An Early Alert System for Traffic Congestion based on Social Messages on Smartphones

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ABSTRACT
Road traffic congestion is a global problem and large amount of money is being invested to cope with traffic congestion problems. These interventions focus on reducing traveler time on roads and highways in particular. Various approaches such as loop detection and automatic vehicle detection have been utilized for this purpose but all these happen to be very costly. The main purpose of this study is to propose a smartphone application through which users can share congestion information through social messages. This application is based on client-server architecture. On the client side, it gives traffic congestion information to the server; while on the reverse side, it takes information from the server and disseminates it to relevant users. A user searches for congestion information shared through social messages on a planned route in order to check if his path is clear or congested. In this way, the user can get timely be informed and thus be able to avoid that congested path and look for alternative routes.

Keywords
Congestion, traffic, information, smartphone, social messages.

1. INTRODUCTION
One of the critical problems in metropolitan cities is the ever increasing traffic congestion. Congestion may be defined as the condition where a vehicle covers little distance and moves slowly due to high concentration of vehicles that are beyond the holding capacity of the road [1]. This steadily growing traffic leads to heavy congestion and mobility problems, especially during busy hours. This pattern is almost similar in urban areas and highway networks. This causes massive economic losses every day. According to Texas Transport Institute [15], to date, billions of gallons of fuel have been wasted due to traffic congestion.

Traffic congestion causes time wastage in certain days of the week during school and office conveyance hours [4]. To reduce this problem, new roads are constructed and existing infrastructure is upgraded to minimize the traveler's trip time. Moreover, other factors may add to the increase in traffic congestion. These include increasing number of vehicles in the cities, road construction, accidents, bad weather and fluctuating situations of law and order. Under these circumstances, two distinct research areas have emerged using mobile network data; namely, road traffic analysis and prediction [2].

Traditional solutions to traffic congestion are based on infrastructure up-gradation, which is a costly solution. In the current work, the propose system is an alternative approach: a user can use his experience in real time for others in traffic to avoid congestion [3]. In this regard, an up-to-date information system about congestion is a crucial requirement, fulfillment of which has been made sure in the study at hand.

Today, it is the era of smart phones with modern mobile operating systems like Android and iOS. These operating systems are user friendly and developers are given freedom to design applications that attract the end users. A mobile application is built specifically for entertaining and helping end users in various ways. Keeping in view the wide use of smartphones, a smartphone app that helps a user find congestion location during traffic. This way user can figure out a clear and safe route to his destination. The core concept behind working of this app is that of mutual information sharing. A user in the problem area (termed as 'Victim User') uses this application and posts comments about road jams due to congestion or road block. In this way other users can locate the road jams through information shared by victim users.

2. RELATED WORK
Resolving the challenge of traffic congestion is not a mere walk in the park. According to Wang et al [6], the increasing number of vehicles on roads has complicated the said congestion problem. In today's era of smart phones, a multitude of positioning technologies has come over that can be utilized to better resolve the congestion issue. These include networks like GPS, 3G, GPRS and Wi-Fi. These personal devices serve in a number of ways; for example, connecting to Information Traffic System (ITS) and searching the latest real time traffic information by using GPS. In this context, the traveling network of roads and traffic infrastructure potentially increase complexity. As per Wang et al. [6], lack of traffic information exchange and route guidance lead to waste of time and energy (due to the uncertainty about traffic). Heavy traffic, therefore, increases congestion and accidents and hence gives rise to security risks. With the development of science and technology, solutions are being sought for these problems. For instance, the ITS system provides traffic information via a mobile network which can be accessed anytime and anywhere as possible. Similarly, the intelligent transport system proposed in [7] regulates traffic flow so as to control traffic congestion.

