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VHDL Based FPGA Implemented Advanced Traffic Light Controller System

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Abstract**—**Vehicular traffic at intersecting streets is typically controlled by traffic control lights. The function of traffic lights requires sophisticated control and coordination to ensure that traffic moves as smoothly and safely as possible. In recent days electro-mechanical controllers are replaced by electronic circuits. Besides being reliable and compact is also cost effective and to meet the requirements of solid state traffic light controller by adopting FPGA (field-programmable gate array)board and VHDL language as the main controlling element, and led's as the indication of light. The system can be tested and implemented in hardware using Xilinx Spartan 3E. The sensor and camera can also be interfaced with FPGA. The system has many advantages over the exciting TLC's on most of the parts of the world. The scope of this paper is to present the initial steps in the implementation of a smart traffic light control system based on Programmable Logic Controller (PLC) technology. We intend to measure the traffic density by counting the number of vehicles in each lane and their weight, and send this information to TCC (traffic control centre) and then it deviate the vehicles accordingly. VHDL makes the system versatile as the on and off time can be easily varied by changing the delay loops through software.

Keywords**—** Programmable logic controllers (PLC); weight sensor; counters; LEDs; SCADA traffic light control system; field-programmable gate array (FPGA).

I. INTRODUCTION

The main aim of designing AI (artificial intelligent) traffic controllers is that the traffic controllers have the ability to adapt to the real time data from detectors to perform constant optimizations on the signal timing plan for intersections in a network in order to reduce traffic congestions, which is the main concern in traffic flows control nowadays, at traffic intersections. The FPGA traffic light control system needs to consider the current traffic situation, which is base on the data from sensors. The FPGA gets current signals of vehicles passing crossroad and base on those signals send next step will be taken. Also it creates free path or green waves for easy flow of traffic by synchronizing data with TCC (traffic control centre) and using ad-hoc and GPS technology. Traffic parameter Estimation has been an active research area for the development of intelligent Transportation systems (ITS). Traffic signals are the most convenient method of controlling traffic in a busy junction. But, we can see that these signals fail to control the traffic effectively when a particular lane has got more traffic than the other lanes. This situation makes that particular lane more crowdie than the other lanes. If the traffic signals can allot different lanes to different vehicles based on their weight, like buses, trucks etc. in one lane, cars in one lane and like this the traffic congestion can be solved by diverging the traffic accordingly. In this project Field Programmable Gate Array (FPGA) is used which is a reconfigurable hardware platform useful for the implementation of high digital functions. Using fixed point, parallel computational structures, FPGA provides computational speeds as much as 100 times greater than those possible with Digital Signal Processors (DSP).Xilinx Spartan-3 FPGAs are ideal for low-cost, high-volume applications and are targeted as replacements.

II. SYSTEM IMPLEMENTATION

A. *Roads Structure*

Generally, a traffic signal system has three lights. A green light on the bottom of the signal indicates the traffic to proceed, a yellow light in the middle warns the traffic to slow and prepare to stop, and red light on the top indicates the traffic to stop. Figure 1 shows structure of any chowk consisting of four main roads and each road is divided into two main roads (straight and cross). We are using eight traffic signals L1, L2,…L8. There are four sensors on roads SW1, SW2, SW3 and SW4 which will be on the speed breaker of every lane. SW1, SW2, SW3 and SW4 sensors switches are linked with traffic signals on (L1, L6), (L2, L5), (L3, L8) and (L4, L7) respectively. Whenever any one of the sensors output is enabled, appropriate traffic starts to continue on the roads according to the position and priority of the switches and rest of the signals are off.

