirements of the COVID patients in home quarantine. It is required to understand the best practices of field data collection by citizens or department representatives using latest technologies. The framework should also address the data organisation in a centralized repository and systematic moderation of the data collected for its correctness. The data can be visualized in tabular as well as in geo-spatial formats for better understanding and retrieve the data to analyse for effective decision making (Dasgupta, 2010). The use of location-based services to capture geo-spatial component as a part of data collection is the ideal method. For identifying the COVID patients the solution must have provision to capture personal information. It must have provision to report status of health condition and store data in a central repository towards data collection activity. Though all these information is kept in public domain, the authorized government officials can only access the data. The data storage process draws attention for data security mechanisms. The collected COVID information must be used to communicate to the citizens that prevents the spread.

Components of Framework Design

The Geo-ICT application framework design for COVID-19 can be categorised into five major components to design and develop a solution. Based on the discussed and envisaged technical requirements, the framework

components are considered as data, people, hardware Infrastructure, software Infrastructure and procedures.

Data

The data are most important component of the framework. Keeping the basic requirements of the solution, the datasets with schema are framed. It is designed in consultation with local health administration. There are different types of data requirements in different stages. They are generated during field data collection, data landing in the centralized repository, data moderation and COVID-19 data to alert the citizens.

Field Data

The following are the datasets captured while collecting field data. The information on the name, age, gender, mobile number, aadhar number are captured to identify a person. The information on symptoms like cough, cold, throat pain, fever, etc., are captured to understand the health condition of the person. The information like visit to other countries, associated family members, etc., are captured to know the possible variant of the virus and understanding the source of infection. The data like longitude, latitude, altitude and time stamp are captured to precisely locate home quarantined person geographically. The details like whether COVID-19 test conducted, what is its result and details of COVID-19 test laboratory are also captured. The identity of the data collector is captured. The basic essential requirements of the home quarantined patients are also captured. The above-mentioned sets of parameters are recorded as a part of attribute information in field data collection. The pictorial representation of the person with COVID symptoms are also captured in the form of photograph, which is optional. The attributes, geo-location parameters and photographs are together recorded as field data collection and also called as evidence-based geo-tagging (Lesslie et al., 2015). The captured data are stored in encrypted format with systematic naming convention, and they are stored in the XML or JSON formats to avoid data tampering (Altuwaijri & Ghouzali, 2020).

Additional Data

The automatically generated data identification number and time stamp information are added to each record at the time of data landing in the centralized repository. The process of data validation for its correctness and quality is called as moderation. The person who conducts moderation is called moderator. The details about moderator are essential to track who has conducted moderation on the dataset. The information like name of moderator, mobile number, email

id, organisation, etc., is captured. The process of moderation generates data like status of moderation and moderation result. The reasons for rejection are addressed, in case of rejected records by moderator (Arulraj et al., 2015; Lesslie et al., 2015).

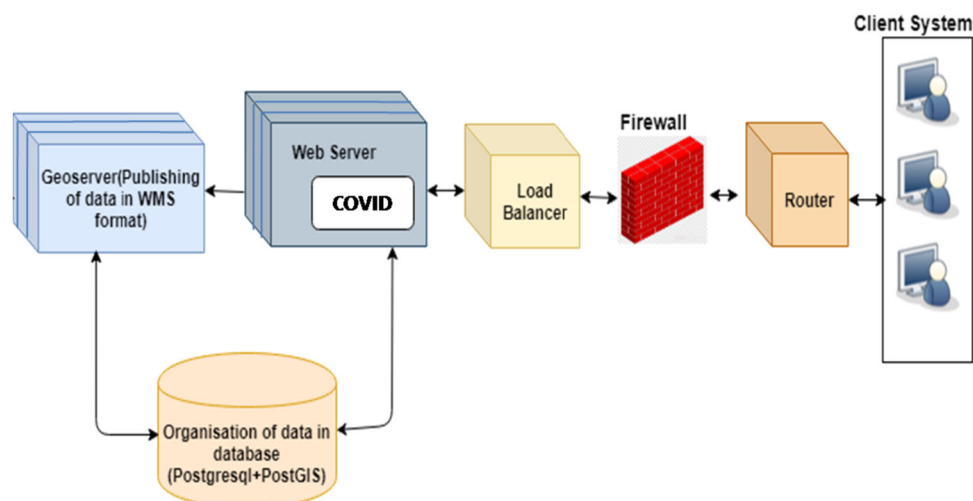
People

The use of human resources at different stages with their roles is important component to form a workflow. The software designer is important and responsible for designing the software architecture based on the envisaged end user requirements. The designer is responsible for solving the problem if any in implementing the solution. The software engineer needs to implement the design and build software code to automate the activities. The test and evaluation process is conducted on the solution by designer, developer and user. The designer/developer must possess the skills to work in geo-spatial technology apart from information and communications technologies (Lesslie et al., 2015). The government officials and citizens are utilized to report the symptoms of COVID-19 in the neighbourhood and get COVID alerts. The government officials at district or block levels are designated as moderators to validate the reported information. The citizens use the COVID alert to minimise the spread of disease.

