Real-time Smart City Map On Temporal Data

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Introduction

This report presents the idea of a mapping system for a defined campus/city using various graph related techniques on GPS data sets containing the data points of people who use the locations in the map on a regular basis which is different from regular conventional GOOGLE MAPS as it basically intended to implement the temporal data and restrictions that are NOT PERMANENT or even long lasting and are imposed for smaller amount of time with attempts of several high performance mechanisms implementations for real time data processing.

- Here we try to achieve various high performing and highly accurate navigation mechanisms to be used on GPS data sets including day to day data points from user's mobile or equivalent sensors.

- In this process we discovered various methods to generate missing data points in the map like image processing methods (average filter, contour equalization, etc) to build the basic structure of map.

- Functionalities of this Real time MAPPING system includes
  - *Notification for the user for any restrictions imposed between the intended path to destination.*
  - *Providing a powerful dashboard for the administrator to manage the restrictions that may get uplifted after a predefined time interval.*

Motivation

- When we talk about maps for navigation always GOOGLE pops up in our minds but google maps as we all know takes at least around a month to get updated but also the information it conveys is not too detailed.

- Consider a situation or rather a premise where a lot of people work/live just like our college campus, if we need to go to a particular location and the usual road is under construction or the particular building is closed today then either we have to go there in person or rely on the information of anyone who went there recently since we cannot find such information on google maps.

- So this project popped in our minds to connect a populous and large premise with this kind of real time dynamic navigation system and save precious time of everyone.

Problem Definition

The problem definition can be precisely framed as Real-time Map for a smart connected campus / premise where situation and condition (temporal) about any place can be obtained on user's mobile phones and also an administrator side which allow to impose and uplift certain temporary restrictions within.

Literature Review

- Environmental factors and other meta information factors can also impact the GPS trajectory data, thus consideration to these must also be given (*Kaveh Sarrafan et al*) [6].
- To generate map we just need the data points of the GPS sensor which can be used to create a consistent and unambiguous map [12]. The data points can be converted to a neat map using only a 4 step image processing inspired algorithm using averaging, contours filter followed by creating a Voronoi Graph (A set of points that are situated at equal distance from the nearest two points (the boundary points) of a set of polygons which are closed.
- Then the updation can be carried out using BIPARTITE graph methods generation the basic map structure for further processing.[12]

Literature Review

- In a very recent work citywide travel times, traversed paths, and missing values over a large-scale road network are estimating using spatially and temporally sparse GPS traces *(Weizi Li et al)* [1].
- Utilizing Hidden Markov Model(HMM) algorithms, online Viterbi algorithm on the Collected accurate location data at high sampling rate (1 sample/sec) using a combined GPS/GLONASS receiver a real-time map for noisy cellular-based trajectory traces is achieved.[1]
- Prior work primarily related in this area is about detection of the real-time traffic congestion and suggesting the optimal path through smartphone *(Garg et al)* [15].
- A weight based shortest path and vehicle trajectory aided map-matching algorithm is therefore required (*Mohammad Quddus et al*) [10]. For map matching purposes sensors are used for GPS trajectory data collection.

Literature Review

- To predict the traffic in real time, and planning the new fastest routes according to the predicted traffic [4] can be done by Gaussian Process Regression, KNN graph techniques with the help of SCATS sensor using STRF model over the service layer API of the OpenTripPlanner.
- The comparison of the map generation algorithm [11] like KDE algorithm, minimum link algorithm, incremental track intersection, k- means algorithm is done in this paper using the OpenStreetMap dataset. So we can use the efficient and compatible algorithm for our Temporal map.
- To generate map use simple graph theory and map matching algorithms by creating and updating routes and sub routes in real time. [3]

Work Structure

Data Collection:

- Real-time location data is acquired in terms of Longitude and Latitude from the mobile application. The location data is fetched at high sampling rate (1 sample/sec) using a combined GPS/GLONASS receiver *(Moustafa et al)* [2].

- Along with exact date and time format. This location data is stored as a single .csv or .kml file in each application API installed smartphone.

Data Preprocessing

1. **Cleaning Un Important Data**

Since the data is collected over mobile and using google API the data contains several attributes many of which are irrelevant to the project hence needed to be removed.

2. **Removing Inconsistency in data**

Since the modern day GPS data is not 100% correct or reliable due to GPS inaccuracies. Some data points are way out of the usual positions and hence acts like Outliers and need to be removed.

3. **Overcome Missing Values**

Due to poor network connections and/or black spots (no network coverage) the data can be spare at some points or no data points could be there in case of roads. So, the roads may become incomplete and could make no sense. So, we added any possible missing values in the dataset.

Divide data into Points and Roads

The data at first contained 3 types of geometries :

1. **Data Points :** This type of geometry contains all the points having information about a specific point along with its other attributes as described before.
2. **Way Points :** This type of geometry contains set of Data points to form a road with source and destination and turns.
3. **Multi Geometry Points :** This geometry contains set of data points and waypoints to form complex paths.

Note : The Multi Geometry was way inconsistent and also not useful enough So we had to remove this geometry.

Dataset Description:

- **Waypoint/Line String** : having several attributes like colour, width, track name it belongs to, its description. This type of entity describe data point in between a waypoint/road/track.

