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Design and Implementation of an RFID-Based Intelligent Transportation System (ITS) using IoT and Data Analytics

Palvi Soni[1], Gajendra Tandan[2]

[1]*Assistant Professor, Depart ment of CS & IT, Kalinga University, Raipur, India.*

[2]*Research Scholar, Department of CS & IT, Kalinga University, Raipur, India.*

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Abstract

The creation of fine-grained vehicle traffic data for an entire city or a wider area is mostly dependent on an Intelligent Transportation System (ITS). A road network's traffic flow is optimised using real-time traffic data. However, developing nations like India have limited ITS infrastructure because to the costly expense of sending and support, making it trying to create continuous traffic data on a wide scale. Therefore, an affordable ITS solution is required. In India, a significant portion of the road network is covered by the extensive cellular network deployment. However, cellular network-based positioning data is not appropriate for estimating edge level transit time or speed due to its substantial location inaccuracy (250-500 meters). The growing number of smart phone users and GPS-enabled cars makes GPS probe data a desirable source for estimating travel speeds in real time. However, it is unsuitable for developing nations like India due to its limited penetration and the fact that only certain types of vehicles—cars and buses—have GPS. About three-quarters of all vehicles on Indian arterial roadways are two-wheelers. In this work, we investigate the issue of producing cost-effective real-time traffic information. Numerous proposals that are tested under different traffic situations and make use of one or more alternative sources of traffic information have been published in the literature. The majority of these solutions either employ information from different sources, either regardless of combination, or they utilize cell network information alone, which brings about a significant mistake in the produced rush hour gridlock data. In order to produce precise traffic statistics, this dissertation proposes a novel method of combining data from restricted ITS infrastructure, GPS probe data, and broadly accessible cellular network data.

Author's e-mail: ku.palvisoni@kalingauniversity.ac.in, gajendra.tandan@kalinga-university.ac.in

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Introduction

Interest for street transportation, and modified methods of transportation (vehicles and bikes), specifically, has increased as a result of persistent economic expansion, rising urbanisation, and rising disposable income.[1] At a growth rate of 9.9%, there were 141.8 million registered motor vehicles in 2011, up from 55 million in 2001. However, over the same time period, the country's road network has grown at a rate of 3.4%. In other words, throughout that time, the number of vehicles has increased three times faster than the road network. Even though India's road network density (1.42 km/square kilometre) is favourable when compared to many other nations, the country's road network expansion was unable to keep up with the rapidly increasing number of vehicles. Time, gasoline, and money are all greatly wasted due to congestion. In America's 439 urban areas, congestion is a major issue, according to the 2011 Urban Mobility Report.[11] Due to congestion in these locations, 1.9 billion gallons of gasoline were wasted in 2011. This led to a delay and fuel cost of $101 billion. In 1982, the average commuter paid $301; in 2010, that amount was $713, adjusted for inflation. To increase the effectiveness and safety of surface transportation, an Intelligent Transportation System (ITS) makes use of information technology, electronics, and communication.

The following traffic parameters are of interest: speed, congestion, space occupancy, and vehicle flow. The quantity of cars moving through an edge in a certain amount of time is known as vehicle flow. It is a gauge of a road network's edge's service rate. A directed roadway that connects two intersections is called an edge in a road network. The proportion of the quantity of vehicles on an edge to the quantity of jams on the edge is known as the edge's space inhabitance at a specific second. The best number of vehicles that can be obliged on an edge is known as the jam count. It is corresponded with the length of the edge and the quantity of paths.[17] The expressions "space inhabitance" and "inhabitance" are utilized reciprocally all through the rest of the proposition. Blockage is a measure of how agreeable drivers are on an organization of streets. It is depicted as how vehicles cooperate to make it more hard for each other to move. As the interest for street space arrives at limit, these communications and their effect on the singular travel become more huge. Traffic sensors (like circle finders, traffic cameras, and so on), correspondence and calculation foundation for handling crude information from individual traffic sensors to deliver accumulated traffic data, and traffic signal, (for example, dynamic message signs, versatile traffic signal control, and so on) make up the ITS framework. The expense of conveying and keeping up with ITS foundation for various undertakings is definite in the U.S. Branch of Transportation's ITS Report.[4] Shut Circuit TV (CCTV) costs $50,000 per camera site, as indicated by the exploration. At the point when equipment and programming organization and upkeep costs are considered, the expected yearly expense of the Coordinated Hall The executives framework for the I-880 Passage in San Francisco, California, is $7.5 million.[8] Alternative alternatives are being investigated as a result of the high expense of installing and maintaining traffic sensors. Globally, cellular networks are a commonly used communication infrastructure.