Traffic Jams occur at junctions and at peak hours when there is a high density of vehicles and everyone waits for his turn to pass. According to Mulay, et al. [7], congestion generally occurs at office or school timing when people are in a hurry to reach their workplaces in time. Besides, if commuters have to wait for too long at the signals, they occasionally start doing irrational activities like breaking traffic rules and disobeying signals. The major goal of work is to provide a solution for traffic congestion and to make the transportation system effective and safe.

Traffic congestion is a problem that needs to be solved as early as possible [3]. Some handy tips can be used to solve this critical problem. Among these, proposals of new roads and railways is an alternative way to minimize traffic congestion problem and reduce the traveler trip time. As far as measurement of traffic congestion is concerned, a variety of habitual ways exist that serve this job. Since commuters often rely on their past experiences to avoid traffic problems, it is difficult for them to be well aware about congestion without a proper system. Matter-of-factly, the need of an up-to-date information system on road traffic becomes crucial.

In this work, the aim is to develop a system that can give real time traffic information to users through mutual information sharing. Furthermore, final output of this study is to provide travelers with an application that is intelligent enough to deal with traffic congestion by utilizing mutually shared traffic data. Reliability of the said data can increase once the app starts to be practically utilized for the job it's made for. Subsequently, the system server (frequently updated with the road traffic condition from victim users) becomes able to generate timely information concerning congestion at the road ahead of a user. It is note-worthy here that this traffic congestion information is kept in the server for one diurnal period only. This is so because application works on 24 hours based validity and information is upgraded upon the next day.

Road traffic congestion is a problem that has been the center of investment of large amounts of incentives in many countries. According to Reza, et-al [8], governments all over the world have been allocating huge budgets to solve this hitch. Alongside, the continual growth of traffic has emphasized the need of a viable solution such as traffic monitoring, improvement in traffic flow, road safety and environmental protection. In this regard, the developed countries have started using the concept of Big Data Analysis. In this concept, data are collected from sensors and installed on vehicles in the form of black boxes. These, in turn, send data to a server that processes and displays the collected data to the user in an XML format.

Thiagarajan, et-al [9] have elaborated the significance of delay estimation in their work. As per the authors of [9], road traffic delay estimation using mobile phones is helpful in saving time and fuel. Also, it reduces the frustration of travelers.

3. METHODOLOGY

As discussed in the previous sections, this work focuses on the development of a smartphone application meant to provide an effective solution for traffic congestion. Android based open source software development platform has been used to design this application. It is primarily a dual mode client server based networking application. In one mode, a user can upload traffic related information on the server; while in the other mode, he can get helpful information on congestion, uploaded by other users.[3]. As far as the second mode is concerned, the server provides relevant information only if the given points happen to be located on the intended path of a user stuck in traffic. Fig 1. Shows the system model that the proposed application works in. Front end of this system shows congestion and/or road blockage through early alert and shared messages. The application works in the following manner: Initially, it verifies whether the phone has internet connectivity. If it has, the application starts; otherwise a dialogue box appears showing no internet or limited connectivity. A screenshot of this verification step is shown in Fig 4.