- **Legend Point** : This entity is usually some building / important place or a legend in the map having mainly 4 attributes:
  - Name
  - Description (coordinates and height)
  - Timestamp
  - Visibility (binary, 0-not visible 1 - visible)

Merged Data.kml

Find in table

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	name	description	timestamp	visibility	styleUrl	styleHash	stroke	stroke-opacity	stroke-width
1	07-Feb-2019 5:06:18 PM	Track no. 1		0	#red	-4850ec2f	#FF0014	0.7843137254901961	4
2	food plaza	- Coords: 25.437574, 81.88222 Elevation: 66 ft Time: 07-Feb-2019 5:29:32 PM	2019-02-07T11:59:32.000Z	1					
3	07-Feb-2019 5:28:53 PM	Track no. 1		0	#red	-4850ec2f	#FF0014	0.7843137254901961	4
4	Waypoint no. 1	- cycle hospital	2019-02-07T12:27:54.000Z	1					
5	07-Feb-2019 5:56:47 pm	Track no. 1		0	#red	-4850ec2f	#FF0014	0.7843137254901961	4
6	3d wall presentation	- Coords: 25.428827, 81.87865 Elevation: 14 m Time: 07-Feb-2019 6:40:48 pm	2019-02-07T13:10:48.000Z	1					
7	jal police station	- Coords: 25.428854, 81.880325 Elevation: 11 m Time: 07-Feb-2019 6:39:03 pm	2019-02-07T13:09:03.000Z	1					
8	women's police station	- Coords: 25.429054, 81.88049	2019-02-07T13:08:29.000Z	1					

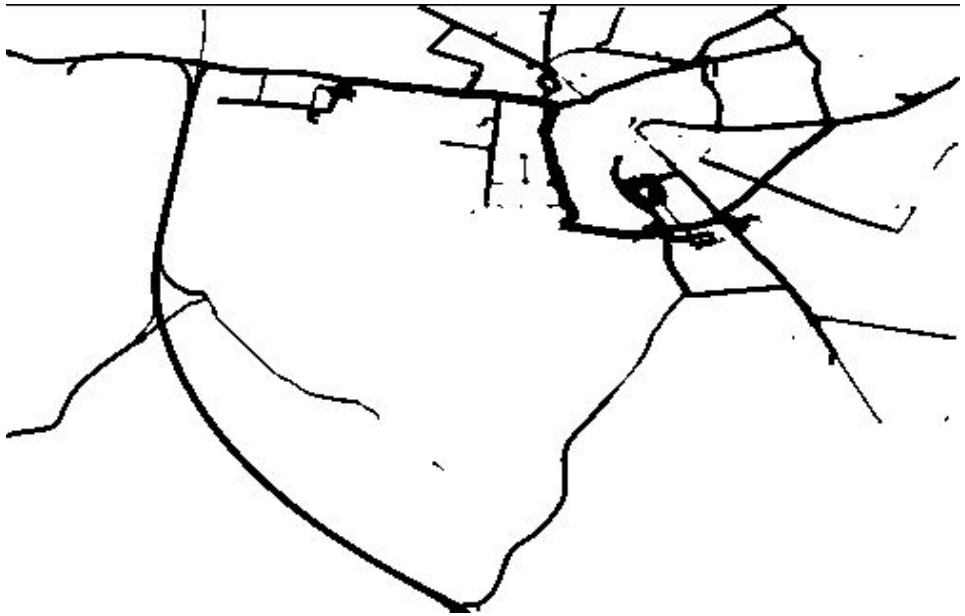
Map Generation:

Utilizing the Google API services for both Location and Map the real-time map is generated by plotting the location data in terms of Longitude and Latitude at each pre-specified time instance. To specify the starting and ending location points map-markers is used on the generated map.

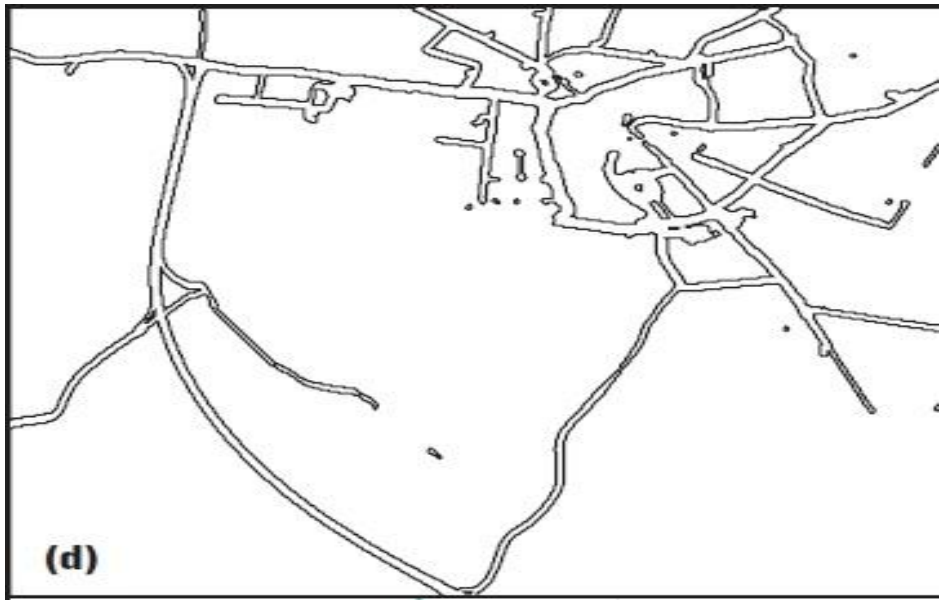
- **Generate a 2D histogram indicating the number of GPS fixes found in each cel**l.
- **Applying average filter.**
- **Binarization with thresholding.**
- **Apply a “Contour filter” to trace the boundary of the roads.**
- **Create a centerline on the roads (Spiked graph) and remove spikes with thresholding.**

