e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:08/August -2020 Impact Factor- 5.354 www.irjmets.com

SMART TRAFFIC SYSTEM USING LOADCELLS AND IR SENSORS

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ABSTRACT

Optimizing vehicular traffic has been a challenge to both government and citizens since the number of vehicles is increasing day by day. Inappropriate timing of traffic signals is one of the major causes of traffic. We have proposed a system that can optimize the vehicular traffic by sensing the density of all the lanes and setting the timer based on them. The system uses IR sensors and load sensors to detect the density of all the lanes in a junction. The system also includes a special feature to clear the way for emergency service vehicles using RFID system. A GSM system is also included in this system to notify the authorities if there is any malfunctioning in the system.

Keywords: Traffic signal system, Arduino, load sensors, IR sensors, RFID, emergency service vehicles.

I. INTRODUCTION

Traffic signals are mainly developed to ensure proper flow of vehicular traffic to help vehicles and pedestrians cross a junction and to avoid accidents. The existing traffic systems have fixed timings and do not depend on real time traffic densities. Traffic signals operating on fixed signal timing delays cause difficulty in controlling the traffic congestions. There is a need to upgrade this system to solve various problems of traffic congestion. There is no facility in the existing system that can assist emergency service vehicles like ambulance, fire engine etc. Whenever these vehicles enter a junction, there would be a chaos which could lead to accidents and could cause more congestion, especially when these vehicles are entering the junction from multiple lanes.

We have proposed a simple, low-cost, and real time traffic signal system that aims to overcome many problems and thus optimizes the traffic system. The system is based on Arduino Mega that evaluates the traffic density using IR sensors and load sensors according to which the lanes are set with timers for green signal. It also has a remedy to the problems that occur due to entrance of emergency vehicles.

II. LITERATURE SURVEY

There has been a great usage of surveillance systems and video monitoring [1] for traffic control in recent years. Innovations have been made for examining the density of the traffic through image processing [4, 5]. But these techniques require good images whose quality is weather dependent, especially when it is raining or when there is a huge amount of fog. The image captured in the traffic signal is processed and converted into grayscale image, then its threshold is calculated based on which the contour has been drawn in order to calculate the number of vehicles present in the image [13]. But this cannot be used in real time applications as it is very slow and the software is usually not free of cost. Automatic detecting and counting vehicles in unsupervised video on highways is a very challenging problem in computer vision with important practical applications such as to monitor activities at traffic intersections for detecting congestions, and then predict the traffic which assists in regulating traffic [14]. Manually reviewing the large amount of data they generate is often impractical. There are various vehicle detectors such as radar, ultrasonic [2], and microwave detector. But these sensors are usually expensive, difficult to implement, have less capacity, and extra maintenance charges will be there. Radar sensors are affected by metal barriers near road. Passive acoustic detector array, Piezoelectric, Photoelectric, Inductive loop detector, magnetic detectors [11] and other similar sensors are some of the commonly used sensors in the field of traffic monitoring systems. These sensors are less accurate as well as expensive [3].

The system which we have proposed uses an Arduino MEGA interfaced with IR sensors [6, 8] and load sensors [9, 10]. For every lane, there are three IR sensors with three corresponding load sensors placed beside and under the road respectively for detection of traffic density of that lane. According to this, there are four modes of lighting transition slots [7]. The proposed system has a feature to clear the way for emergency service vehicles such as ambulance, fire fighting vehicles etc. An RFID tag will be mounted under every emergency service vehicle. The basic idea behind this feature is that the RFID tagged emergency service vehicle shall be detected whenever it passes on the RFID reader [12]. A GSM module [2] is included in the system to notify the authority if there is any malfunctioning in the system.

IRJMETS
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III. METHODOLOGY

a) Block Diagram:

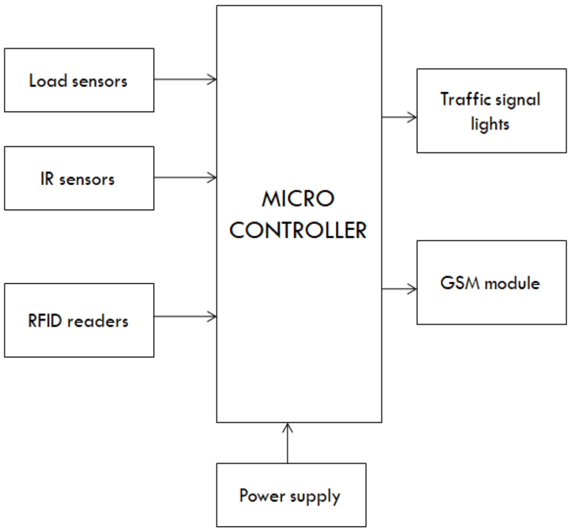

Figure-1: Block diagram of Density Based Traffic Signal System

Figure above shows the block diagram of density based traffic signal system. It has 2 major sensing systems for detection of density levels. They are Load sensors and IR sensors. Each lane consists of 3 such sensors and hence there are 3 levels of densities

