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An Approach towards Reliable and Cost Effective Dynamic City level Traffic Mangement using RFID-Sensors for developing and populated countries like INDIA

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Abstract— Traffic congestion is a major problem in many cities of India along with other developing countries across the globe. Inefficiency of signals and a plethora of vehicles plying on the road has led to traffic congestion, which is a grave situation. One of the major problems with Indian cities is that the existing infrastructure cannot be scaled, and thus the only option available is better application of traffic management, along with better traffic sense. Traffic congestion has negative impacts on a country's ailing economy, the environment and the overall quality of life. Hence it's time to effectively manage these problems. There are various methods available for traffic management such as video data analysis, infrared sensors, inductive loop detection, wireless sensor network, etc. All these methods are effective methods of smart traffic management, and have proven to improve the concerns that have affected the country. On the other end the problem with these systems are installation time, the cost of installation and its high maintenance cost. The following paper introduces an optimized solution which uses Radio Frequency Identification (RFID), which can be coupled with the existing signaling system that can act as a key to smart traffic management in real time. This methodology provides a well-defined solution which is cost and time efficient. This will require less time for installation with lesser costs as compared to other methods of traffic congestion management. Use of this new methodology will lead to reduced traffic congestion, Bottlenecks will be detected early and hence early preventive measures can be taken thus saving time and money. The methodology is researched in depth and proves to curb this persistent problem in India and other countries like India.

Index Terms— RFID, Traffic congestion, Dynamic Signaling, Infrared Sensors, Dynamic traffic Analysis, Traffic Video Analysis, Smart signaling.

1 Introduction

Traffic congestion and Bottlenecks are visuals seen daily on road networks which depict vehicles with slower speeds, increased trip time and increased queuing of the vehicles on a particular direction of the lane. When the number of vehicles exceeds the capacity of the road, traffic congestion occurs. In metropolitan cities of India and developing countries elsewhere traffic congestion is a major problem, Traffic congestion occurs when the demand exceeds the current road capacity. This is known as saturation. Individual incidents such as accidents or sudden braking of a car in a smooth flow of heavy traffic have rippling effects which in-turn cause's traffic jams a common citation in India. There are even severe security problems in traffic system's due to anti-social elements which also leads to stagnation of traffic at one place. In country like India, there is an approximate annual loss of Rs 60,000 crores due to poor traffic management (including fuel wastage)[3]. Congestion in India has also led to slower speeds of freight vehicles, and increased waiting time at checkpoints and toll plazas, frequent honking has resulted to numerous instances of Nerve damage. The average speed of Transport vehicles on key corridors like Mumbai-Chennai, Delhi-Chennai is less than 20kmph, while it is mere 21.35kmph on the Delhi-Mumbai stretch. As per the transport corporation of India and IIM, India's freight volume is increasing annually at a rate of, 9.08% and that of vehicles at 10.76%, but that of road is merely by 4.01%. This has resulted in reduced road space in accordance with the number of total vehicles .The average fuel mileage in India is only 3.96kmpl. The major reason for which is wide spread traffic congestion. India is the 2nd most populated country after China in Asia, thus with increase in population, the number of vehicles has also increased. The economic growth has certainly had an impact on urban traffic. As the income rises, more and more people begin to go for cars rather than two wheelers. Hence there is a need to manage traffic in a smart way as the management of traffic with the conventional way such as the signaling system is not having a major effect in curbing congestion of vehicular traffic.

2 Existing Methodology

2.1 Inductive Loop Detection

Inductive loop detection works on the principle that one or more turns of insulated wire are placed in a shallow cutout in the roadway, a lead wire runs from roadside pull box to the controller and to the electronic unit located in the controller cabinet. When a vehicle passes over the loop or stops right on the top of its loop, the induction of the wire is changed. Due to change in induction, there is change in the frequency. This change in the frequency causes the electronic unit to send a signal to the controller; indicating presence of the vehicle .Inductive loop detection is useful in knowing the vehicle presence, passage, occupancy and even the number of vehicles passing through a particular area.

Problems associated: There are a few problems with this system:

- Poor reliability due to improper connections made in the pull boxes.
- Poor reliability due to application of sealant over the cutout of the road.
- This system is ineffective where digging of the roads is frequent and then the problem of reliability is aggravated.