Hardware Infrastructure

The hardware infrastructure component is divided into two components, which represents the field segment and data centre segment. Different handheld devices integrated with GPS receiver, digital camera, mobile data, Wi-Fi, Bluetooth and compass in the form of smartphones are available in global market. The use of handheld mobile devices is cost effective method for field data collection (Lesslie et al., 2015). The smart phones are available with many different features and price ranges. The high-end computer server is used to host free application on web and store the data on open-source relational database management system emphasizing extensibility and SQL compliance are part of data centre. The large volume of storage systems interfaced with integrated communication systems enables to implement high end technologies for data transfer. High-end servers are required to host the developed web application for the data visualization, moderation and data analysis over the web. A firewall is used to improve defence mechanism in network security system. The load balancer is used to effectively receive and distribute the incoming requests to the multiple backend servers, and these are part of data centre activities (Arulraj, 2015) as shown in Fig. 1.

Fig. 1 Hardware Architecture for web application



Software Infrastructure

The software components in the current application framework consist of two major segments. (1) Field segment representing activities carried out in the field using mobile devices. (2) Data centre segment representing activities carried-out on uploaded data, visualization, moderation activity, data transfer using web services and analysis. All the functions and methods are developed using open source software tools and technologies.

Mobile App

The mobile app is developed using an open source mobile application development framework. It allows developing hybrid based mobile applications using standard web technologies (de Andrade & Albuquerque, 2015). The mobile app has features to capture geo-location parameters using GPS receiver, capture photographs using digital camera, capture direction using compass and upload the captured data using mobile data or Wi-Fi (Cordova, 2020). The solution have user friendly methods to fill attribute information by means of combo box, radio button, toggle button and checkbox selections. The key-in methods have text box with alphabet, numeric and alpha-numeric data type with predefined character width. The attribute value are validated and encoded for any special characters supporting other local languages. The solution enables user to capture information in no internet connectivity zones with provision to store data in the mobile. The data are stored in local storage of the mobile device can be in JSON or XML formats (Lesslie et al., 2015). The field data captured contain personal information of COVID patients and data collectors which cannot be stored in open text formats. Such collected datasets need to be stored in a tamper proof form. Hence they need to store in encrypted

format and readable only using the software (Altuwajri & Ghouzali, 2020). The map module uses web map service for geo-spatial representation of base data in the background. The GIS-based layers are generated in on-fly mode using JavaScript API's in the map module (Agafonkin, 2020). The data transfer is carried-out using post web services from server to mobile and vice versa (Lesslie et al., 2015).

The HTML5, CSS3 and JavaScript software languages are used to develop mobile apps on cross-platform application development framework. The hybrid framework is a mixture of both native application and a web view that can access device level APIs in form of plug-ins (Dadheech & Jain, 2018; Jain et al., 2015). The Android, iOS and Windows are some of the popular mobile operating system platforms supported by Apache Cordova (Cordova, 2020) (Lesslie et al., 2015). The plug-in API's are add-on codes which provide JavaScript interface for accessing native components to use native device capabilities beyond web apps. The Dialog-GPS plug-in is used to display a dialog and redirect to GPS settings when the GPS is disabled. The Cache-clear plug-in is used to clear the Cordova web view cache. The Camera plug-in is used to capture photographs through a function that is passed as a call-back to the event listener. It will be fired when it is executed. The plug-in enables to capture photographs through a camera app and pass the uniform resource identifier of the captured photograph to upload or store in the local storage. Device plug-in captures mobile device related information like make, model, OS version, universally unique identifier (UUID). Device-orientation plug-in allows to record direction relative to geographic north using compass. Dialog plug-in used to integrate native dialog UI elements. File plug-in is used to read and write access of files and create/delete the files in the mobile devices. The plug-in also creates and deletes directories. Geo-location plug-in enables to capture

geo-location parameters like longitude, latitude, altitude, accuracy, altitude accuracy, heading, speed and timestamp in two modes, i.e. in current position and watch position. Media plug-in used to record and play audio in the mobile app. It has options to play, pause, stop and volume up-down. Network-Information plug-in enables information about network connectivity. It has provision to inform network state, connection type like Ethernet, Wi-Fi, 2G, 3G, 4G, online or offline (Cordova, 2020). The Leaflet is JavaScript library which allows to develop mobile friendly interactive map interface. It supports markers with custom icons, data on Geo-JSON, GIS layers of raster and vector data models, layer groups, layers control, pan, zoom levels and tile layer (Agafonkin, 2020). The Turf JS is JavaScript API to carry out geospatial data analysis in the browser environment. It can help to analyse, aggregate, and transform data to visualize on leaflet (TurfJS, 2020). The open source technologies are used in development of solution as shown in Table 1.

Web Services and Application

The data centre segment has software tools to receive uploaded data in the web application servers. The Apache web server is used to host web application. The Postgres SQL with Post GIS is used as database software supported to store geo-spatial data. The spatial data visualization on web is supported by open layers at client side. The map server/geo-server are used to publish spatial data on web in compliance with OGC standards (Bhuvan Document-1, 2009). The server-based tools are written in PHP to read the data and organize them in relational database management system like Postgre SQL. The geo-spatial information is stored in specialized GIS-based database system like Post GIS extension. The open source software is used to display geo-spatial data in the web application for interactive map display and query using Open Layers and Map server (Al-Saiyd, 2015; Singh et al., 2012). The Geo-server is used to share process and edit the spatial data. The moderation mechanism is developed to carry-out validation on the each record of the data. The attribute keys and its values are displayed with photographs for moderation. The

moderation will have provision to approve the correct record and reject the erroneous records with its reasons for rejection. Web services are developed to query and transfer data from mobile to server and vice-versa (Arulraj, 2015; Arulraj et al., 2015) as shown in Fig. 2. The online report is represented in tabular form and has filters to query the data. The report consists of name, mobile, age, gender, health issues along with photographs.