The system uses an Arduino Mega 2560 that is based on ATmega 2560 microcontroller. This takes the inputs from the sensors and hence prioritizes the lanes accordingly. By this way it decides the glowing time of traffic signal lights of all the lanes. The system can either be powered up using External battery or adapter. It can also be powered up through USB.

The RFID readers detect the RFID tags of emergency service vehicles and provide these data to the microcontroller. Taking these data as input, the microcontroller assigns highest priority to the lane that has emergency service vehicle incoming.

The microcontroller keeps checking for any malfunctioning that can happen in the system. In case of any faults in the system, a notification will be sent to the authorities using the GSM module.

b) Working

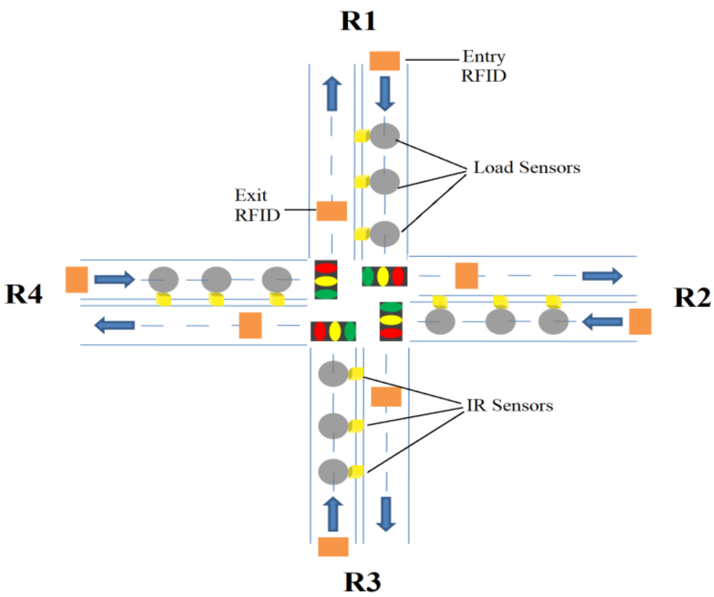

Figure-2: Working diagram of the Density Based Traffic Signal System

Figure-2 shows the Working diagram of the Density Based Traffic Signal System in a 4-way junction. It consists of 4 lanes R1, R2, R3 and R4 passing through a common junction. Every lane includes 3 load sensors and 3 IR sensors. These sensors detect the density of their corresponding lane.

Load sensors are generally used to measure the weight of any object that is placed on them. Here, the sensors measure the weight of the automobiles that would be standing on them. A minimum weight will be preset, above which the detected values will be taken as automobiles and thus a HIGH value will be considered by the Arduino. The sensor value will be considered as LOW if the value is below the minimum weight, assuming that the object is not a vehicle but some pedestrian or so. The HIGH value indicates that vehicles are standing upon this particular sensor. Similarly, IR sensors can detect any obstacle that is placed within their range. A maximum range will be preset; within which if it detects any obstacle, it considers that as vehicle and sends a HIGH signal to the Arduino. If there is no obstacle within the preset range, a LOW signal will be sent to the Arduino. Hence it can detect vehicles that are stationary in front of them. In this system, load sensors are the primary sensors and IR sensors are included just to assist the performance of the load sensors.

The system initially checks the density of lane R1and the density of this lane will be decided based on the values of the sensors in that particular lane. Every sensor's value will either be considered as HIGH or LOW. If all 3 sensors of this lane are HIGH, then the lane will be considered to have high density and the timer of green light for this lane will be set to a maximum value. If only first 2 sensors are HIGH, it will be considered as medium density and the timer will be set to mid-range value. If only the first sensor is HIGH and other 2 are LOW, it will be considered as Low density and the timer will be set with a lower value. If all 3 sensors are LOW, this lane will be considered as no traffic lane and hence the timer will be set with the minimum value. After the timeout, the system checks for the lane R2 and the operation is similar to the first lane. After R2, the system checks R3, then later R4 and again checks R1. Thus the cycle repeats continuously.