Conclusion: Though used extensively it's unfit for Indian road conditions. Hence results are minimal.

2.2 Video Analysis

Video analysis consists of a smart cameras placed on the cross road junctions which consists of sensors, a processing unit and a communication unit. The traffic is continuously monitored using a smart camera. The

video captured is then compressed so as to reduce the transmission bandwidth. The video analysis abstracts scene description from the raw video data. This description is then used to compute traffic statistics. This
Statistic includes frequency of the vehicles, average speed of the vehicles as well as the lane occupancy.

Problems associated:

- The overall cost of the system is quite high
- The system gets affected in case of heavy fog or rains
- Night time surveillance requires proper street lighting.

Conclusion: Currently employed by the Indian Government, its functionality can be mimicked while employing the proposed RFID methodology along with multiple features.

2.3 Infrared Sensors

Infrared sensors are used to detect energy emitted from vehicles, road surfaces and other objects. The energy captured by these infrared sensors is focused onto an infrared sensitive material using an optical system which then converts the energy into an electrical signal. These signals are mounted overhead to view the traffic. Infrared sensors are used for signal control detection of pedestrians in crosswalks and transmission of traffic information.

Problems associated:

- The disadvantages of infrared sensors are that the operation of the system is affected due to fog
- Installation and maintenance of the system is tedious.

Conclusion: India is affected with "Smog "a denser version of fog. Hence this method is rendered inefficient.

3 Proposed Methodology

RFID Controller:

The RFID controller consists of RFID interrogator. This interrogator is used for the communication with the RFID tag. Messaging interference is used to send commands and data messages from the controller components. Controller core is present inside the RFID controller. The controller core listens to the interrogators and depending upon the configuration; the controller core can perform read/write operations upon the RFID tag or can do both listening and performing operations. The RFID controller can have serial interface through which external GSM/GPRS devices can be interfaced with it to make a dual radio device.

RFID Tag:

RFID tags are wireless devices which make use of radio frequency electromagnetic fields to transfer data, which is used for identifying and tracking of the objects. RFID tags are of two types: Active and Passive. Active RFID has a battery installed, while the passive RFID doesn't have one. We are using the Areoscout RFID tag which is a Passive tag.

Passive RFID has to depend on external source for working. Tags information can be stored in a non-volatile memory. Tag consists of a Radio Frequency transmitter and receiver. Each tag can be assigned a unique serial number.

4 RELEVANT ALGORITHM

Input:

Max_red denotes the maximum time for which the signal can be red.
Max_green denotes the maximum time for which the signal can be green.
Min_freq_count denotes the minimum frequency of vehicles passing per second stored statically in controllers.
Act_freq_count denotes the actual frequency of the vehicles passing per second = ∑vehicles/second.

Algorithm:

S-1] when the signal turns green and
While (Timer<Max_green and Timer is not 0)