1. U.K. map histogram with one pixel per cell

2. Applying average filter

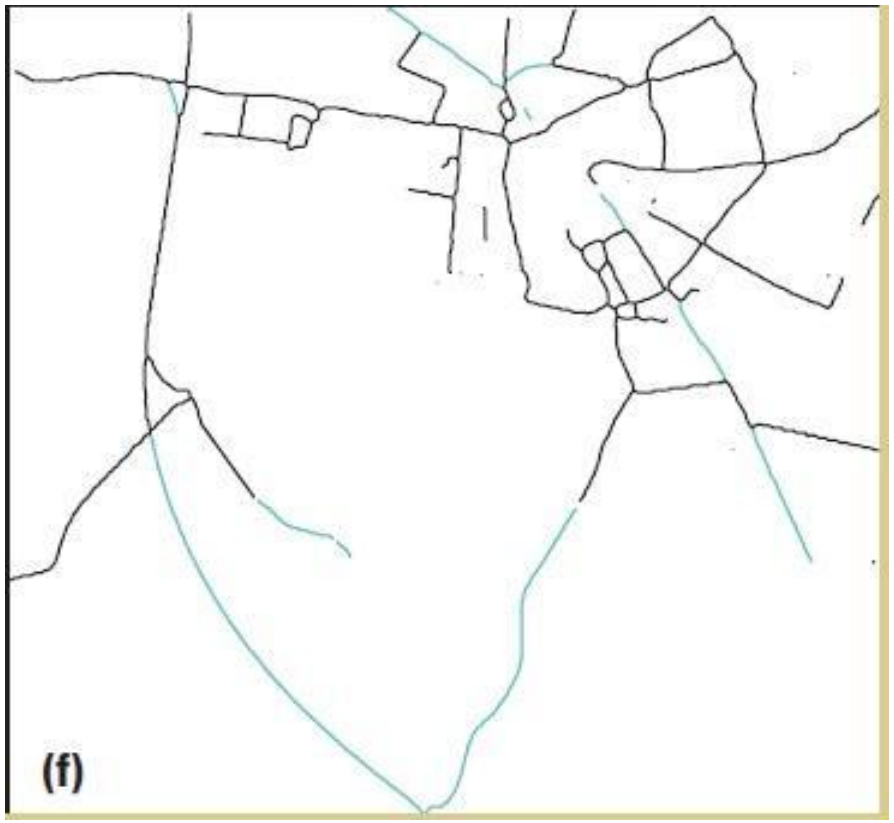


3. Image after binarization



4. Image after contourization

5. Spiked Graph

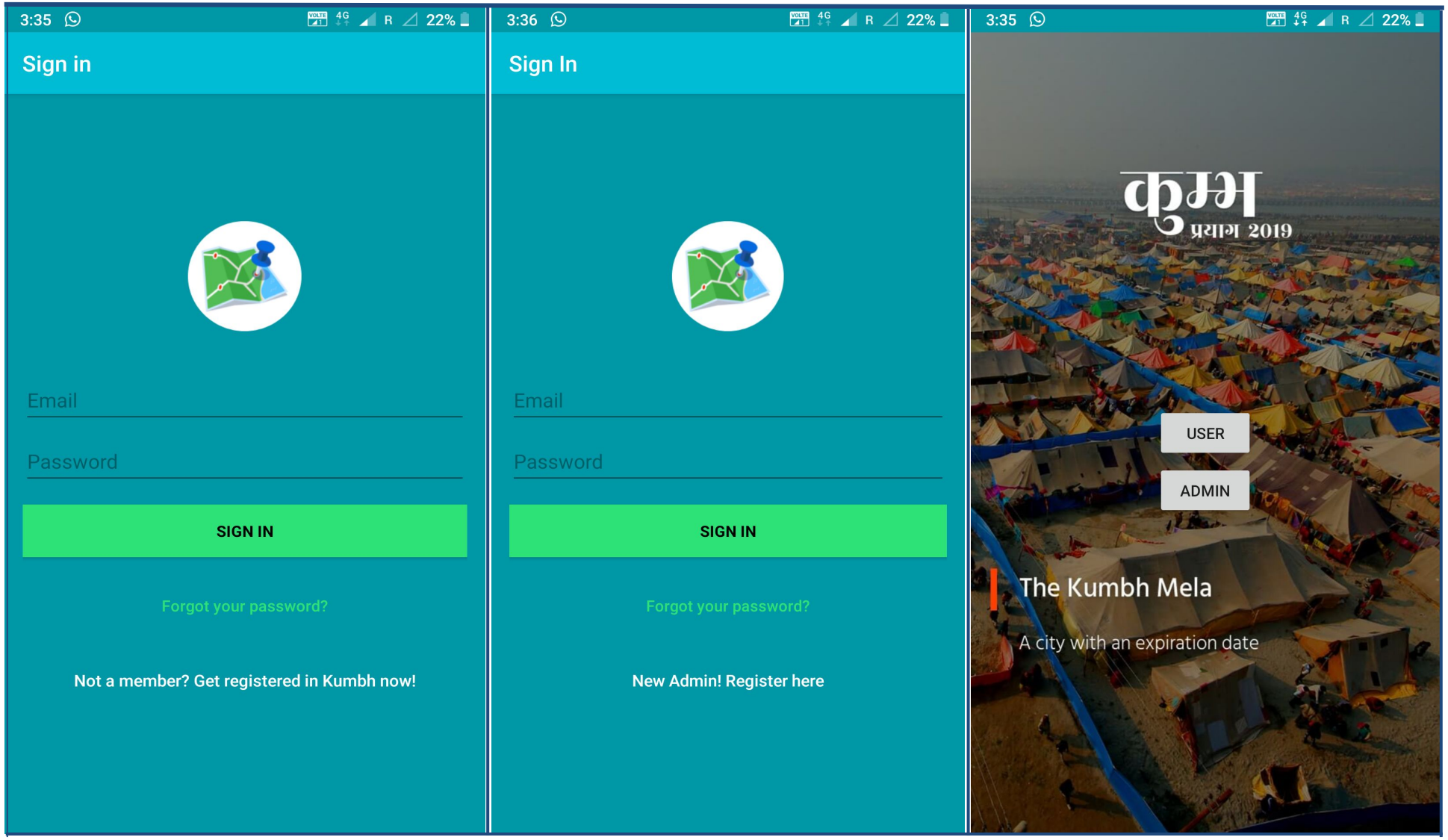


6. Final output

App Formation: Front End

1. **Register, Login, Signup (User and Admin)**

The users are provided with registering option which allows new users to avail the facilities provided by the app. Previous existing users are authenticated by their email id’s and passwords. On successful authentication they are forwarded to dashboards.