Procedure

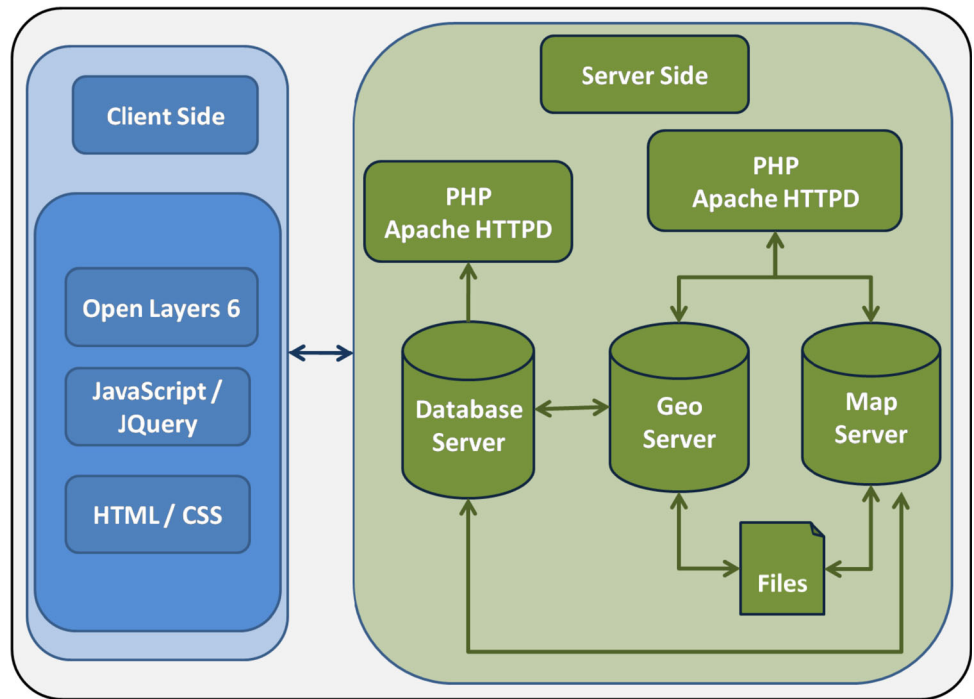
The procedure depicts the workflow in different phases of the solution. The application has three major phases. They are data collection phase, data moderation phase and alert system phase. The activity carried out by the citizens or health department officials who can report the COVID-19 symptoms come under data collection phase. There are three basic parameters to be captured as part of data collection phase. They are attributes data filling, photograph capturing (optional) and data saving or sending. The attribute filling parameter allows to record information about the COVID-19 symptoms of a person including profile of the data collector. The photographs of the person with COVID-19 symptoms are captured with the person's consent. The location parameters consist of longitude, latitude and altitude along with timestamp. The data capture is carried out at patient's residence or home quarantine centre. This phase also addresses the provision to save the data and upload the data immediately by means of internet connectivity. The data can also be stored in the mobile to upload it at later stage. The received data are organized in central data repository in the data centre. The data moderation phase is carried out by middle level managers of health department at district level or block level. They moderate the data and are called as moderators. The moderators access data through web application through secured authorization credentials (Fig. 3).

The browser-based application will have provision to moderate each uploaded record. The process involves examining of each record for its correctness with respect to photographs, attribute data entry and consultation over phone or visit of field officials to the home quarantined

Table 1 Software's used in the development of the solution

Mobile application activity	Open source technologies
Mobile device based application development	Apache Cordova API, HTML5, CSS3, JavaScript, Java, JQuery, Android & XML
Server/middleware applications	Apache WebServer, PHP, XML
Database/GIS DB	PostgreSQL, PostGIS
Spatial visualization	Open Layers, Map server, Geo-Server

