Autonomous Controllers for Urban Traffic Management

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***Abstract*—Modern computers have solved many complex and real time problems. These are also used to track and control vehicles in an efficient way. These types of systems not only reduce the manpower but also provide accurate results. In this paper, architecture of the autonomous and intelligent traffic system is presented. It controls the vehicle traffic on road and removes congestion. A microcontroller finds out current traffic density at the traffic signal and assigns opening time. Moreover, emergency vehicle is identified by using the Radio Frequency Identification (RFID) technology and managed on the priority basis.**

***Index Terms*—traffic, control, architecture, agent**

I. Introduction

The process in which vehicles are controlled and planned at the traffic signals is called as traffic management. Usually, it is performed to move vehicles on roads as well as traffic signals in an efficient way. The limited resources on roads which are available may also increase the traffic congestion. The traffic density depends on the specific time of the day, week and year.

Traffic monitoring authorities need to find out new methods and techniques to overcome the traffic problems such as construction of new roads, flyovers, increase in number of lanes; and development of sophisticated traffic detection, monitoring and control system. When traffic signals, sensors, sonic sensors [1] and controllers are used and managed intelligently then traffic run smoothly without any distortion. Traffic flow can be maintained by adopting the automation and smart control to the available infrastructure as well as vehicles.

Intelligent Traffic Signal Management and Control System is the software which is based on the traffic density. In this system, scheduling algorithm is used for controlling traffic on junction that has four roads. Generally, vehicles at the traffic signal can move in three directions (i.e. left, right and straight) [2].

Autonomic computing is used to solve many problems without any human environment [3]-[7] where autonomous components manage the vehicle traffic. Agent oriented system comprises of various agents that interact each other in order to provide solution of the given problem [8]. In conventional traffic control system, constant time is allotted to each side of the side that never changes according to the current traffic density or some special event. So, here fixed signal timing is allotted to each side of the signal. However, often higher traffic density at one side of the junction demands longer green time as compared to the standard allotted time and in the same way that side should be opened for less time from where traffic volume is less.

In the proposed system, a microcontroller is used with sensor to count number of vehicles and assign time accordingly. The allocated time of the signal changes with the change of traffic flow at the junction which is measured by the infrared (IR) sensors. Emergency vehicles are detected and managed through Radio Frequency Identification (RFID) tags that are mounted on each emergency vehicle.

The literature presented in this paper is organized as: Section I provides an overview of the conventional and proposed traffic architecture. Section II elaborate the literature review related to traffic control and management problem. Section III presents the suggested architecture through Unified Modeling Language (UML) diagrams. Section IV provides the overview of proposed solution to handle traffic at signal. Subsequently, section V summarizes research and set some future directions.

II. Related Work

Much of the research is carried out that provides algorithms, models and techniques to control the traffic. Shamshirband *et al.* [9] proposed a new cooperative learning method where agents calculate the expertness of other neighboring agents and allocate weights to these agents accordingly. The intelligent transport system is introduced in [10] where the wireless communication technology is adopted in a multi-agent system. It assists the drivers in order to take rapid decisions that occur due to the road emergency. This system provides the algorithm in order to handle the traffic signal with simulation results [11]. Mathematical functions are used to calculate the suitable timing and interval for the red, green and orange signal lights. The vehicles are sensed by the developed system within certain range by setting different time interval of the traffic signal.

The research [12] describes the traffic lights system through the UML diagram where State charts are modeled. The state charts are modeled for eight, six and two traffic lights. All the conditions and events are clear by showing the traffic light system in this way. The architecture is proposed to handle the emergency vehicle

Manuscript received January 15, 2019; revised June 20, 2019.

doi: 10.18178/jtle.7.2.47-52

[13] where RFID is used to calculate the traffic intensity and managed subsequently. Information about the stolen vehicles provided to the security agencies when RFID of any stolen vehicle is found exact location will be identified through GPS. The buzzer is used by emergency vehicle driver and signal will remain green until emergency vehicle exit from the signal. In another research, Digital Traffic Infrastructure Network [14] is used that consists of various traffic junctions each known as node. The proposed work calculates the path with least crowded path. However the proposed system is very expensive to implement for real traffic. System becomes very complex with wired or other network. Moreover, separate VA cannot be given to each and every vehicle. The concept of inductive loop was used in [15] where both ends of the wire are connected to a Monitor Unit (MU). Loop resonates at a constant frequency. The proposed system saves lots of time of each vehicle due to this automation and rescue vehicle can pass quickly, so a lot of time will save. This system fails when there is bad or rough weather. Another traffic management system is discussed in [16] where a communication system is used to guess the traffic congestion. However, it is very difficult to equip every vehicle with OBU. A multi-agent system with two modes is introduced in [17], [18]; initially agents of the system take training from other agents while later on they learn from their nearest agents by adopting an algorithm. In another system, rescue vehicles are passed on the priority basis without any delay. Two modules are discussed [19] in which transmitter and receiver are introduced. When any rescue vehicle is detected, the transmitter of the rescue vehicle sends the signal which is collected by the Receiver subsequently. Here, maximum range of these radio signals is only twenty five (25) meter and due to this there is chance of accidents. Traffic system in [20] takes input from the sensors such as number of vehicles, their average speed etc. But system is inefficient in somehow as all traffic signals must have synchronization. Research proposed in [21], [22], counting of vehicles is performed through Round Robin Scheduling approach. Our proposed traffic management approach is different from above discussed studies. We have used IR sensors to detect and count vehicles. Another difference is the dynamical allocation of signal cycle time (total time for all four sides). All vehicles are assigned time according to traffic density where average wait time of all vehicles is reduced.