Related Wmork

In order to produce traffic information, Vodafone's Traffic Online[12] examined signalling data on the An and Abis interfaces. Without identifying the techniques or algorithms employed in signal processing, they assert that they produce high-quality traffic information. The authors use sparse cellular handover data to calculate edge level speed and cell residency time.[6] They suggest the LinChangHuangfu (LCH) scheme and assess how well it works for estimating speed on Taiwan's National Highway 3. Street section separating (utilizing area region data) and verifiable vehicle follows are utilized to speed up assessment's precision. To estimate speed, the cellular data from a fifteen-minute period is combined. The mean difference between the loop detector data and the cellular-based speed estimation, after bias is

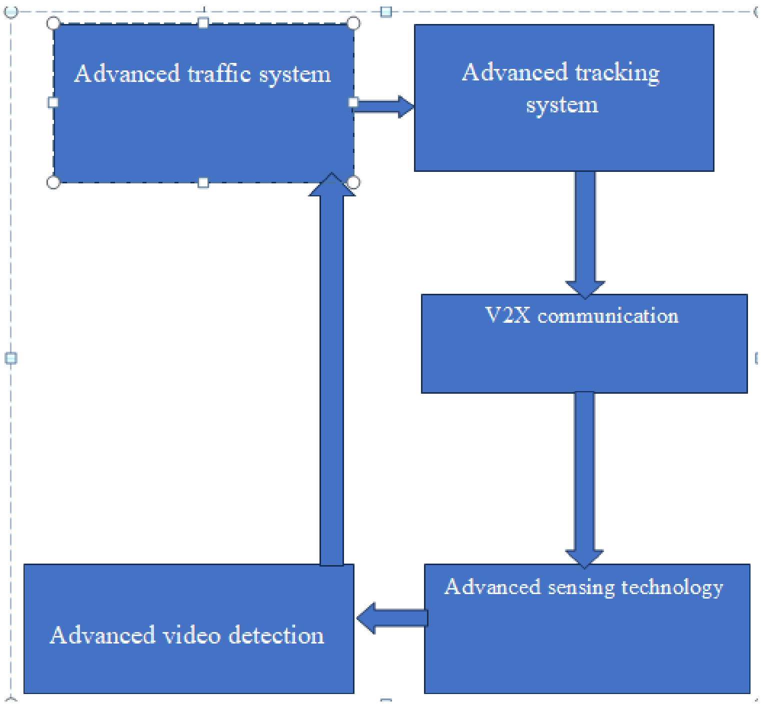


Figure 1: Benefits of RFID

eliminated, is 7.51%. In,[15] non-realtime traffic state information is generated from cellular handover data. According to the study, there is a relationship between the number of handovers in a given cell and the volume of traffic on a road segment (a claimed correlation coefficient of 0.76). The artificial neural network (ANN) and multinomial logit are used in the solution to relate the handover's scanty data to the traffic situation on arterial roadways. Five Lisbon, Portugal, case study sites are used to assess the effectiveness of the suggested methodology. The traffic state estimation achieves 78.1% accuracy. In,[13] note that the number of cars passing a cell boundary or location area border can be determined by counting the number of handovers (taking into account the level of clients settling on a decision at a given time) in the event that the limit is precisely known. On the off chance that the cell is sectored and the cell limit or area limit guides to an unmistakable street segment, this can be used as an enlistment circle identifier to count the quantity of vehicles navigating it.[2] The paper's reason, that the area region or cell limit is precisely known and relates to an unmistakable street segment, is ridiculously doubtful. The impact of area accuracy, recurrence of area estimations, and number of areas observed on the formation of traffic data using cell networks was evaluated by Cayford et al. at the Organization of Transportation Studies, Berkeley.