There are 8 RFID readers in this system, out of which 4 are used to check the entrance of emergency service vehicles and other 4 are used to detect their departure. The system keeps on checking the entrance RFIDs to detect emergency service vehicles' entry as this is more important compared to density check. Every emergency service vehicle will be provided with RFID tags and the Arduino will be provided with information of all the tags. Whenever the entrance RFID detects the emergency service vehicles, highest priority will be given to this lane and all other lanes' signal will go red regardless of their densities. As soon as the entrance RFID is detected, the exit RFID gets activated. This state is maintained until exit RFID is detected with same vehicle. Only after the departure of emergency service vehicle from the junction, the system continues to work based on the densities.

c) Flowchart

Figure-3 shows the flowchart of the Density Based Traffic Signal System. In the figure, R is the lane number from which emergency service vehicle is approaching the junction. Initially R is set to 0 and it stays in this state unless an emergency service vehicle is detected. R changes its state from 0 to 1, 2, 3 or 4 depending on which lane the emergency service vehicle is approaching the signal. When R is not equal to 0, that means the emergency service vehicle is approaching the junction. This particular lane's signal turns green and all other lanes' signal turns red, regardless of the densities of their lane. Only after the Emergency service vehicle leaves the junction, R becomes 0 and density checking system is executed.

Density check is executed only when R is 0, since checking for emergency service vehicles is more crucial than general density checking and management. Hence the system keeps on checking for the value of R. For density check, K is the lane number. Initially K is set to 1, checking the first lane. The density of the lane can either be high, medium, low or too low and the timer is set accordingly.

Table-1: Timer values to be set for different densities.

Sl. No.	Density	Timer value(T)
1	Very low	T= 5 seconds
2	Low	T= 30 seconds
3	Medium	T= 60 seconds
4	High	T= 120 seconds

The value of the timer is set as per the table above. When all 3 sensors are HIGH, that is for highest density, the timer value is set as 120 seconds (2 minutes). When first 2 sensors are HIGH, for medium density, timer value is set as 60 seconds (1 minute). When only the first sensor value is HIGH, for low density, timer is set as 30 seconds. When all 3 sensors are LOW, there is a possibility that some vehicles would be standing beyond where they are supposed to stand and sometimes, they could be standing on zebra crossing too. Hence the timer is set as 5 seconds in this case and is considered as too low density.