Fig. 2 Software architecture for web application



Architecture

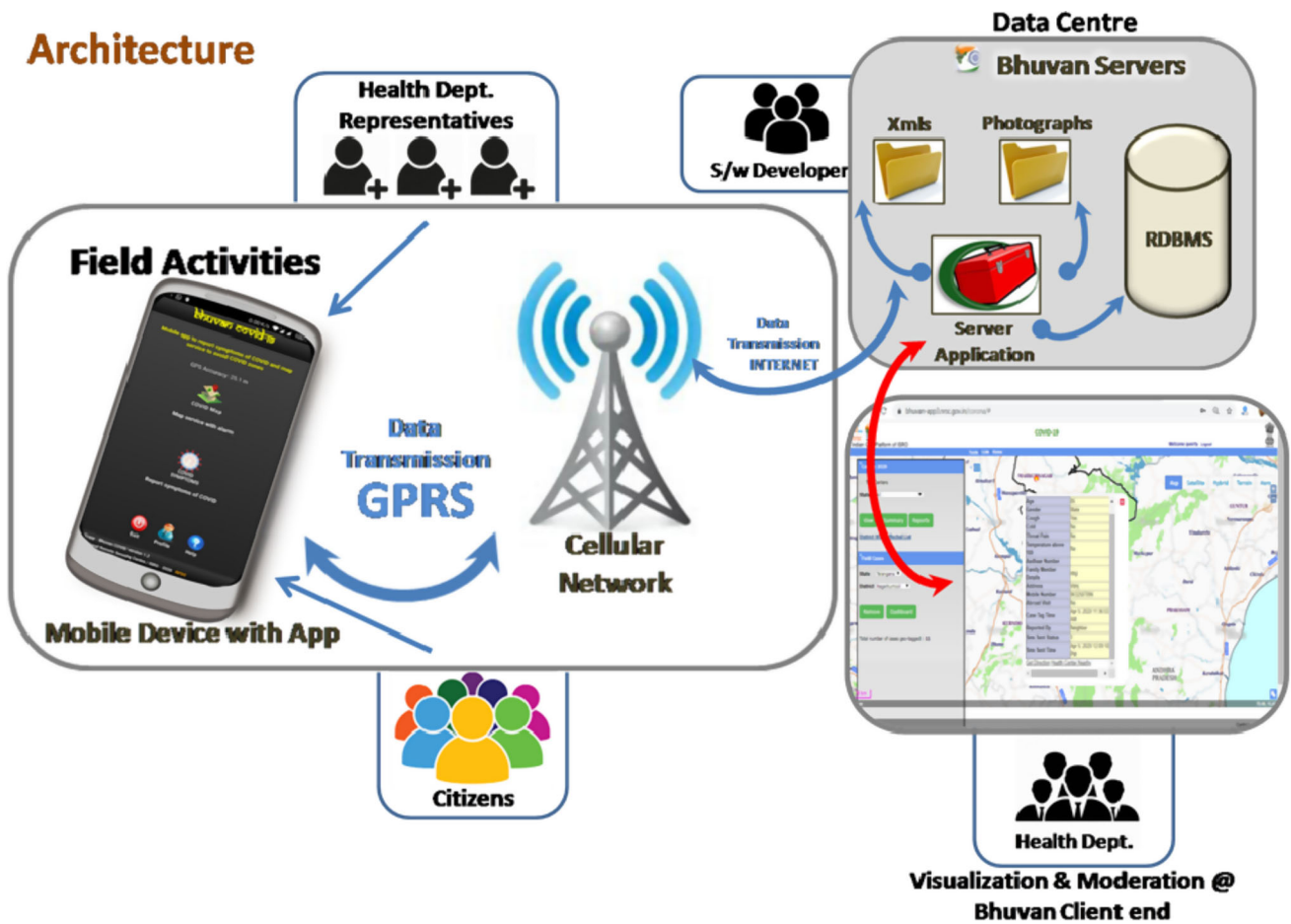


Fig. 3 Solution architecture depicting field and data centre activities

patients. Dashboard would help generate query on the data or generate statistics for decision makers of the government agencies. The reports are generated if the patient is cured from illness, etc. Further, the solution effects the removal of cured patient records from home quarantine clusters in the mobile app. The alert system facilitates citizens to locate COVID-19 clusters in form of interactive map component in the mobile app. The citizens are given an alert with siren if they are in home quarantine clusters. If the citizen him/herself is COVID-19 patient then alert with siren is given if the person moves out of home quarantine cluster.

Data Schema

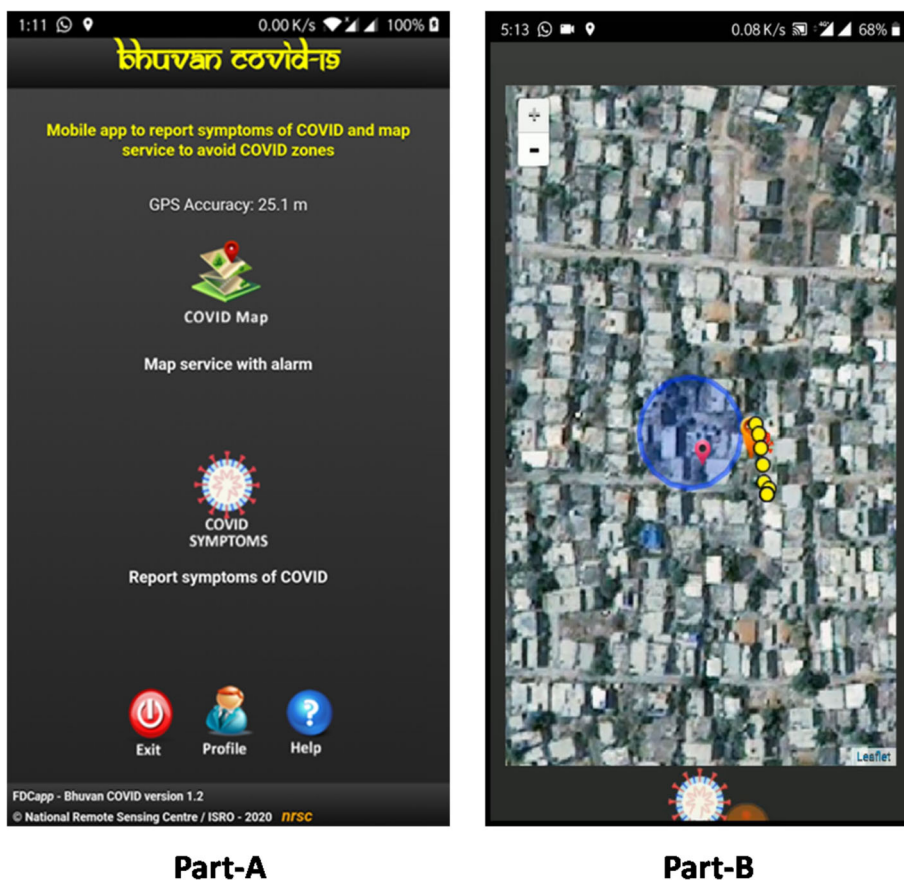
The attribute module consists of data on symptoms of the patient as defined below for Officials and Citizen mobile app (Table 2). The schema showcases the attribute information, data type (data entry method) and options in the attribute values. The ** represents the mandatory attribute information.