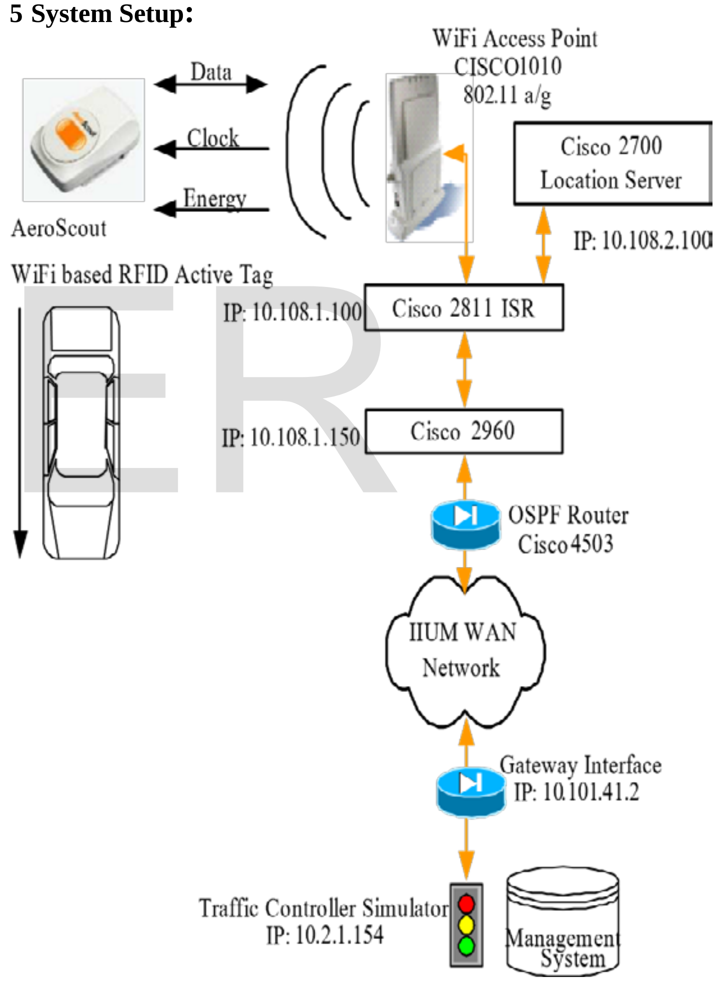
Do

If (Act_freq_count>Min_freq_count)

Keep the signal green. Decrement timer count by 1.
Else if (Act_freq_count<=Min_freq_count) Goto 2.

S-2] Make the signal red. Turn the adjacent signal green. Goto 1.
S-3] End

5 System Setup:



5.1 Key Components:

1- OSPF router
Network packet filter which sends desired packets to a particular source
2- Areo scout RFID
RFID tags embedded on Vehicles to identify them uniquely.
3- WAN network
Wide area network used to take this model to a city level model.
4- Management System
The key component of our System model which allows us to use this highly indigenous solution to provide man made solutions by collecting information from all RFID controllers from wide range

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of Controllers in the city.

6 System Overview

Each vehicle will be installed with a RFID tag. This RFID tag would store all the information regarding the vehicle such as the vehicle number, chassis Number, owner identity, etc. RFID tags can be used in identifying Vehicle uniquely and also helps the driver to receive useful traffic congestion updates which will definitely help the driver to adapt with the chaos ahead.

The existing signaling system can be coupled with the RFID controller. As described in figure 1, each signal can have the information regarding every vehicle that passes by it. Thus when a vehicle passes by a signal, the signal can automatically keep the count of the vehicles passing by it, and help in detection of traffic congestion. Each signal should be stored with a threshold value for which it should be red and green. Now depending upon the frequency of the vehicles passing by the signal per second, the timer can be dynamically controlled. Each controller of the signal should be stored with a value of minimum frequency of the vehicles passing by the signal

6.1 Working Principle of the Flowchart via a Diagram:

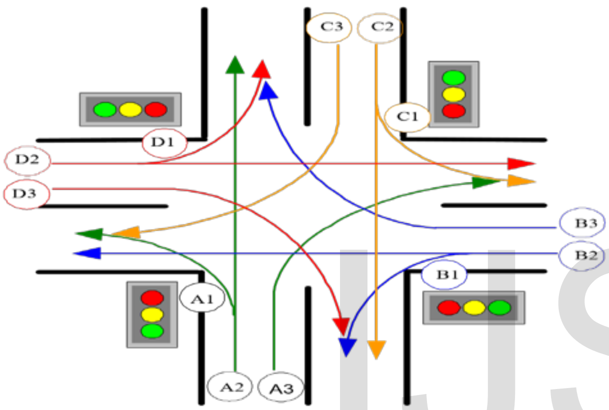


Fig 2. Signaling with RFID and Traffic management.

The above Diagram wodrks on the Simulation based on the Research methodology adopted by the University of New York, The simulation is based and works on 2 basic principles.

1- All Vehicles follow Lane Discipline.
2- Traffic norms and Lane cutting to be minimal.

The Working experimental setup was based on the similar model presented above in our research analysis. The results were astonishingly high as they scored a 96% accuracy. The model allows the System Data admin to view the overall functioning of a particular junction so as to provide solutions to the changing demand of the Traffic trends, the System DBA has the authority to change the course of the desired route numbered from A1-D3, the RFID tags work on Radio frequency which allow the System DBA to provide the various drawable solutions according to the adaptive changes prescribed by collectors present over the wide area network one such naïve and innovative concept to take this over a particular Junction to a whole city level approach we together with our mentor have designed this structure of a city based planning model which is well explained in our later diagram here.