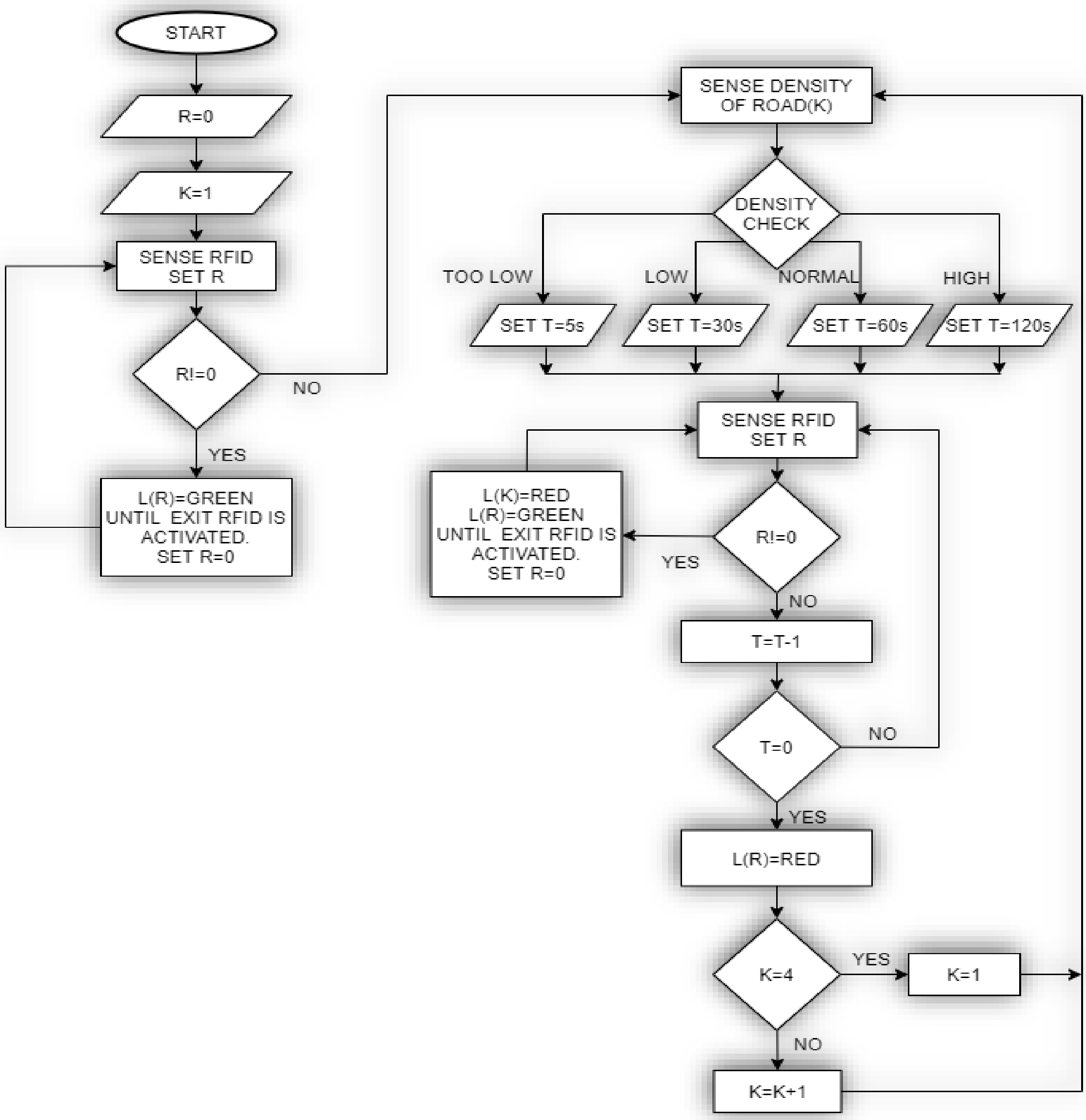

Figure-3: Flowchart of Density Based Traffic Signal System

As soon as the timer is set, the signal for this particular lane turns green and the timer starts decrementing by 1 second. The system checks for the value of R, that is it checks for any emergency service vehicles approaching towards the junction from any lane. If the R value is 0, that is no emergency service vehicle is approaching, it continues to countdown the timer. If R is anything other than 0, then this lane's signal is made red and the lane from which the emergency service vehicle is approaching is made green. Until this vehicle exits the junction, the density system will not be continued. As soon as this vehicle departs from the junction, the density system is continued from where it had been paused. The timer keeps decrementing every second and the value of R is monitored simultaneously. When the timer becomes 0, the signal of this lane turns red. After this, the value of K is incremented by 1. Thus next lane's density is checked and the operation is carried out as same as the first lane. After the timer becomes 0, the signal becomes red and K is incremented again. This process is continued until all 4 lanes are completed and K will be set to 1 again. Thus this cycle repeats continuously.

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IV. RESULTS AND DISCUSSION

a) Setting Timer Values According to Densities:

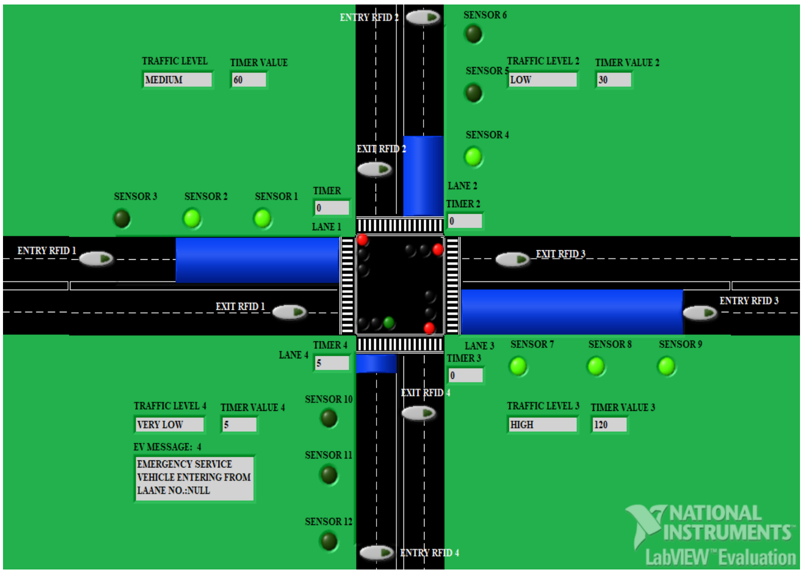
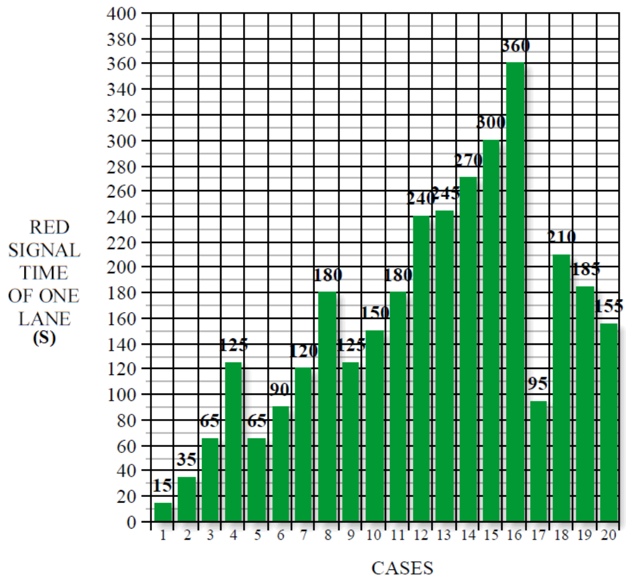