The utilization of GPS test vehicles to produce traffic measurements on a motorway was displayed in the Portable Century field explore.[9] More than a ten-mile street portion on the I-880 road, near Association City, California, 100 GPS test vehicles were utilized to gather information for eight hours. As per the information examination, during a five-minute total period, at least one speed perusing for each going across point out and about length requires a 2-3% infiltration of GPS tests. Because of predisposition in the information from one or the other source, it was seen that the speed information got from circle identifiers and GPS tests didn't agree at a couple of spots. The effect of the amount of GPS test tests nervous level speed assessment is analyzed by Zhao et al. The authors utilise GPS probe data to estimate traffic information using the Curve-Fitting Estimation Model (CFEM).

The usefulness of the obtained traffic information and the viability of large-scale implementation are also assessed for the suggested ITS. As a result, a distributed processing framework based on MapReduce is created for the suggested ITS. To determine whether large-scale deployment is feasible, the framework's compute, communication, and storage requirements are examined. The proposed ITS generates real-time traffic data that is used to create an Advanced Traveler Information System (ATIS). Based on the traffic conditions on a road network in real time, the ATIS recommends changes to end users' travel routes and en route. According to the simulation results, the road network's average trip time and congestion have considerably improved.

Overview of proposed Framework

The entire street organization's edge level traffic information, including vehicle stream, blockage, and speed, is delivered progressively by a multi-modular Smart Transportation Framework (ITS).[7] The two models — Edge Inclusion MOdel (ECOMO) and Congension Inclusion MOdel (COCOMO) — are intended for assessing edge level speed and conveying ITS foundation. The nature of the produced traffic data (mistake in assessing traffic boundaries) and the accessibility of traffic data (spatiotemporal inclusion) are utilized to evaluate the viability of the recommended ITS. Furthermore, by making a disseminated registering system and looking at the handling, correspondence, and capacity needs, the feasibility of ITS huge scope sending is laid out.[4] Traffic applications can use the organization wide ongoing traffic data for various reasons. For example, a High level Voyager Data Framework (ATIS) helps suburbanites with movement arranging by utilizing ongoing traffic information. To implement speed limitations, path control, versatile traffic light control, or to give re-routes to stay away from obstructed regions in a street organization, a High level Traffic The board Framework (ATMS) utilizes traffic information. Ongoing traffic information is utilized by the High level Public Transportation Framework (APTS) to design transport courses and estimate when public transportation transports will show up at different areas.[10]

We utilize the continuous speed gauges delivered by the proposed models (ECOMO or COCOMO) to make an ATIS.[14] Constant assessment of edge level traffic measurements, for example, vehicle stream, space inhabitance, clog level, and speed, is made conceivable by the recommended models. In any case, the produced traffic data has the accompanying qualities: (I) it contains some misstep, and (ii) because of confined foundation sending, the traffic data probably won't be accessible for a negligible portion of edges or for specific levels of clog. While planning the application, the previously mentioned properties are considered. The application separates drivers into two gatherings: the people who are educated (canny vehicles) get traffic data refreshes consistently and alter their courses in light of the framework's suggestions, while the people who are not educated (non-shrewd vehicles) never get or handle traffic data refreshes and consistently take the most limited course. The program is not difficult to utilize and requires less handling power. It just purposes the current traffic circumstance of the street organization to compute and suggest backup ways to go; it makes no forecasts about how the traffic condition will change because of rerouting the educated suburbanites. Each vehicle picks the best course toward the beginning of its excursion and chooses to reroute when it is going to arrive at an intersection (going to complete the ongoing edge crossing). This clear technique works really since different vehicles go with rerouting choices at various times. Moreover, a vehicle possibly modifies its direction when there is a perceptible improvement in venture time, for example, a gth decrease. The recreations use gth = 0.05.