6.2 City level adaptive Functioning Diagram:

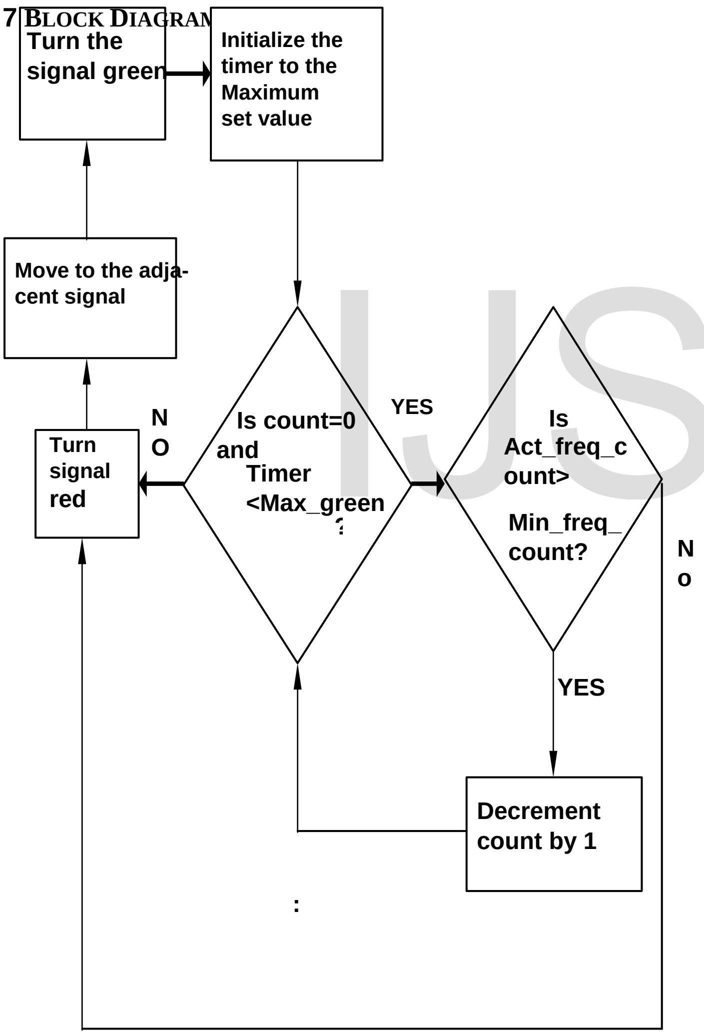
Fig.3 City level adaption of Fig.2

6.3 City Level Working

Effective congestion management and Smart Signaling is coupled to achieve city level working for this setup. The following is the detailed analysis.

Once when the minimum frequency is reached, the controller shall send a command to the signal to turn red. This allows the signal to operate dynamically. For example, suppose for a signal, maximum time for which a signal can be red is set to be 30 seconds and maximum time for which the signal can be green is set as 20 seconds, the controller is stored with the value of minimum frequency of vehicles passing by it per second as 5. Now once the signal turns green, the timer starts with a maximum value of 20. Initially the frequency of the vehicles passing the signal per second is 10, after 10 seconds this frequency reduces to 5, and then automatically the RFID controller sends a command to the signal to turn red [11]. Thus the signal turns red and its adjacent signal in that junction turns green. This process continues in a cycle. Thus dynamic controlling of the signal helps in reduced trip time. This also helps in avoiding traffic congestion as a priority is given to a high vehicular traffic road. This system helps in detection of traffic congestion. If the frequency of the vehicles passing the signal per second remains higher than the value even though the maximum value of the timer is reached, then the congestion has occurred at that point. Once the congestion has been detected, the RFID controller can send a message to its preceding signal's controller notifying it to temporarily stop traffic along that stretch. After receiving the message from its successor signal the RFID controller will put ON the red signal for that stretch towards that congested crossing point for a predefined time period. When the congestion is released at the crossing, the respective signal's controller will send another message to its earlier controller indicating to resume the traffic flow again in that direction. Accepting this message the controller of the preceding signal turns Green and restarts the signal cycle as before.