Figure-4: Working diagram showing different timer value set for different densities.

In figure-4, the timer values for different densities of traffic are shown. Lane 1 has level-2(medium) density; hence the timer value is set to 60 seconds. This means that when lane 1 is allowed, green signal would stay for 60 seconds and becomes red after that. Similarly, lane 2, lane 3 and lane 4 have level-1(low), level-3(high) and level-0(very low) densities respectively. TIMER, TIMER 2, TIMER 3 and TIMER 4 in figure, shows the countdown time of green signal of their particular lanes. In figue-4, we can see that all entry RFIDs are inactive, this means that no emergency service vehicles are entering the junction

b) Red Signal Time of One Lane for Different Densities of Other Lanes:

RED SIGNAL TIME OF ONE LANE FOR DIFFERENT CASES OF OTHER 3 LANES



CASE NO. (x-axis)	DESCRIPTION (Densities of other 3 lanes)	RED SIGNAL TIME(S) (y-axis)
1	All lanes very low	15
2	1 lane - low, 2 lanes- very low	35
3	1 lane - medium, 2 lanes- very low	65
4	1 lane - high, 2 lanes- very low	125
5	1 lane – very low, 2 lanes- low	65
6	All lanes low	90
7	1 lane - medium, 2 lanes- low	120
8	1 lane - high, 2 lanes- low	180
9	1 lane - very low, 2 lanes- medium	125
10	1 lane - low, 2 lanes- medium	150
11	All lanes medium	180
12	1 lane - high, 2 lanes- medium	240
13	1 lane - very low, 2 lanes- high	245
14	1 lane - low, 2 lanes- high	270
15	1 lane - medium, 2 lanes- high	300
16	All lanes high	360
17	1 lane - very low, 1 lane – low,1 lane-medium	95
18	1 lane – low,1 lane-medium, 1 lane – high	210
19	1 lane - very low, 1 lane – high,1 lane-medium	185
20	1 lane - very low, 1 lane – low,1 lane-high	155

Figure-5: Graph of red signal time of one lane versus cases of other three lanes and table of description of these cases.

Figure-5 shows the graph of waiting time (red signal time) of a lane with respect to the densities of all other 3 lanes. The cases are described with timing in the table. These data are true when there are no emergency service vehicles are entering the junction at this time. The minimum time of red signal is 15 seconds when all other three lanes are low. The maximum time of red signal when no emergency vehicles are entering the lane is 360 seconds. This takes place when the densities of all 3 lanes are high. This is shown as case 16 in the figure-5. These values of red signal time would change if any emergency service vehicles enter the junction. The amount of time between the entry time and the exit time of an emergency service vehicle is added to the red signal time.