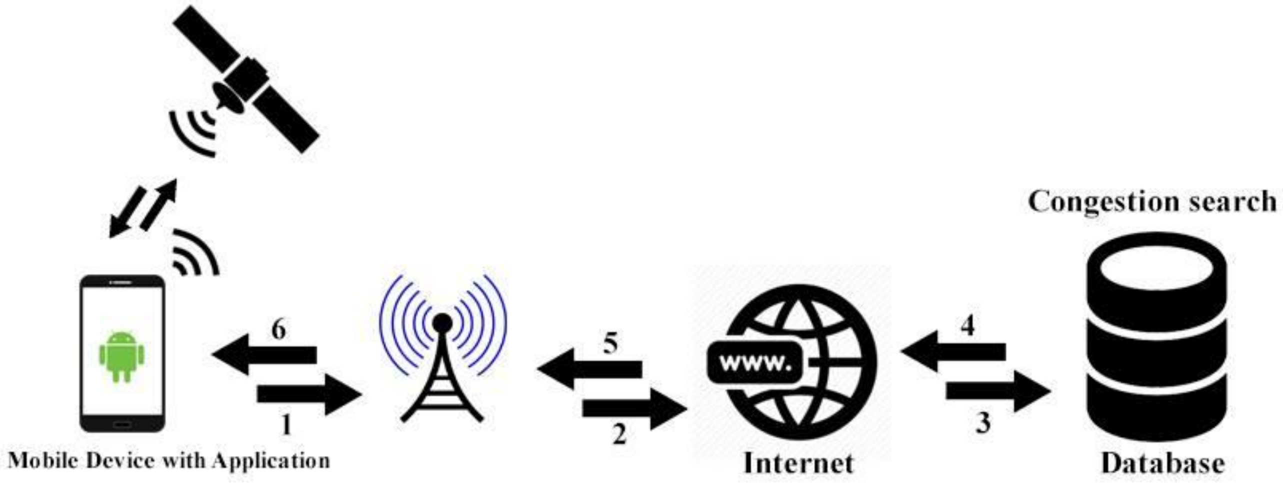

Fig 1: System model for the proposed application

Upon starting the application, it locates the latitudes and longitudes of the user's current position on road. This it does with the help of a Geo-Coder. Alternatively, a user can enter a location manually taking help from autocomplete text as shown in Fig 5. In this way, when the user types a destination name, a list of related locations appears. This is a time saving activity that aids in finding a location that actually exists in the database. Once the current and destination locations are successfully mentioned, a line appears between them on the map. The purpose of this line is to indicate the path of interest (to search congestion in). From here onwards, data already there in the server comes into play. If the line passes through points (within a range of 20 meter) that are already there in the database (uploaded by victim users), a marker shows up. When user clicks this marker, it tells the location, comments, and time of upload. For this, the app takes help from GPS installed in the phone.

Each time a user gets congestion information, the application makes sure that he gets the latest information. This in ensured by two means: first, the app contains data on daily basis and doesn't show data from the previous day; second, if multiple users have uploaded congestion information about the same position, it keeps fresh information and deletes the previous one. With more and more uploads by victim users, information provided by the server becomes reliable than before. Ultimately, the system becomes able to provide accurate and timely information concerning congestion on the road.

As already mentioned, congestion location on routes is ensured by a client/server architecture [3]. The client uses the interface of the proposed mobile application that contacts the server to exchange various navigation particulars. Connection between client and server can be established in two scenarios, details of which are as follows:

I. To retrieve a congestion-free travel path to the destination.
II. To pass over collected information about congestion of the ongoing road segment to the server.

Fig. 6 and Fig. 7 demonstrate results of the query search. As a result of a query, the user is showed a path from his current location to the desired destination. With this, it is also showed whether his selected route is clear or has congestion. Fig 7 shows an illustration of this. Hence, the user gets to know the exact location and time of congestion at a certain point in his route. Using this information, he can then rearrange his travelling time or choose another route if any in order to avoid congestion. This is an early traffic congestion alert system that enables commuters to foresee traffic conditions and accordingly manage routes so that time, vehicle fuel and his own energy be saved.

Other material utilized in the development of this application is now elaborated.

3.1 Google Map API V2

Google maps API v2 is used to aid users explore the routes with rich map provided by Google [10]. Before starting work on google maps, one has to ensure that API v2 key is built through google API console so that Google Play services may be easily incorporated. Including google map helps in finding locations, customizing markers and mapping data with custom connections embedded as map fragments. A new map provides features of 3D by including it into an xml activity as a clip. These features comprise hybrid view, terrain view, satellite view, and street view [10]. Users can add markers to a point of interest. They can also add polylines and polygons to the path to enhance information gathering from the map.