III. Suggested Traffic Architecture

UML diagrams for the purposed traffic management and control architecture is described in following section:

A. State Chart Diagram

In Fig. 1, a signal has three (03) lights Red, Yellow and Green. At a time, only one light remains ON. Therefore, three are (03) states: Green light for (Go) state, Yellow light for (Ready) state and Red light for (Wait) state. Green light can switch to Green or Yellow; while Yellow light can switch to Red or Green, however Red light remains either Red or Yellow.

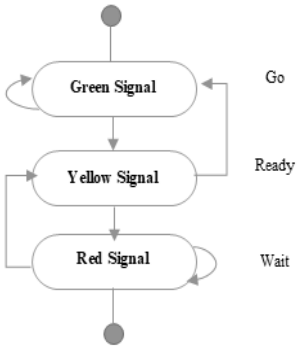

Figure 1. State chart diagram for signal lights

B. Collaboration Diagram

Collaboration diagram is known as communication or interaction diagram. It illustrates the relationships and interactions among the software objects in the Unified Modeling Language (UML). The relationships between the objects (shown in rectangles) are depicted through the lines or arcs (shown in Fig. 2). This diagram visually represent the relationship between the objects of the proposed system.

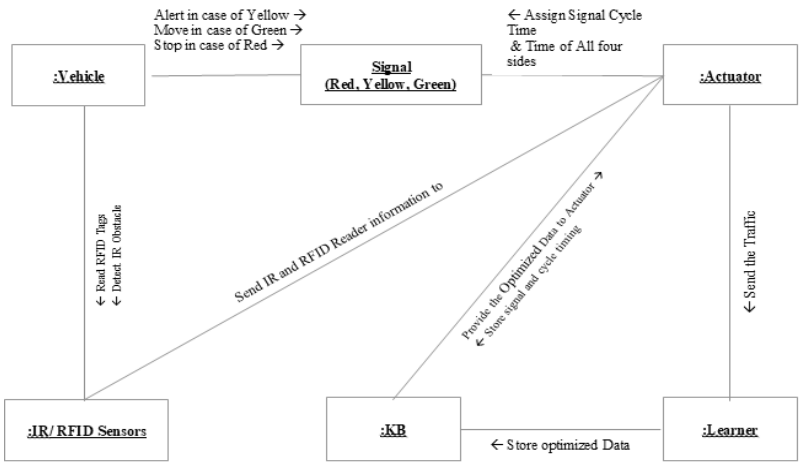

Figure 2. Collaboration diagram

C. Activity Diagram

Activity diagram is just like a flowchart that is used to represent the flow from one activity of the system to another activity as shown in Fig. 3. These activities can be described as an operation of the system.