7 Block Diagram



7.1 Dynamic Algorithm Analysis

This algorithm for traffic control allows it to adapt changes dynamically to priorites and ensure easy implementation to facilitate the efficient traffic control at certain junctions. This also can be extended to multiple junction control. It is based on an automatic intelligent selection of traffic sequence in a multilane traffic flow. The multilane traffic flow is shown in (Fig.3).

Where A1, A2 and A3 represent vehicle moving from a direction where A1 is moving to the west, A2 is moving forward and A3 is moving to the east. The orientation is similarly applied to the vehicle moving from B, C and D direction.

Figure, shows an example of how the algorithm works. Assuming A, B, C and D are traffic column in which A from south can go forward, east or west, with timing slot that is dynamically determine according to the number of vehicle for each route. The same sequence is then shifted to B, C then D.

The decision process for the intelligent traffic control depends on the real time information as provided by the RFID system. The data is also recorded and saved in the centralized management database. A number of readers are deployed to detect and count the vehicle at each junction. The reader captures the time-in for each vehicle passing within its range. The practical arrangement and the location of the readers around the junction are shown in Fig. 4. The captured information such as location (ln) and time-in (tn) for each vehicle are saved as a tag reference table ID

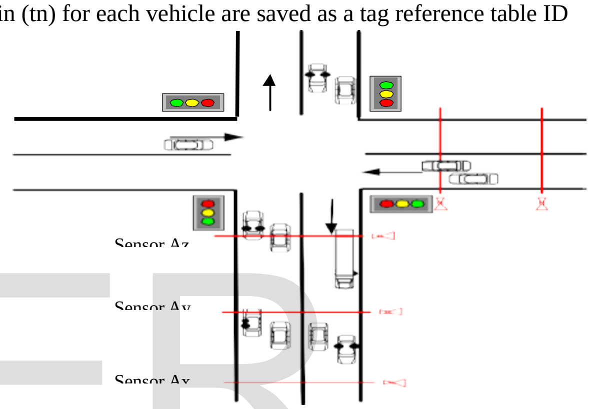


Fig.4. Algorithm's Digital functioning

Theoretically, the waiting time at each junction is

Same as defined in Table 1. This algorithm can change the sequence dynamically depending on the real time situation at the specific junction with respect to situations that currently exist in other junctions of the surrounding area. If, for example the accepted waiting time at each junction is 90 sec, the period for Green and Yellow states may probably be 30 sec at each junction.

In reality, the state of traffic condition and congestion change with time. Hence, the timing for a Yellow state can be fixed at 3 sec which is long enough for a driver to stop. The Green state at B represents as BG while Yellow state at B represents as BY and it is applicable to other parameter e.g., CG, DG, CY and DY. The waiting time for example can be computed for a state A as:

Await BG+CG+DG+AY+BY+CY+DY

Await BG+CG+DG+4(3s)

Await BG+CG+DG+12s

Where Await, Bwait, Cwait and Dwait are not equal.

Table 1: Waiting time at each state

State	Waiting time at each state
A	AY + BG + BY + CG + CY + DG + DY
B	BY + CG + CY + DG + DY + AG + AY
C	CY + DG + DY + AG + AY + BG + BY
D	DY + AG + AY + BG + BY + CG + CY

Table 2: Captured time-in

Vehicle	Sensor Ax	Sensor Ay	Sensor Az
Vehicle 1	Tx1	Ty1	Tz1
Vehicle 2	Tx2	Ty2	Tz2
Vehicle 3	Tx3	Ty3	Tz3

Vehicle 4	**Tx4**	**Ty4**	**Tz4**
…	**…**	**…**	**…**
Vehicle n	**txn**	**tyn**	**tzn**

Table 3: Collected vehicles speed databases
Database of the Speed of Moving Vehicles

AxAy	**AyAz**	**BxBy**	**ByBz**	**CxCy**	**CyCz**	**DxDy**	**DyDz**
v11	**v21**	**v11**	**v21**	**v11**	**v21**	**v11**	**v21**
v12	**v22**	**v12**	**v22**	**v12**	**v22**	**v12**	**v22**
v13	**v23**	**v13**	**v23**	**v13**	**v23**	**v13**	**v23**
…	**…**	**…**	**…**	**…**	**…**	**…**	**…**
v1P	**v2P**	**v1P**	**v2P**	**v1P**	**v2P**	**v1P**	**v2P**