Table 2 Attribute information of the mobile app

S.no	Attribute info	Data type	Action/options	Users/remarks
1	Name**	Text	Key-in	Both
2	Age**	Number	Key-in	Both
3	Gender**	Combo	Select from male, female, other	Both
4	Cough**	Combo	Select from yes, no	Both
5	Cold**	Combo	Select from yes, no	Both
6	Throat pain**	Combo	Select from yes, no	Both
7	Body temperature above 100° Fahrenheit**	Combo	Select from yes, no	Both
8	Have you or your family members visited any country in 2020**	Combo	Select from yes, no	Both
9	Aadhar number**	Number	Key-in	Both
10	Associated family member**	Text	Key-in	Both
11	Mobile number**	Number	Key-in	Both
12	Reported**	Combo	Select from self, family member, neighbour	Both
13	Address**	Text	Key-in	Both
14	Reporting officer	Text	Key-in	Official only
15	Reporting officer mobile number	Number	Key-in	Official only
16	Department	Text	Key-in	Official only
17	Whether called 104	Combo	Select from yes, no	Official only
18	Whether test carried out	Combo	Select from yes, no	Official only
19	Name of the lab	Text	Key-in	Official only
20	Test result	Combo	Select from positive, negative, waiting for result, not applicable	Official only
21	Quarantine	Combo	Select from home, hospital, quarantine centre, not yet quarantined, not applicable	Official only
22	Quarantine address	Text	Key-in	Official only

The location parameters consist of longitude, latitude, altitude and timestamp and stored in float data type

Fig. 4 Part-A represents Base module interface with COVID option and COVID symptoms recording. Part-B represents Map module showing home quarantine location with COVID-19 cluster boundary and user movement depicting traces on map



Implementation of Framework and Discussion

The field data collection-based solution is implemented considering the five important components of Geo-ICT framework. Its design is discussed in this section. The mobile app is developed using open source technologies to report the COVID-19 patient with symptoms, their identity, geo-location and health condition. The solution geo-locates the COVID-19 clusters on the map interface using location-based services of the mobile device. The basic essential requirements for home quarantined patients are also envisaged in the solution. The web applications are developed to facilitate officials to visualize the COVID-19 data on map interface. The uploaded field data are made available in near real time for moderation. The post request-based web services are used to transfer the data from mobile to server and vice-versa. The dashboard in web application is developed to query the data for fast and immediate action.

Mobile App

The solution is divided into four modules and each module has sets of components and the actions are carried out using

developed methods and functions. The base module starts with device readiness, enables folders structure and basic files with information required to prepare the software environment ready for operational activity. The module also checks whether the mobile GPS/Location is enabled with alert (Cordova, 2020). The GPS watch position method is used for continuous GPS data acquisition. Subsequently dynamic indicator of GPS accuracy is facilitated as stated in the mobile app of software infrastructure of components of framework design. The module also provides facility to switch user to map service or symptoms reporting service as shown in Part-A of Fig. 4. The leaflet library is used to prepare map canvas and keep ready for GIS data overlay (Agafonkin, 2020). The map module initially finds out the internet connectivity. The latest COVID data is downloaded from the Bhuvan server for the current status and stores in the mobile app. The COVID data contain information like collected identification details, location parameters, COVID data validation information, patient details, health condition, house address, COVID test details and travel details (if any) as stated in Software Infrastructure. The downloading of COVID data is mandatory for first time users. The Hypertext Transfer Protocol Secure (HTTps) post request is used to download the data into the mobile.

Fig. 5 Some important attribute data filling and other features. Part A Personal information, symptoms of the patient and associated information; Part B Source of information and address; and Part-C Options to capture photographs, save and send data

Report symptoms of COVID

Part-A

Name : Das

Age : 58

Gender : Male

Aadhar Number - optional : 9876543210

Mobile Number : 9876543210

Cough : Yes

Cold : Yes

Throat Pain : Yes

Body Temperature Above 100° Fahrenheit : Yes

Have you or your family members visited any country in 2020 : Yes

Associated Family Members : Wife, son, daughter

Part-B

Address / House No / Village / Town / Mandal / District / State : HNo 1, RP Road, Hyderabad

Reported : Self

Part-C

GPS Accuracy: 10.7 m

Photo (optional)