In the existing traffic signal system, vehicles from one lane have to wait for a fixed amount of time. This is a major disadvantage in most of the cases. Assuming that the fixed time of green signal for a lane is 100 seconds, a lane which turned red has to wait for all three lanes to get completed. That is, it has to wait for 300 seconds even when there are no vehicles in all 3 lanes. This is not feasible. In our system, when all 3 lanes have no traffic, the lane which turned red has to wait for 15 seconds to turn back to green. This is shown as case 1 in figure-5. Comparing to the existing system, the wastage of time is reduced by 95%

c) Emergency Service Vehicle Entering from One of the Lanes:

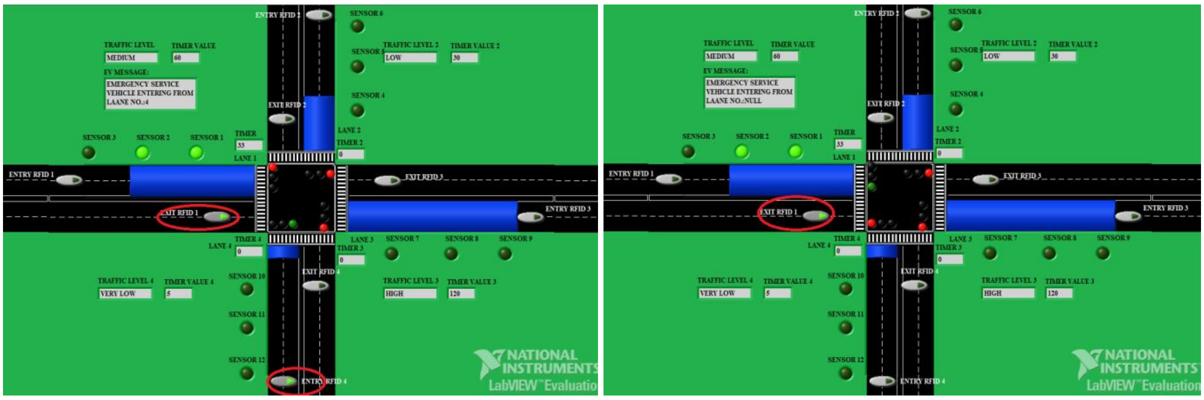
(a) (b)

Figure-5: (a) Entry of emergency service vehicle from lane 3 **(b)** Exit of emergency service vehicle through lane 2.

Figure-5 shows the entry and exit of an emergency service vehicle through a junction when lane 1 is under execution. When entry RFID 3 is detected, a message is displayed showing that the emergency service vehicle is entering from lane 3. Lane 1's signal turns red and its timer pauses. Lane 3's signal turns green and stays green until the vehicle leaves the junction. This is depicted in figure-5(a). Here, lane 1 was green and the timer value was set to 60 seconds. After 5 seconds, the lane 3's entry RFID is activated due to the entry of the emergency vehicle. Hence the timer is paused at 55 seconds. As soon as the vehicle leaves the junction, that is if any of the exit RFIDs is activated, then the lane 3 turns red, lane 1 turns green and the timer continues to countdown from 55 itself. This is depicted in figure-5(b).

d) Emergency Service Vehicles Entering from Multiple Lanes:

(a) (b)



(c) (d)

Figure-6: (a) Entry of emergency service vehicle from lanes 1, 2 & 3, **(b)** Emergency service vehicle from lane 1 leaving through lane 3, **(c)** Emergency service vehicle from lane 2 leaving through lane 1 and **(d)** Emergency service vehicle from lane 4 leaving through lane 1.

Figure-6 depicts the entrance of emergency service vehicles from multiple lanes at the same time. Figure-6(a) shows entrance of these vehicles from lane 1, 2 and 3 at the same time. A message is displayed indicating that the emergency service vehicles are entering the junction from lanes 1, 2 and 3. For this case, lane 1's timer is paused but the green signal stays until the vehicle from lane 1 is exited through any of the lanes. This vehicle is exiting through lane 3. This is indicated by the activation of exit RFID 3 as shown in figure-6(b) and the message indicates that the vehicles are entering through lanes 2 and 4. Now, lane 2 turns green and lane 1 turns red. Figure-6(c) sows the departure of the vehicle that entered from lane 2 through lane 1. Now, message indicates that the emergency service vehicle is entering from lane 4 and hence the lane 4 turns green with the lane 2's signal turning red. This vehicle leaves the junction through lane 1 as shown in figure-6(d). The message indicated that there are no incoming emergency service vehicles. Thus the lane 4 turns red and lane 1 turns back to green and the timer continues to countdown from where it had paused.

V. CONCLUSION

On implementation of density based traffic signal system in urban cities, wastage of time will be reduced effectively as the timer value of green signal is not fixed but varied based on the traffic densities. This system facilitates emergency service vehicles by allowing them to pass through a junction as soon as possible. This is one of the major advantages of the system. The system also resolves the problem of multiple entrances of emergency service vehicles from different lanes.

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