User Login

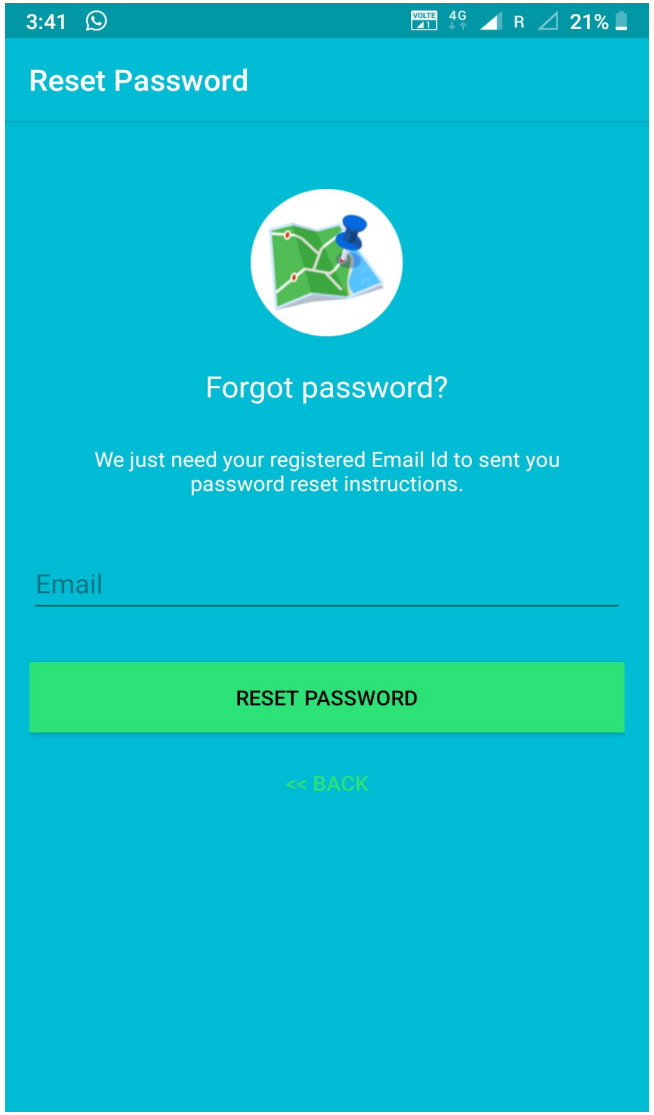
Admin Login

Homescreen

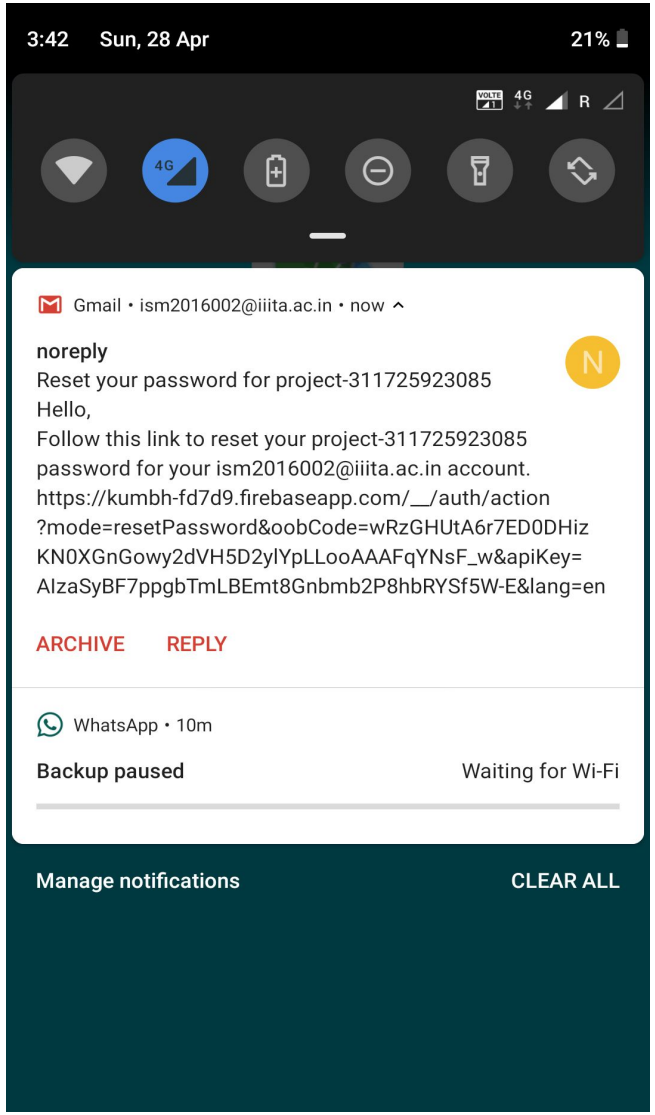
App Formation: Front End

2. Forgotten Password Management and Security

The facility for resetting password is also provided by the app. On clicking the option for forgot password the user is asked for his/her email id to which the password reset link is sent. The user can then change his password. The firebase engine provides a secure method of authentication and server side encryption thus maintaining an effective and secure app experience to the user