3.2 Polyline

Generally, a Polyline is a list of points which is defined as a set of linked lines on the map [11]. Polyline object is created by the interpolation of points having certain latitude and longitude values. A polyline has properties like points, width, color, visibility and geodesic status. In the perspective of this work, to define a polyline as the intended path of a commuter where user is interested to find congestion. The Google MapDirection class is responsible to make request to a google direction API. This class takes latlong values of both the current location as well as destination. Finally, it passes control to the handleGetDirectionResult method to actually paint the polyline on map.

3.3 PolyUtil Library

The google map geometry library's PolyUtil namespace contains utility functions that determine whether a given point is inside or near a polygon/ polyline [12]. The current application uses geometry library providing two methods namely 'isLocationOnEdge' and 'isLocationOnPath'.

'isLocationOnEdge( )' and 'isLocationOnPath( )' functions are used to find out whether the given point lies on or near a polyline or near the edge of a polygon (in a buffer of 20m) drawn by user. These functions pass the polyline and buffer information to another function namely 'google.maps.geometry.poly.isLocationOnEdge() [4]. This function returns true if distance between the incident point and closest point on the nearby road falls within the specified tolerance, otherwise it returns false.

A pop-up marker is displayed on the point at which they meet the 'isLocationOnEdge' criterion. If this was note done, the interface would show no congestion information for the current route. When an interested user taps a pop-up marker, it shows the comments, date, and location shared by the respective victim user. In due course, the intended user is able to know the congestion on route at which he/she wants to travel.

3.4 Sharing Information

Another view of this application is that a victim user can share information about the congestion occurred on a route during traveling. The user runs the application installed on his device that automatically takes GPS points from satellite. These serve as the latitudes and longitudes of his location. He simply adds comments about incidence on road and shares this information on the cloud.

3.5 GPS Points

GPS enabled mobile devices have largely removed the paper and phone survey. Furthermore, smartphones have become capable enough to transfer the GPS collected data to a database server [14]. In order to utilized the same feature in research work: real time data connectivity provides new services to travelers like traffic alerts based on user's instantaneous location.

3.6 Comments Box

When the latitude and longitude points of a user's current location are taken from the GPS, he writes up comments in the comment box that are saved to the database. User can also upload an image of their current area for confirmation but this has been kept as an optional feature. Nevertheless, this option increases the reliability of congestion related information. Next time within 24 hours period, if someone has to travel on the same route, they can check the congestion and accordingly rearrange their travel path after being informed of road blockage. Victim user will write comments and share it to server. Opening of the app will check GPS on or off setting in Fig.2. After that setting writes down comments in the comment box in Fig.3 and simply click share button will share the useful information.