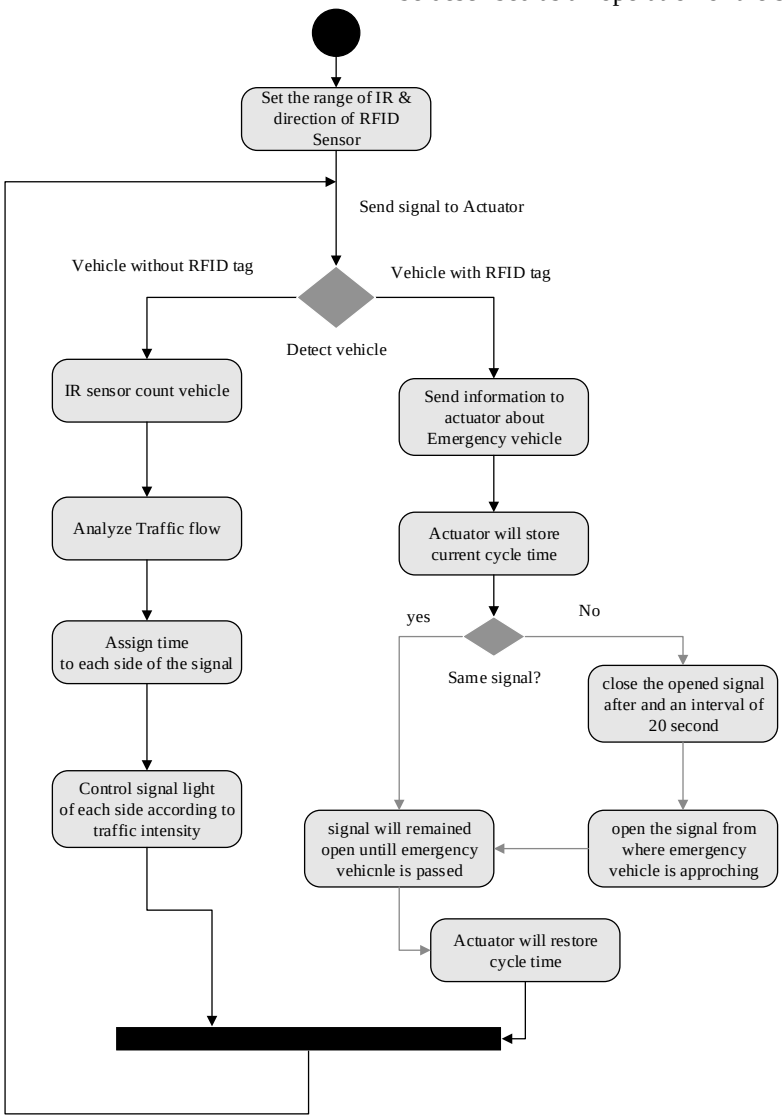

Figure 3. Activity diagram

In the proposed traffic management architecture, initially set the range of two IR sensors and direction of RFID Reader on four (4) way road juntion. One IR sensore is placed on enterance point at each lane to count the vehicles and second is placed on the exit point of the traffic signal. When any vehicle is detected by the IR sensor, this information is sent to the actuator where vehicles are counted. It analyzes the traffic flow and calculate time for each side of the signal. The actuator control the signal and change its light according to that signal time.

If vehicle is detected with the RFID tag through the RFID reader device, it will serve as emegergency vehicle and actuator give it priority. Actuator will save the current signal cycle time after the detection of emergency vehicle. If emegergency vehicle coming from the same signal that is already opened, it will remain open until emegerncy vehicle is passed. On the other hand, actuator close the opened signal after an interval of 20 seconds and open the signal for emergency vehicle. After the passage of emergency vehicle from the traffic signal, actuator will restore the previous signal cycle for smooth traffic movement and remove traffic congestion.

D. Sequence Diagram

Sequence diagrams are sometimes called event diagrams or scenarios. A sequence diagram show parallel vertical lines, different processes or objects that occur simultaneously, horizontal arrows, exchanged of messages between the agents of the proposed system (Fig. 4).