Reset Password

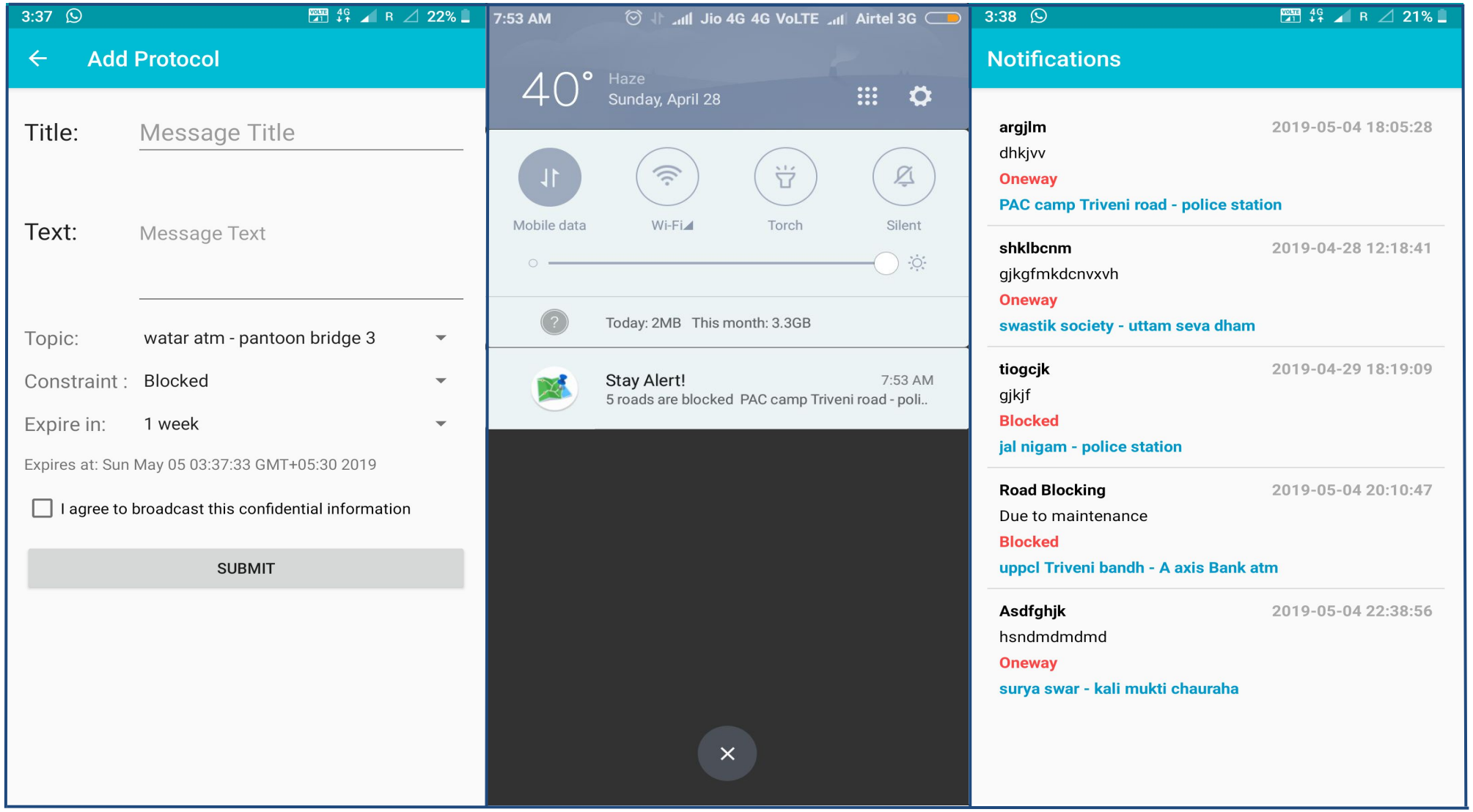


Mail for Password Reset

App Formation: Front End

3. Adding Constraints and Notification

The admin dashboard allows him/her to add constraints on the roads and as soon as this is done a notification is broadcasted to all the users regarding this change when they are logged in.