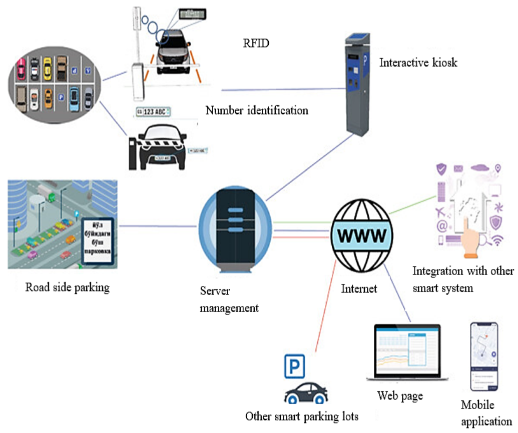


Fig. 2: Proposed flow

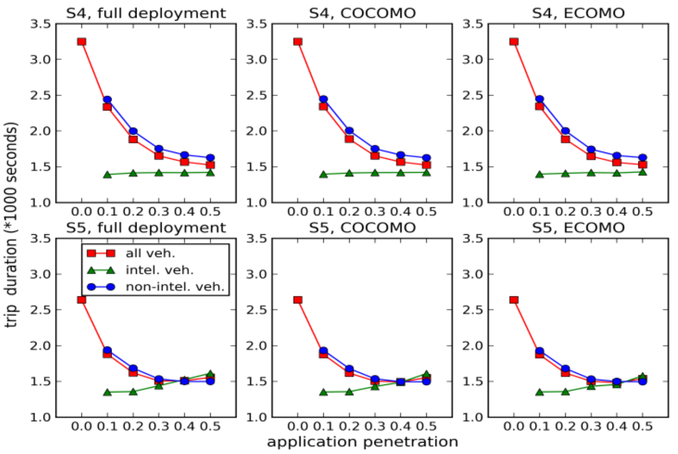
Intelligent Transportation System

The system is adaptable to a range of ITS infrastructure types since it makes no assumptions about the kind of infrastructure (any sensor that can estimate speed can be used, for example, a loop detector, a video camera, etc.). The model doesn't utilize constant GPS test information on account of the low infiltration of GPS tests and their position on specific vehicle types (vehicles and transports). Rather, for each edge in a street organization, the typical GPS test speed information is determined and put something aside for each degree of blockage. The speed assessment from foundation edges to infrastructureless edges is spatially extrapolated utilizing this technique. Notwithstanding the traffic boundaries (vehicle stream, space inhabitance, and blockage) evaluated utilizing cell network information, definite speed data is intermittently available on the edges with ITS hardware.[3] Polynomial relapse is utilized on framework edges to get familiar with the inhabitance speed relationship. The goal is to geologically extrapolate the inhabitance speed relationship found on the edges of the framework to the next street network edges. In any case, it has been noticed that different elements (aside from space inhabitance) impact a vehicle's speed when it is on an edge. For example, there is areas of strength for a between edge length and vehicle development speed. The vehicle moving rate on a more limited edge is more slow than on a more extended edge for similar space inhabitance values. We spatially extrapolate the inhabitance speed relationship from framework edges to infrastructureless edges utilizing verifiable GPS test information to represent or moderate the effect of these boundaries on speed assessment. As per the reenactment results, COCOMO and ECOMO can accomplish exact speed assessment with 90 percentile blunders of 10-22% and 10-13%, separately. The adequacy of the models for foundation organization is surveyed for adaptation to internal failure if a particular level of the framework is inaccessible as well with respect to restricted framework sending (to check the suitability of gradual arrangement). At the point when satisfactory framework isn't introduced or is inaccessible because of disappointment, the models take into consideration the elegant downfall of administration, as shown by the recreation results.

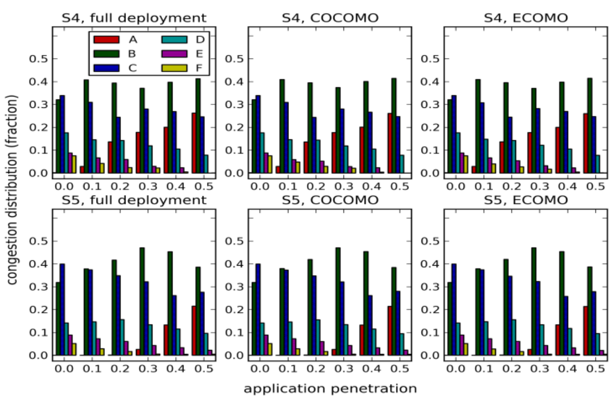
To address the absence of GPS test information, the COCOMO and ECOMO were acclimated to represent the effect of edge static elements, like edge length, number of paths, edge degree, and crossing point traffic signal presence.According to the simulation results, the changed models demand more infrastructure and produce speed estimates that are less accurate (ninety percentile error of 20–25%). There is a degree of error in the system's edge level speed estimates. Additionally, due to infrastructure availability issues, the estimates could not be available on particular edges or at some times. We created an Advanced Traveler Information System (ATIS) that suggests other routes to commuters while they are travelling based on the system's real-time traffic data. According to simulation data, the technology effectively lowers average trip times and traffic on the road system. Furthermore, ATIS's performance when using speed data from the suggested models is on par with that of the ITS system when fully deployed.