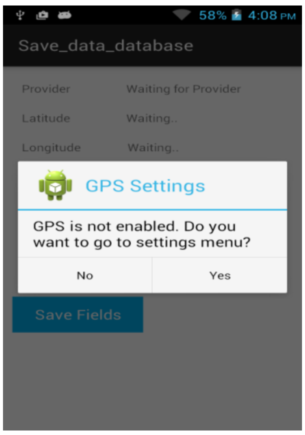

Fig.2 GPS Setting

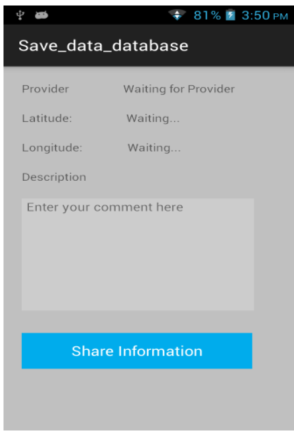

Fig. 3 Comments Box

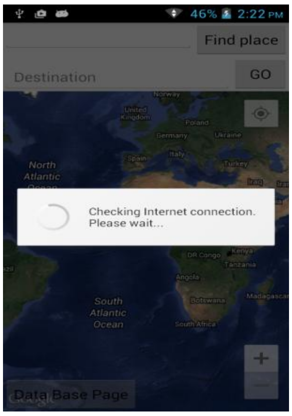

Fig. 4 Internet Checking

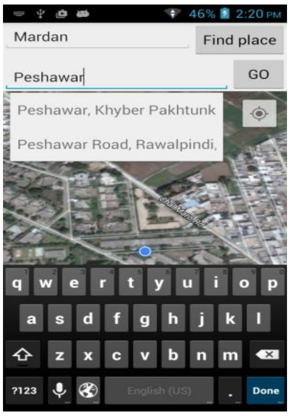

Fig. 5 Autocomplete Text

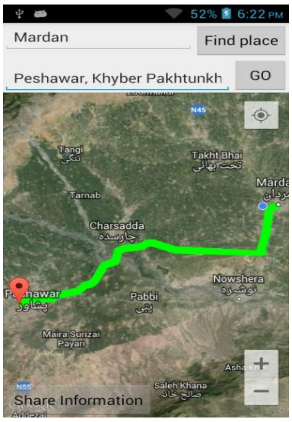

Fig. 6 Poly Line **Fig. 7 Congestion Location**

4. RESULTS AND DISCUSSION

Thorough quest in literature tells that no threshold value has yet been developed to discretize traffic congestion [16]. However, efforts have been made to reduce it to optimal levels. Main objective in this context was to reduce congestion by avoiding congested paths and following the idle paths. This, work made possible for the users by various features in the proposed application that have already been discussed in the previous sections. End results of the application testing have shown that it not only helps in congestion reduction, but also saves the user's time to a large extent.

Fig 8 and 9 summarize average time reduction patterns that have been achieved with the use of this application. It is clear that it takes time to use the application being a commuter; however this cannot be termed as a time wastage as it proves fruitful in the long run. Eventually following the alternate route saves the traffic congestion time and irritation. On the average, a user is able to save 46 minutes if he makes correct use of the said application and actually follows the suggested alternate path.

The challenge however in the context of traffic information systems is how to measure the KPIs (Key Performance Indicators), as objects to be measured are not static neither that can be evaluated inside a laboratory [17]. In order to evaluate the result of our study which is collected from different users, data is saved in a database. A case study is taken to measure the distance between user current location and destination. If user checks travelling route if there is any points matched in their way, user will be able to decide his plan of travelling to follow alternate route either to rearrange his tripe time. So by this way user will be able to save time. In case of moving through alternate route may be bit lengthy but it will save time and avoid the irritation of congestion.