V: Speed of the vehicles between two readers; l: Location of the RFID Reader; t: Time tagged the RFID tag at the particular reader; n: Number of reader; P: Total number of vehicles traveling between two readers

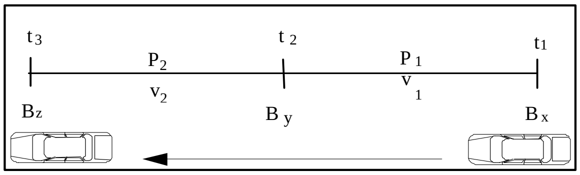


Fig. 5: Reader reading the passing through tag

The Green state timing of AG, BG, CG and DG at each junction can be different from each other because it depends on the congestion conditions and the queue length.
If no vehicles are detected at a particular state, then the sequence automatically proceeds to the next state. On the other hand if number of vehicle in a congested state along a queue is high, the system will check the condition of other junctions and then determine a compromising time for maximum efficiency in relieving the congestion. This will allow a reasonable balance for the overall waiting time.

The decision takes into account real-time data at surrounding junction as well as statistically compiled data for a specific time of the day and day of the week and may even consider whether the data coincide specific event. **[Figure 5]** shows that how the measurement process of time-in were collected when the vehicles entering the reading range of the reader located at Bx, By and Bz.

The raw data from the readers is accumulated in the centralized database and arranged in a database table as shown in [Table 2 and 3]. The database also records the average speed of all vehicles traveling between two readers within the area of the controlled zone. Hence accumulated speed average in the area before reaching the traffic light for all area before reaching the traffic light is calculated as:

$$v_1 = \frac{l_2 - l_1}{t \quad - t}$$

$$\langle v_1 \rangle_{collect} = \left\langle \left| v_i \right|_{i=1}^{i=P} \right\rangle_{collect}$$

$$(v_1)_{avg} = \frac{\left\langle \sum_{i=1}^{i=P} v_i \right\rangle_{collect}}{P_1}$$

$$\langle v_{avg} \rangle_{collect} = \frac{\langle (v_1)_{avg} + (v_2)_{avg} \rangle_{collect}}{2}$$

$$v_{avg} = \frac{\sum_{i=1}^{i=2} (v_i)_{avg}}{2}$$

The average speed and the estimated information are important parameter in determining the proper routing of the traffic utilizing the intelligent algorithm for the traffic flow system.
The average acceleration and average speed of a vehicle which is moving from standstill after the traffic light turns green can be computed.

8 Results and implemented observations

8.1 Model implementation:

The model has been implemented successfully for the system shown schematically in **[Fig.7]** However, this algorithm can manage more complicated traffic problems in a large scale deployment of the RFID network. The main requirement for the deployment of ubiquitous RFID network is that every vehicle must carry a tag. This requirement involves decisions and policies adopted by higher authorities to ensure that every vehicle complies with the RFID scheme.

The RFID system can be enabled by the ubiquitous sensors, which are made as part of the input devices in the traffic management application. Extending the interface capabilities of the sensor is straightforward, by an active tag. The tag is usually placed on the object to be identified or embedded in it.
The proposed tagged object can be a road tax sticker, driving license, a permit, plate number etc. Each tag has the detailed information of the vehicle such as type, weight, length, etc as in the centralized traffic management database. Instead of using AeroScout tag, another room of improvement is to use the RFID tag developed by Security Lab Inc. as shown in **[Table 5]** which may improve the performance.

The system can randomize the reply time so that it can query multiple tags simultaneously hence minimizing contention between their responses. RFID reader is located strategically in order to collect all the data from the vehicles tagged with RFID tag passing ugh its reading range. The collected information is then sent to a centralized database of the traffic management system. The centralized database will process the collected data in order to generate a feedback signal to manage the intelligent timing for the sensor-based.