Experimental results

The effect of utilization entrance and speed assessment mistake on the normal excursion time and blockage circulation in a street network is evaluated through recreations. The measurements for the recommended models (ECOMO and COCOMO) and the whole sending model are differentiated. The street organization's all's edges approach exact speed forecast thanks to the ITS framework in the total sending situation. Figure 3a showcases the effect of utilization infiltration on the normal excursion span of all vehicles for the whole sending model, COCOMO, and ECOMO, as well as canny vehicles and non-insightful vehicles (ignorant workers). The effect of use entrance on the conveyance of traffic in the street network is portrayed in Figure 3b for every situation.



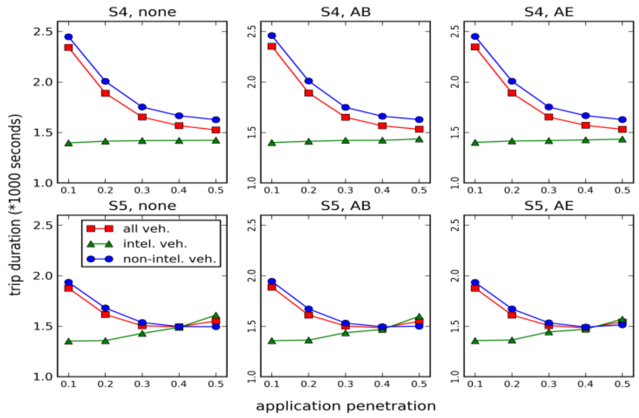
(a)



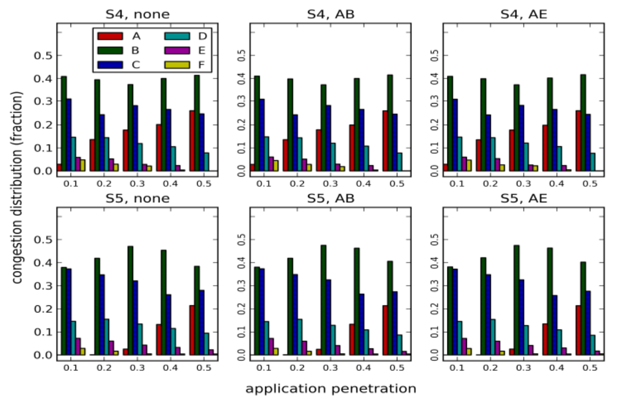
(b)

Fig. 3: Effect of Application Penetration

The effect of COCOMO (not covered clog levels) on venture length and blockage level appropriation in situations S4 and S5 is portrayed in Figure 4. The outcomes are similar to the situation when full inclusion is given, and it is found that the non-inclusion of blockage level(s) affects trip time (Figure 4a) and clog circulation (Figure 4b). At the point when a clog level isn't covered, ongoing pace information for each example of the blockage level in a street network is inaccessible. As recently expressed, the important verifiable GPS test speed information is utilized in every one of these circumstances. The GPS test speed considers the effect of the ongoing measure of traffic on vehicle development speed, despite the fact that it's anything but a solid sign of all vehicle speeds on an edge. The utilization of GPS test speed on a couple of edges meaningfully affects the calculation of the complete outing span since constant speed data is accommodated all covered blockage levels. Thus, a sensibly precise outing length computation is accessible for rerouting choices, even with few uncovered blockage levels. At the point when continuous speed assessment isn't free, past GPS test speed information matched with the ongoing clog level makes a fair reinforcement.