Send Manage Store data

Send Later View Sent

Exit Profile Help

FDCapp - Bhuvan COVID version 1.2
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The COVID data are shared to mobile in JSON format. It contains information like collection ID, GPS accuracy, longitude, latitude, timestamp, quarantine type, moderation status, etc., as stated in web services and application of the software infrastructure of components of framework design. The constraints considered for analysis in COVID data are (1) Quarantine Type—must be “Home”, (2) GPS accuracy—must be less than 50 m, (3) Moderation status—must be “Yet to Moderate” or “Accepted”. The COVID data are converted to GeoJSON layer in a GIS format and overlaid on map frame with pink icon as shown in Part-B of Fig. 4 and stated in the mobile app of software infrastructure of components of framework design. The GIS data are processed for proximity and overlay analyses using TurfJS JavaScript library (TrufJS, 2020). The process includes creation of buffer layer using longitude and latitude information. The buffer data are dissolved and combined to form a COVID cluster boundary in semi-transparent blue polygon as shown in Part-B of Fig. 4. The user footprint point layer is generated to visualize the movements of the mobile app user in the field. The points of current location parameters are captured for every 5 seconds that represents near real time data shown in

orange icon on the map. The captured point is simultaneously added to the footprint layer which represents the movement of the citizen with mobile device as shown in yellow dots in Part-B of Fig. 4. Subsequently, captured point is also overlaid on COVID clusters layer to find the points contained within the polygon. This will represent whether user (normal citizen) has entered COVID clusters location. The home quarantine patient is analysed for not moving out of cluster. The symptoms module enables to fill the information about the patient using mobile app as shown in Part-A of Fig. 5. The app has provision to capture maximum two photographs (optional). The GPS-based location parameters are also captured along with photograph. The location parameters have information of longitude, latitude, altitude, GPS accuracy and timestamp using current position method of geo-location plug-in (Lesslie et al., 2015). The current position method of compass is used to get magnetic heading of the device. The first photo location parameters are considered for location of the observation in case photograph is captured. There are two conditions applied to capture photograph. The GPS accuracy must be less than 50 m and all the mandatory parameters of COVID symptoms need to be filled. On

opening the camera, the symptoms information is stored in the mobile app for further use. The uploading module has components to save the observation and send the observation to Bhuvan server. The user can also opt to store the observation in the mobile and send it later. The captured data are organized in JSON format and written in a file. In case, the observation does not have photograph, location parameters are captured in save data step as stated in above section to be specified .

The Save section captures device related parameters like UUID, device make and model and OS version. The Save component checks the entries of mandatory field parameters and generate SHA 256 value for the photographs, if it is captured before storing the data. The Send component in data collection section is used, in case internet connectivity is available in the field. The steps involved are to check for internet availability, establishing connection with server and post the dataset using post request through hypertext transfer protocol secure (HTTPS). The Store data component is used in case of no internet connectivity in the field site. The dataset are captured and organized in JSON format. The data are encrypted and stored in the external storage of the mobile as stated in the mobile app of software infrastructure of components of framework design (Altuwaijri & Ghouzali, 2020). The module has components to list the stored datasets, along with provision to upload, view the details like attribute values with photographs and delete option to delete the record. The datasets are listed against date and time of data capturing. They are represented with a radio button to select the dataset from the list for sending or view details or delete. The Send option in Send later module initially checks the internet availability, enables data to decrypt and upload dataset using post request of HTTPS. Further on successful callback message, the encrypted dataset is moved to data sent option. The view option of the module enables the selected dataset to decrypt, organize the attribute information and its values, and create a new graphical interface dynamically to visualize the attributes with its values along the photographs. The graphical interface has provision to close its display, which takes the user back to the list of datasets interface. The Delete option of the module enables the selected dataset to delete permanently from the mobile app with a re-confirmation action.

Browser App for Visualization

Bhuvan is a geo-portal platform of Indian Space Research Organization (ISRO). Bhuvan hosts a wide range of services that cover visualization of satellite datasets, thematic maps, free data download, near real-time disaster services, mobile apps for crowd sourcing and diverse geo-spatial applications for governance (Bhuvan Document-1, 2009).

Bhuvan—2D is a map interface with satellite data, hybrid and terrain datasets with tools and features such as draw, area and length measurements, navigation, proximity, add layer and add photo. The Bhuvan-3D has features like 3D visualization of satellite data and tools like navigation record–play–download in video format, 3D models, etc. Bhuvan, as a platform, has developed applications supporting decision making, monitoring and evaluation of various domain-specific applications in collaboration with various ministries, central government and state government departments. There are 182 applications covering 24 ministries and 30 State Portals through Bhuvan. The Bhuvan field data collection server applications are designed to acquire data, to store data in high volumes, to analyse data based on queries, using geo-spatial technologies to present results of applications for the clients over internet browser. Bhuvan application server, enterprise database and web server are designed using state-of-art technologies to handle huge volumes of spatial datasets like raster, vector and tabular information as stated in web services and application of the software infrastructure of components of framework design.

The Bhuvan Home Quarantine tracker is a web application which is used to geo-visualize the geo-tags of COVID patients for district administration along with base layers like administrative boundaries, settlement location, road, railways, forest boundaries, etc. The application allows government officials to register and get approval from state coordinator to become authorized user. The moderators will conduct validation of the data under their area of jurisdiction. Each user is fixed for a district or block. The moderation process involves cross validation of attribute information with photographs and also sometimes field visit as stated in people of components of framework design. There are filters to query based on district, specific date and period. The online report filters can search based on name of patient and mobile number as stated in web services and application of the software infrastructure of components of framework design.

It is visualized in a tabular format. Each patient is represented in each row. The report parameters consist of name of patient, mobile, age, gender and health issues with photographs if any. The geo-spatial representation of the home quarantine patients are depicted in the form of points. The user can visualize the patient on clicking on the point in the map frame. A pop-up window opens with photo and attributes information as shown in the Fig. 6. The authenticated access enables monitoring of data flow, geo-visualization of data shared by citizens, officers, Get Direction and proximity, analysis between inventory location of cases and COVID Testing Centres & Health facilities.