Protocol Addition Window

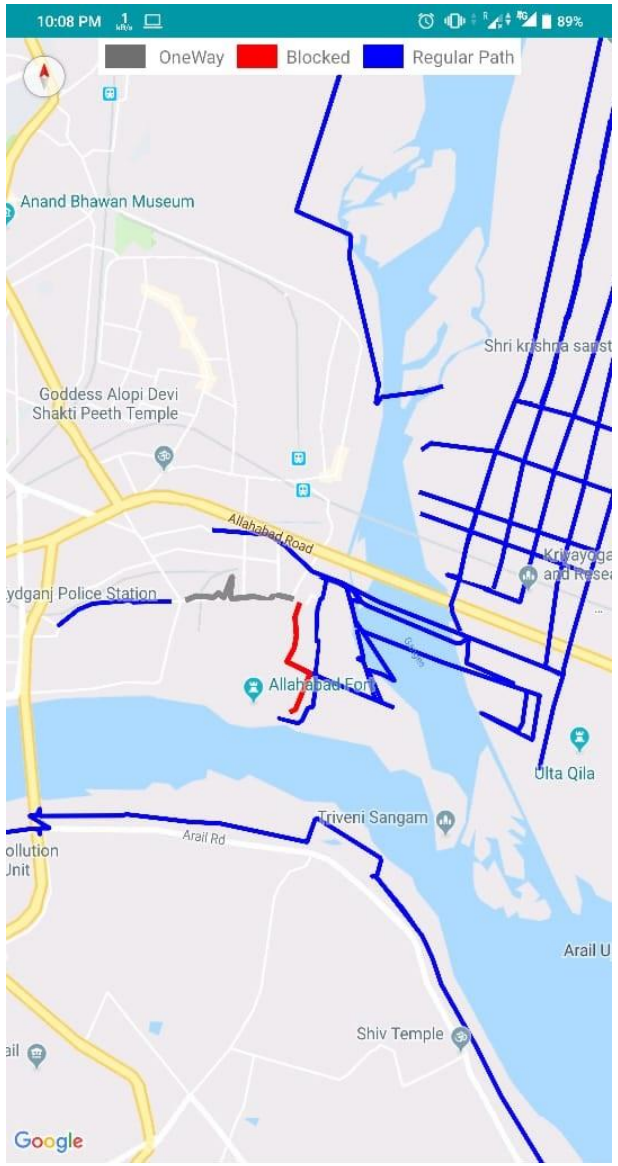
Instant Notification

All Notifications

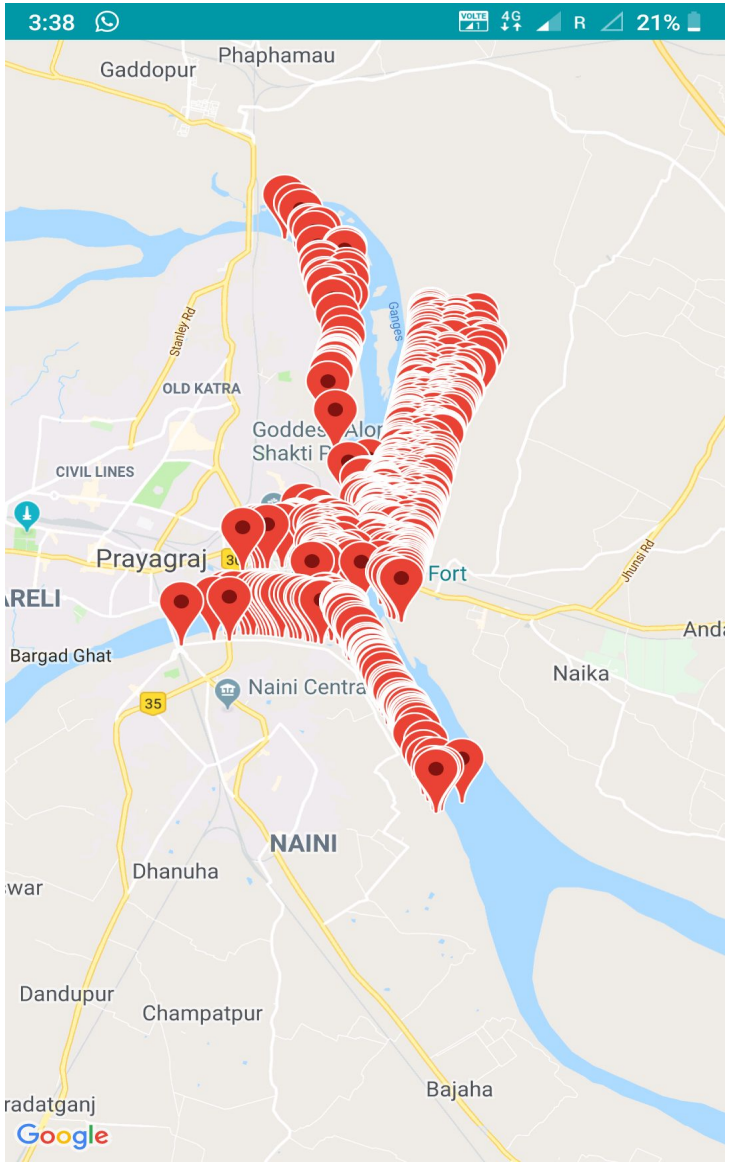
App Formation: Front End

4. Map

The user and admin dashboards allow them to view two maps one showing all the blocked roads (in red color), one way roads (in gray color). and the other showing the markers to coordinates on the local locations in the map.



Map with blocked road marked in Red, one way road marked in Grey and Map with open roads marked in blue