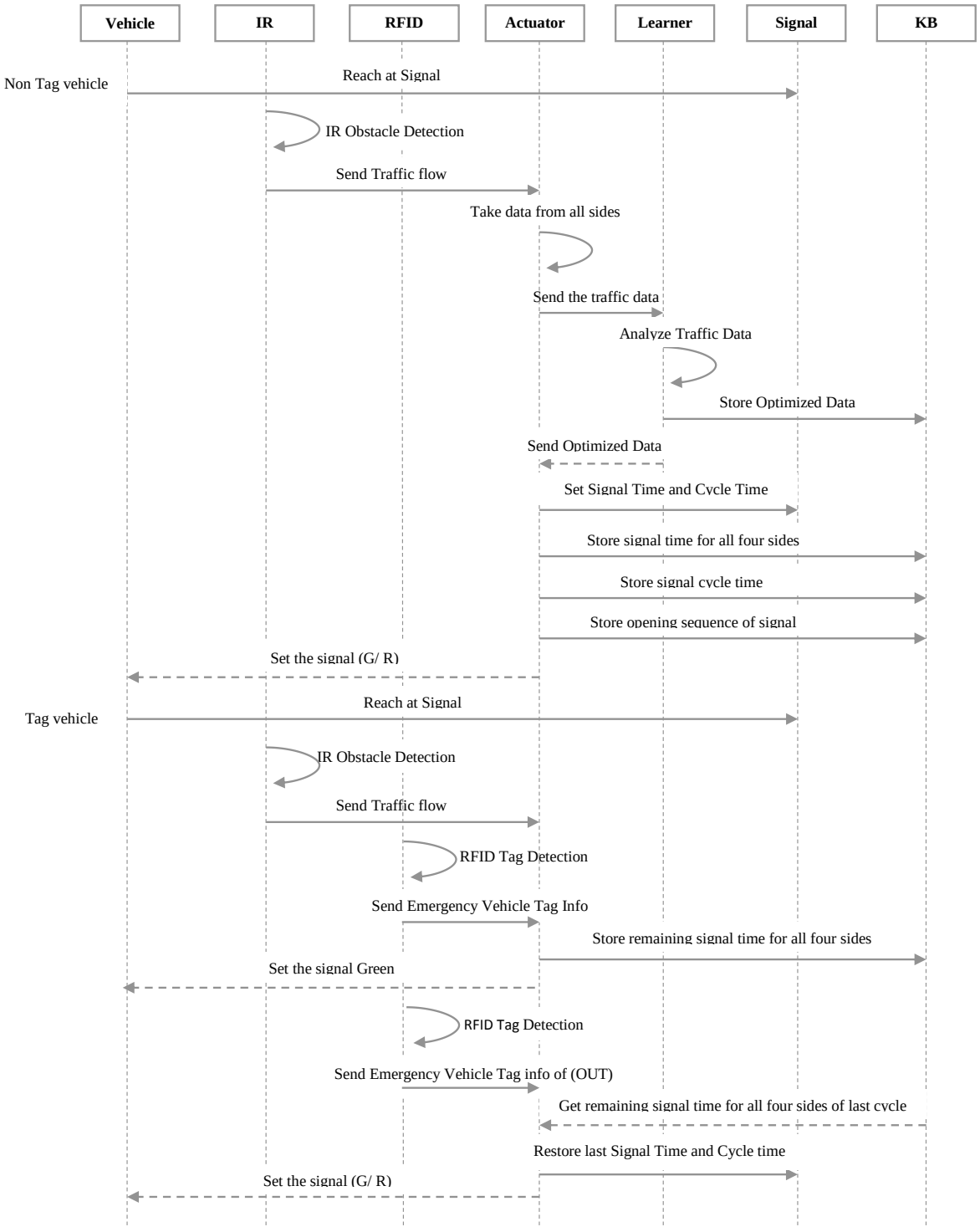

Figure 4. System sequence diagram

IV. Proposed Solution

The proposed traffic architecture is fast, efficient and reliable with cost effective solution to handle the traffic congestion problem. The time allocated to each signal is depending upon the number of vehicles waiting on that side. It is intelligent system for traffic signal management and controlling that reduces the traffic jam and allocates best time for each signal according to the traffic vehicles on the road. It is also the replacement for human on signals. This system has an automatic emergency override feature that gives priority dynamically. Precious lives can be saved by giving priority to the ambulances and fire brigade so that they can't stuck in rush or wait for signal turn

In the proposed traffic management architecture, a microcontroller (18F4550) is interfaced with IR sensor which are installed at entry and exit point of the signal in order to identify and count the vehicles. There are two (2)

IR modules at each road of the signle; i.e. enterance and exit position of the junction. It detects the vehicle that passes or cut the IR beam. At the signal, timing always changes with the size of the traffic density. IR sensors work together with the Arduino board that is placed on the side of road. IR obstacle module has three pins; two are used for input and one for output. Road counting is subsequently considered by the time allocation algorithm at the end of each timing cycle.

RFID technology is used for automatic detection of Emergency Vehicle. In this technique, RFID tags are mounted on each Emergency vehicle like (ambulance, police cars, fire brigade, and VIP movement's vehicles).

When a vehicle with RFID tags reaches in the range of RF field of Readers Antenna, it sends the unique value stored in the tags. This value is sent to the computer or microcontroller (Arduino uno board) and varify the value from the database. If the value matched then a signal pulse is sent to main controlling board to change the signal state accordingly. When the emergency vehicle exits from the junction once again it will be detected by RFID reader and this information is sent to the controller in order to resume the previous cycle. For each road, one RFID Reader is installed at the entry while other at the exit point of road. These RFID readers are connecting to the Arduino board to recognize the emergency vehicle. The system is comprised of a Desktop GUI based application with hardware connectivity that takes inputs and controlling traffic signal on four (04) way road junction.

V. Conclusion & Future Work

In this research, autonomous agent oriented traffic architecture is discussed that controls the vehicles at traffic signals to save time. In this architecture, vehicles are counted by the IR sensor in order to assign signal time according to the traffic volume. The rescue and emergency vehicles are detected by RFID tags. In future, the purposed architecture will be tested by a simulation or prototype. The proposed architecture can also be integrated with other system such as safe city, traffic and many others. Further it can be enhanced by synchronizing all the traffic junctions in the city by establishing a network. This synchronization will have great impact in reducing the traffic congestion.

Acknowledgment

We wish to thanks Higher Education Commission (HEC) of Pakistan and Federal Urdu University of Arts, Science & Technology, Islamabad Pakistan who are supporting this research work.

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