The In-built dashboard provides various reports based on age group, home quarantine cases, etc., as shown in

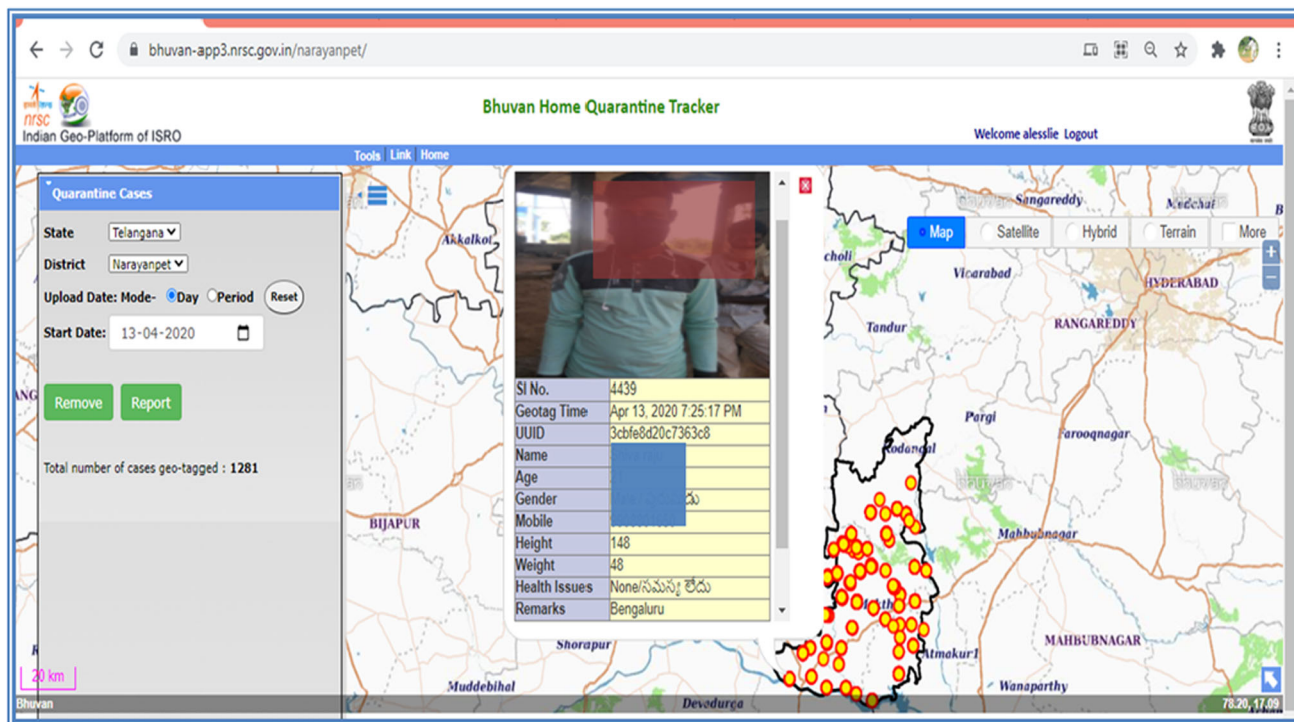


Fig. 6 District wise geo-visualization with filters of districts, dates and moderation

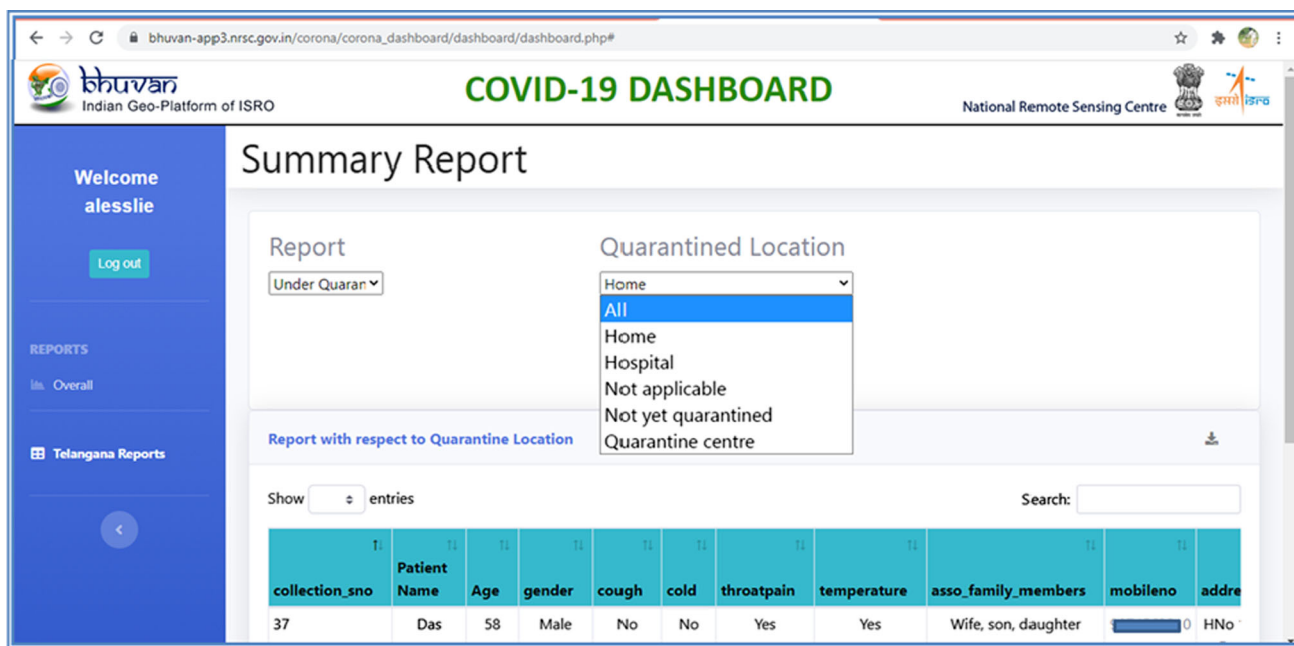


Fig. 7 Dashboard having quarantine location based report along with patient age group