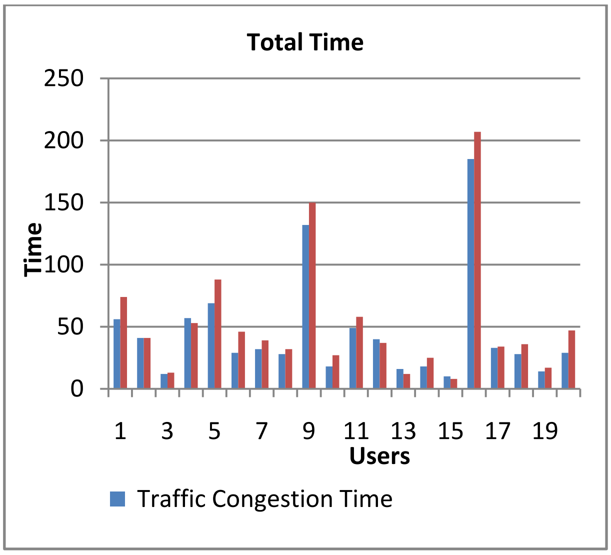

Fig.8 Comparison of traffic congestion and alternate route time

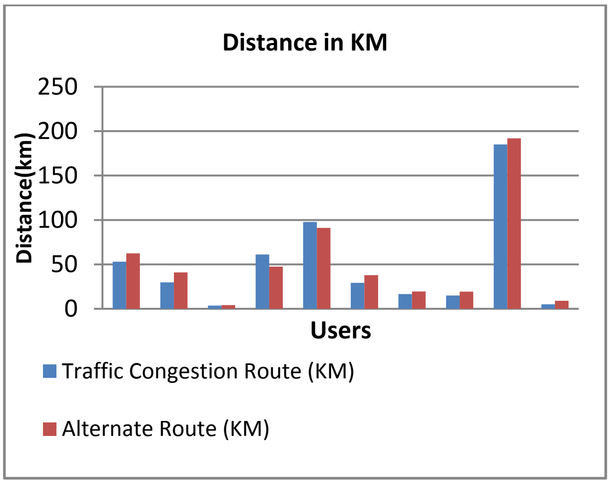

Fig. 9 Total distance of congested route and alternate route

Clearly, a user can take more time than the average time of 46 minutes. This can be seen in Fig. 6 when a victim user is facing traffic congestion/blockage, he may be able to measure the actual time taken by this congestion/blockage. Results are based on the average of the above data.

In order to gauge the traffic flow, researcher has used determination methods based on novel threshold parameters. To use the genetic algorithm and decision tree to do this. These methods discretize traffic flow parameters such as speed, volume and occupancy. Furthermore, Genetic algorithm solves the mutual information maximization problem. Pictured based results of a location. This will add additional information and these will be the geo-tagged images of the location.

Following are some interesting analysis results drawn from this research work:

4.1 Time Saving

The proposed application provides efficient time saving in a sense that the user is able to anticipate congestion with the early message system. Overall time delay then depends upon the severity of congestion and time taken by user to reschedule his route.

4.2 Exponential Increase in Reliability

With increased input from various victim users around a particular area, the truthfulness and reliability of the shared messaged increases beyond the level of doubts.

4.3 Information Enhanced with Images

Uploading images along with congestion data acts as useful information. When another commuter sees them as geo tagged images of a certain location.

4.4 Categorization of Congestion

Provided the congestion information on a particular day becomes mature enough, one can get an idea of the level of congestion. This way, users can not only know that there is congestion ahead, but they can also estimate whether it is low, high or moderate congestion. Greater the input from victim users better be the estimate.

4.5 Resource Efficiency

According to different levels of congestion, one can plan to save less or more time. For instance, more time is saved in the case of severe congestion if the alternate route is followed.

4.6 Different Levels of Congestion

The aforementioned congestion levels and their corresponding results depend on the following factors:

4.6.1 Severe Congestion

Congestion is considered severe if at a certain point in a route, the number of messages received is greater than 5 and geo tagged images indicate destructions like flood etc. In this case there is a chance to save more time than the average.

Table 1. Time saving in severs congestion

Users	Congestion average time (Minutes)	Average saved time
10	45	30
7	35	24

4.6.2 Lesser Congestion

This type can be seen mostly in Pakistan with congestion duration of 30 minutes to 2 hours. In this case, severity of congestion decrease as time passes. Consequently, a user can save time of 30 minutes to 1 hour, depending on the nature of congestion.

Table 2 Time saving in lesser congestion

Users	Congestion average time (Minutes)	Average saved time
22	30	23
13	21	16

4.6.3 False Congestion

In cases when a user receives only one message about congestion at a point, it is considered as no congestion. If the message is not fresh enough, it might be deleted (as per working algorithm of the app) and the user be directed to carry on with his current path.

Table 3 Time saving in false congestion

Users	Congestion average time (Minutes)	Average saved time
40	10	7
27	6	4

5. CONCLUSION & FUTURE WORK

This paper presents an early alert traffic congestion/blockage system based on social messages on smart phone using android operating system. Wide dissemination of this application enables users (commuters) mutually share information about road blocks in real time and hence have a chance to save time and energy. This application can be used for live sharing of road events through videos and pictures at various locations on the map. In future, it is intend to extend this application to information sharing about events other than that of congestion, for example natural disasters and law and order situations.

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