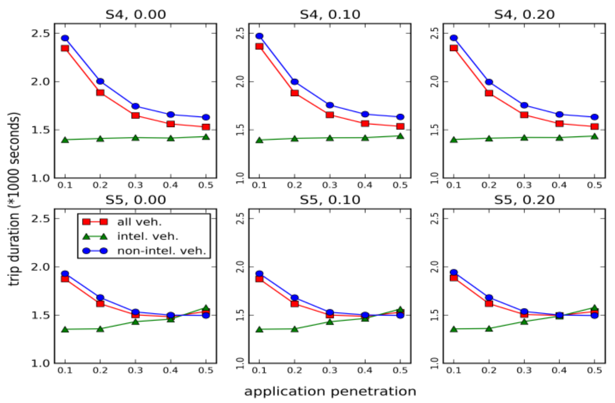
(a) Effect on Trip Duration



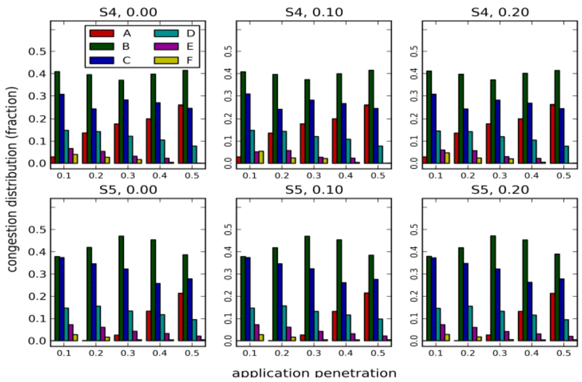
(b) Effect on Congestion Distribution

Fig. 4: COCOMO: Effect of Not Covered Congestion Levels (subplot title specifies scenario and not covered congestion level(s)

An extra finding from reenactment follows is that, while looking at the excursion length of various courses for an outing, each with a couple of edges that notice a degree of clog that isn't covered, the subsequent way determination is ordinarily equivalent to when continuous traffic data is free for all degrees of blockage.[16] The effect of not-covered edges (ECOMO) on movement time and traffic conveyance in situations S4 and S5 is portrayed in Figure 5. In situations S4 and S5, the level of revealed edges is changed by 0.10 additions, from 0.00 to 0.20. The outcomes are like the situation when complete inclusion is free, and it is shown that the shortfall of edge inclusion affects trip time (Figure 5a) and clog dissemination (Figure 5b). Continuous speed gauges for an edge are inaccessible when it isn't covered by framework edges.



(a) Effect on Trip Duration



(b) Effect on Congestion Distribution

Figure 5: ECOMO: Effect of Not Covered Edges (subplot title specifies scenario and fraction of not covered edges

As recently expressed, the verifiable GPS test speed information connected to the edge's ongoing clog level is used in these circumstances. The utilization of GPS test speed on few edges significantly affects the estimation of the complete outing length since continuous speed data is accessible for all covered edges. Therefore, a sensibly exact excursion length computation is accessible for rerouting choices even with few revealed edges. Furthermore, reproduction follows show that when the excursion spans of various courses for an excursion are looked at, with each course having a couple of uncovered edges, the subsequent way determination is regularly equivalent to when ongoing traffic data is accommodated each edge.

Conclusion

A ATIS that utilizes continuous traffic information for versatile vehicle directing and trip arranging is made to evaluate the value of the gave traffic information. Recreations are utilized to survey what application reception means for traffic conditions (normal vehicle trip time and clog conveyance) in a street organization. The discoveries of the reenactment exhibit that traffic conditions significantly work on even with a little level of educated suburbanites. Moreover, the application's presentation while involving the recommended models for speed assessment is comparable to that of when the ITS framework is completely sent. A street organization's outing time and clog dispersion are surveyed when traffic data for a negligible portion of edges (ECOMO) or a bunch of blockage levels (COCOMO) is inaccessible. The program can endure the absence of constant speed data, as per recreation results, and further develops trip term and clog conveyance, the two of which are practically identical to the situation where all blockage levels or edges are covered. At the point when continuous speed assessment is inaccessible, the previous GPS test speed information and the ongoing clog level are essential.

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