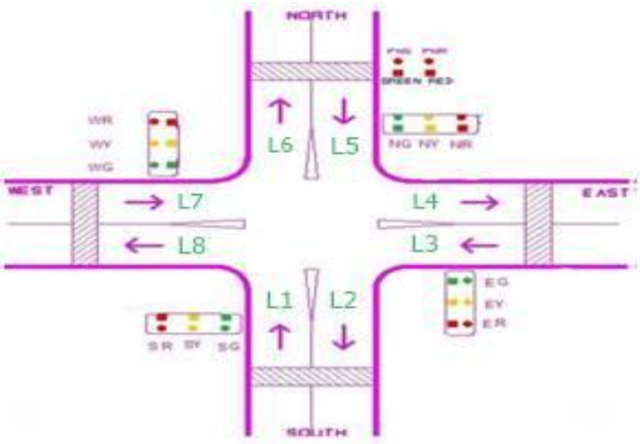

Fig. 1. Structure of any chowk.

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In order to implement the applications indicated, a certain level of intelligence is required in both the traffic light and the regulator. Traditional traffic control systems are unidirectional, from regulator to traffic lights, without any response from the status of the traffic lights. One strategy for optimum control and traffic management is the coordination of traffic lights to create green waves. Currently, there exist different strategies to calculate green waves. The main purpose of these techniques is to reduce the Number of stops and minimize the travel times in trips. Here we intend to use weight sensors and counters to control the traffic with ease. And send this information to TLC for control of the traffic system.

III. Modeling Overview

Components of our proposed model and their functions are briefly summarized below.

A. *On-Board Units (OBUs)*

On-Board Units are responsible for car to car and car to infrastructure communications. An OBU is equipped with at least a single short range wireless
Communications network device. The network device is used to send, receive and forward data in ad hoc domain.

B. *Road-Side Units (RSUs)*

A Road-Side Unit is a physical device located at fixed positions along roads (and highways), or at dedicated locations. An RSU is equipped with at least a network device for short range wireless communications radio technology. The main function of RSU are extending the communication range of an ad-hoc network, possibly running safety applications, possibly providing Internet connection to OBUs, possibly cooperating with other RSUs in forwarding or in distributing safety information etc .

C. *Traffic Light Controller (TLC)*

We suppose that TLC can wireless/wired communicate with OBUs, RSUs, and other adjacent TLC, and takes into account the physical presence of vehicles, and queue length of vehicles for deciding signal timing. It also takes into account the Adaptive traffic light control system using ad hoc vehicular communications network figure 2. The propose model for adaptive traffic light control system.

D. *Traffic Control Center (TCC)*

Traffic Control Center serves as the focal point for the management of the transportation system in urban area. It integrates data from a variety of different Sensor sources and provides a means for operators to manage traffic and inform the public from a centralized point.

OBUs and RSUs can be seen as nodes of an ad hoc network. As a result, RSUs may allow OBUs to access the infrastructure. The main objectives of Vehicle-to-Vehicle (V2V)/ Vehicle-to-Infrastructure (V2I) communication are automatic and fast transmission between vehicles and between vehicles and road side units. The ad hoc V2V communications enable the cooperation of vehicles by linking individual information distributed between multiple vehicles. Constantly, the system is collecting data and predicting traffic congestion on roadways throughout a large region. The traffic light controller uses information collected by OBUs and RSUs and sensors to automatically calculate the green time for each traffic light phases and the green wave offset for a wide range of cooperative intersections. In order to predict the green wave offset, we assume that the system monitors the action of the drivers, the position and the behavior of all other nearby vehicles. The effect of this approach is less stops on roadways resulting in increased traffic flow for equipped vehicles.

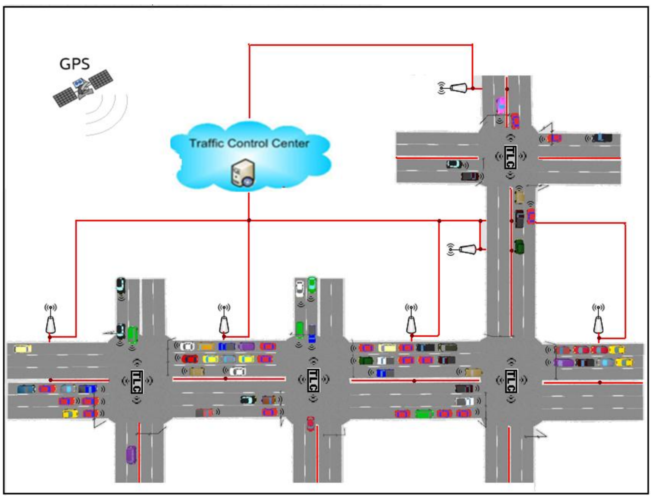

Fig. 2. Model for adaptive traffic light control system.