Fig. 7. The dashboard also can be used to search specific patient by any attribute values as stated in Data schema. It also facilities user to visualize data based on quarantine location. The user can switch between dashboard and map interface as stated in web services and application of the

software infrastructure of components of framework design and procedure.

Browser-based application on Bhuvan COVID-19 portal for visualization of COVID-19 state wise statistics based on colour representation along with base layers like administrative boundaries, settlement location, road,

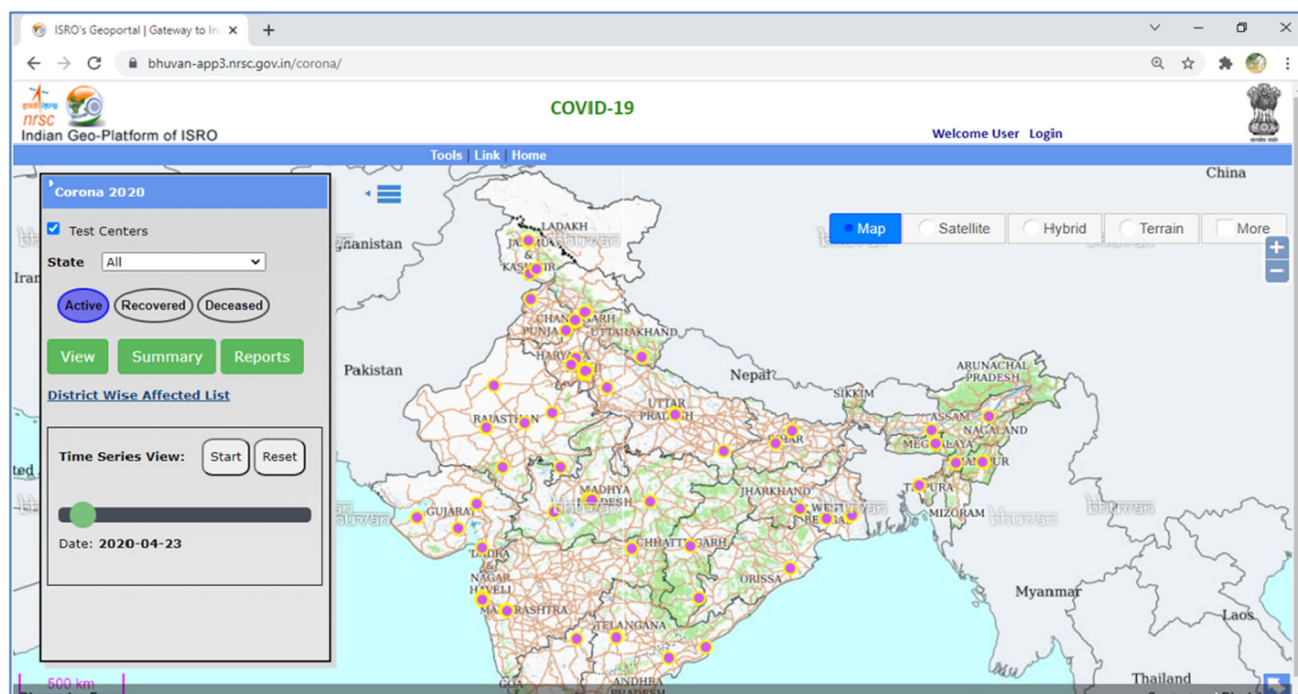


Fig. 8 State level geo-visualization of cases reported with day-wise time series view

railways, etc. It also provides visualization of day-wise time series view of COVID-19 cases.

Conclusion

The design of Geo-ICT framework solution for COVID-19 is important for government departments dealing with the pandemic. The solution is designed using space technology-derived inputs, open-source software technologies, freeware tools and APIs. The solution, addressing the systematic data capture of COVID-19 symptoms with geo-spatial parameters, helps in building the hotspot clusters of home quarantine layer that is dynamically generated in the mobile app. The COVID indicator component enables generation of warning signal to the citizens if they enter the hotspot zone. This study has demonstrated a quick and best possible solution for home quarantine and containment clusters for the affected people. The solution helps minimise the disease spread. The web service integrated on Bhuvan geo-platform also enables the solution to operate 24 × 7 covering PAN-India. The use of location-based services of the mobile device, Bhuvan satellite data map service as a background base map, GIS layer generation in mobile using disseminated COVID-19 data/information in near real time can be termed as Geo-ICT service to the citizens, affected people and a tool for government department to effectively manage the pandemic. We

suggest that the study is a way forward for COVID management for Telangana state and the country as whole.

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Declarations

Conflict of interest No potential conflict of interest among authors on the article.

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