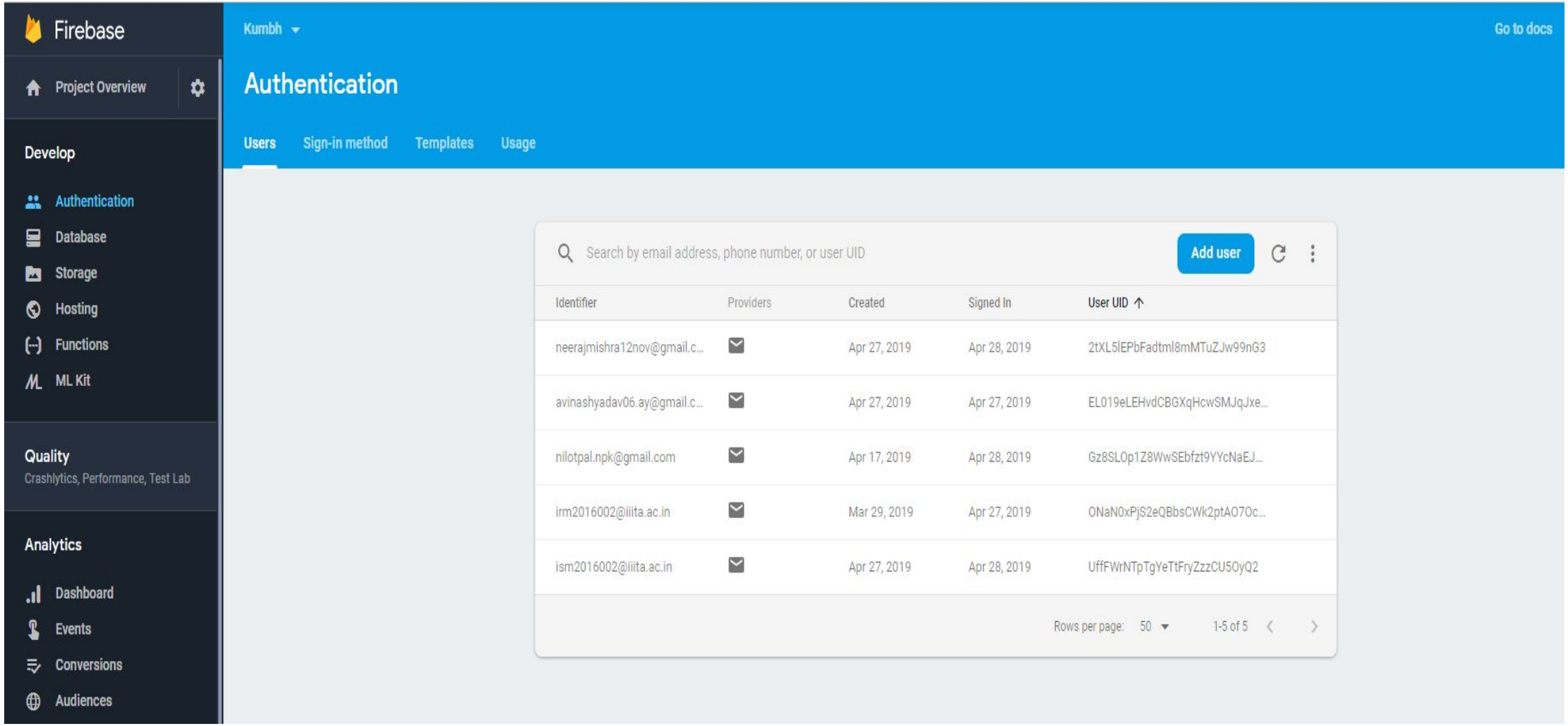


Map with marked locations in Red

App Formation: Back End

1. **Firebase**

This the online application providing server access and management for any mobile application usage and user engagement. We have used Firebase for login/signup data management and notification sending protocol. There we are storing user login user-id and password during sign up and during login the authentication is checked to enter the user to the android application.