Table 5: Specification of RFID tag for the proposed RFID based Traffic management system

Features	Security lab Inc. Specification
Transponder type	Active
Reading range	Up to 80m
Maximum object speed	
With guaranteed tag reading	Up to 180 kmh^{-1}
Frequency	434.5 MHz, 433.3 MHz
Life time battery	1 year
Radio emitted power	Less than+0 dBm

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8.2 Implemented Snippet of the Model

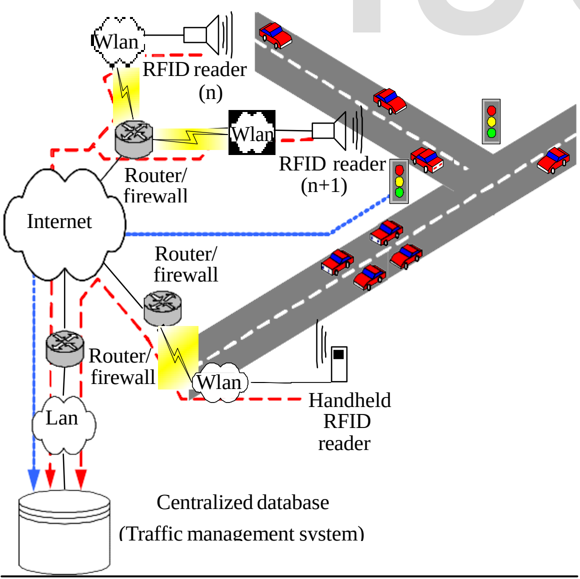

Fig.7: Schematic design of the ubiquitous RFID network for traffic light management.

Traffic light, as shown in Fig.7.The computed statistical data in the centralized database can be shared with other local authority databases through the secured structured network.
This model was tested in regard to the setup explained in the paper earlier and the results predicted were achieved [22].

9 Applications apart from core objective

9.1 Management of Trafic for City Planning

In addition to the earlier method of traffic congestion detection, one more method can be used. A server can be maintained which can receive certain crucial data calculated by the Controller of the signals. The main aim is to understand the amount of vehicles plying on the road and the raods which are hevily populated, whether the area is congested or uncongested are important to understand while developing plans for new road networks and city escalation. If sufficient data is collected to make changes for a particular part of the city area the Mayor can make necessary rules which can prove beneficial towards the people dwelling in that targeted area.

9.2 Automatic Detection of Speed limit Violation

We can use this technique to calculate the speed of a motorist and to detect if he/she violates the prescribed/set speed limit,
If the motorist violates the rule, a warning message will be sent to the motorist via audio and/or video interface and penalty will be calculated on the server and will be billed monthly to the vehicle owner.

9.3 Automatic Billing of Core Area / Toll Charges

Automatic toll collection and automatic ―core area charge‖ collections are also done using the same framework. Controller unit will be placed at toll-booth and along the motor able roads around the core area which will detect each individual vehicle uniquely within its zone by capturing their device ids and will keep records of the time during which the vehicle was seen by those Controllers within its reading zone. This information will be sent to a main server. Accordingly the main server will calculate the charges and raise bills against the vehicle ids.

10 CONCLUSION AND FUTURE WORK

The proposed work focuses on Smart Traffic management System using RFID which will eliminate the drawbacks of the existing system such as high implementation cost, dependency on the environmental conditions, etc. The proposed system aims at effective management of traffic congestion. It is also cost effective than the existing system.
The Following has been simulated and tested to produce efficient results as well as documented the same above.
Furthermore, the study presents the problems in metropolitan areas all over the world caused by congestions and the related sources. Congestions developed to a problem, which affects economies worldwide. Particularly metropolitan areas are worst hit under these conditions. Congestions have a negative impact on the financial situation of a country, on the environment and hence the overall quality of life. The proposed system can be enhanced by using any other powerful communication network other than GSM, alongside Rubee chip being the next big Blossom to the world of Communication, Rubee is known to append data both on-Chip and off-chip via Rubee readers like RFID tag readers. The Rubee chip is cost-effective and can be used in accordance with the RFID tag to cache user data alongside with smartly managing other useful RFID operations, unlike the RFID it doesn't possess long distance reading capability, it still allows partial range at a lower cost than half the RFID but the feature of broadcasting along with the wavelength of wifi and Radio frequencies.

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