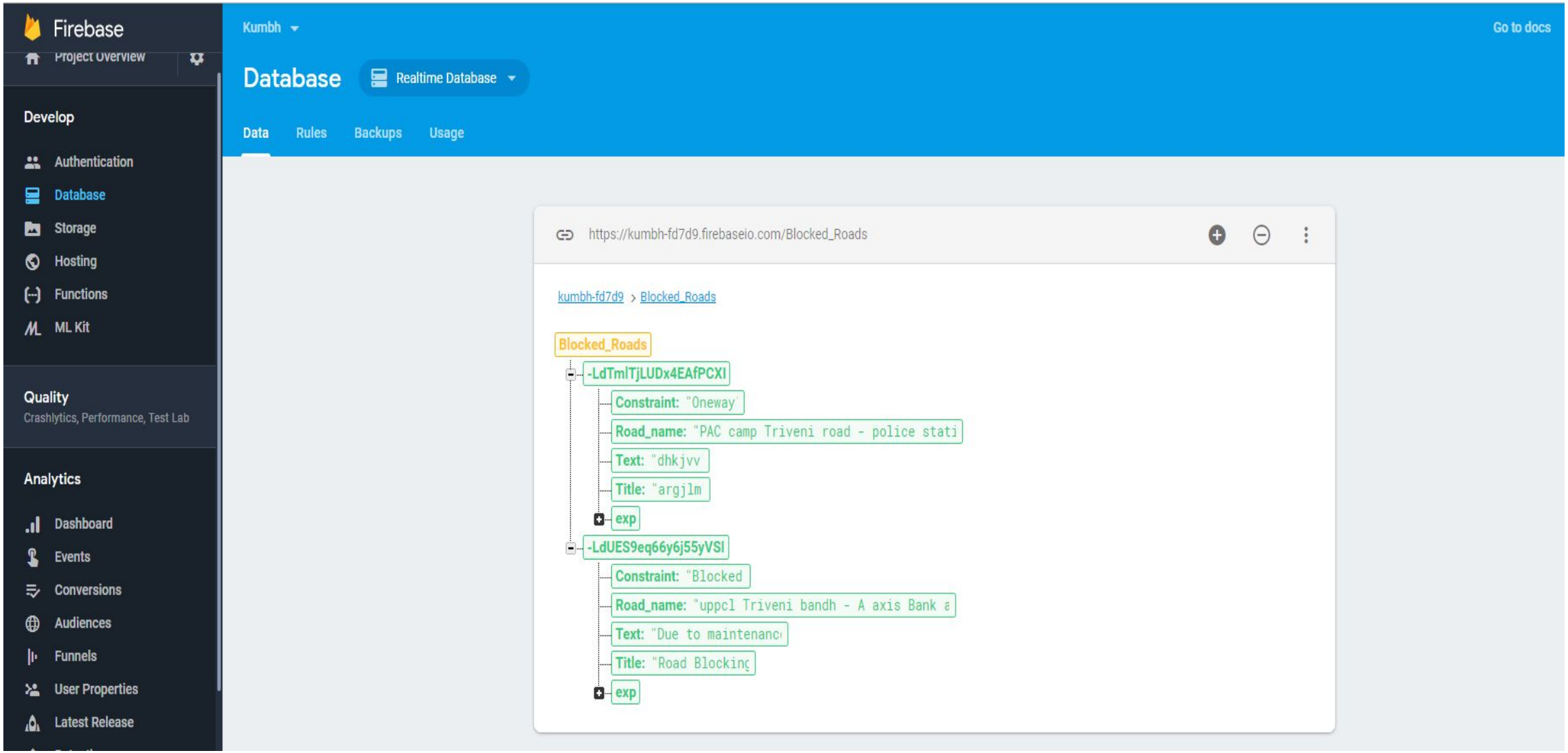


User Details stored in Firebase

App Formation: Back End

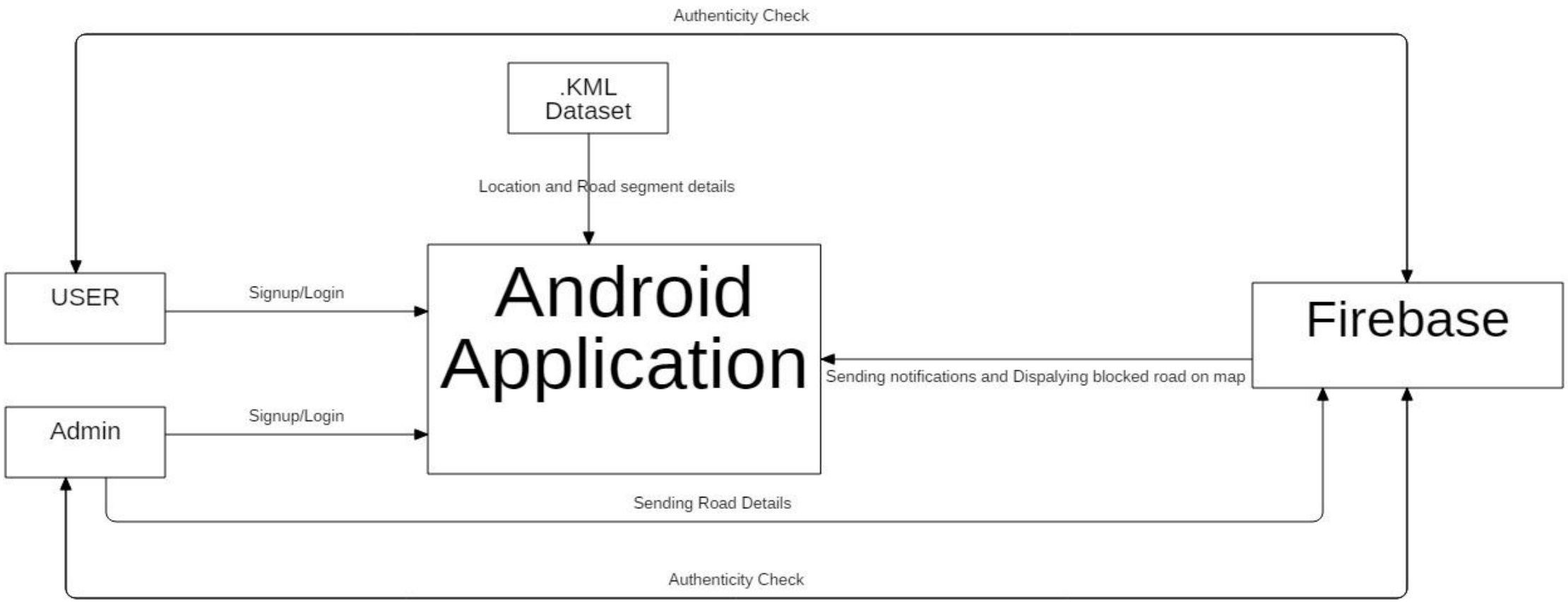
2. Cloud Messaging, Realtime Database

This is a part of Firebase protocol which has been used for providing instant notification to the application. After each specific entry of information to the firebase database from the admin side an instant notification is generated over the users mobile as “Stay Alert!!”.



Real time database for road details

Architecture Diagram



Outcome

- A fully functional map capable of implementing temporal restriction that can be lifted by setting a predefined time.
- The App is secure in terms of Authentication (Encoded Data is stored rather than Real Data).
- App is readily producing Notifications to all the Users

Future Scope :

- The future scope for this application can be some cases like, at some location, if government gets an information about catching fire or planted bomb so they can easily notify all users through this app.
- On the hand of user side, User can rate a location(pandals, shops, ghats) and give some feedback.
- If somewhere riot got happened, so any user can notify admin and admin can confirm that news and further notify to all users.

Timeline

S.I.	TIMELINE / MODULES	Jan	Feb	March	April
1	Resaerch Papers Review				
2	Experimental Setup and dataset collection				
3	Design and Coding				
4	Final Testing and Report Preparation				

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Thank you


Firebase
72.5%
Gender
Admin SDK
HTTP/XMPP
Notifications Console GUI
Trusted Environment
Firebase
Cloud Messaging
Android
iOS
Web