IV. System Working

In this method we are proposing to reduce the heavy traffic and congestion on the road by using PLC based traffic diversion system. This would work on weight sensing using sensors whose output will be fed to a PLC, which will control the traffic diversion. This method is in two parts:

A. *Diversion*

Weight sensor is placed at toll booth. It senses the weight & sends signal to PLC. PLC will generate a slip having the info about the vehicle in the form of barcode. PLC will give the diversion according to the weight of the vehicle.

B. *Congestion Control*

In this there are two counters– UP Counter (at the starting of the road) & DOWN Counter (at the end of the road) whose max value is 100. When a vehicle enters the road, UP Counter is set and vice versa. There are 3 conditions for allowing the vehicle in the area figure 2.

I. If UP Counter==100 & DOWN Counter==0, then red light will be shown i.e. no vehicle will be allowed to enter the area
II. If 100>UP Counter>80 & 20>Down Counter>0, then yellow light will be shown i.e. vehicles will be told to be ready to enter the area.
III. If UP Counter<60 & DOWN Counter>40, then green light will be shown i.e. vehicles will be allowed to enter the area.

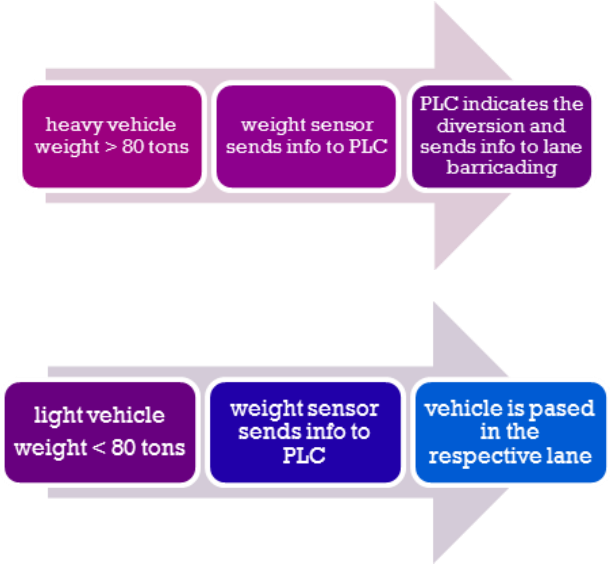

Fig. 3. Flow chart for diversion of vehicles based on weight.

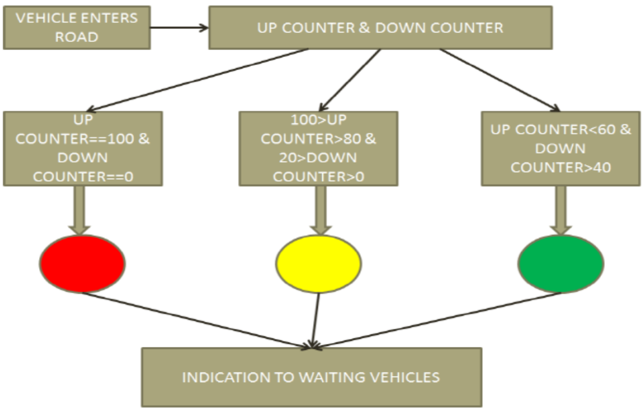

Fig. 4. Flow chart for diversion of vehicles based on traffic density.

Now according to the information given by the sensors information is manipulated by predefined software program implemented in FPGA and accordingly the time delay of the traffic light of specific Lane can be changed. Also green waves will also be created for fast moving of vehicles from one destination to other. E.g. for morning time traffic let there be a rush-hour at 8.00 am and there is more traffic from north to south so the time for green light will be more based on the data gathered by weight sensors, counters and traffic control centre. Similarly in evening the time delay of traffic light from south to north will be more. It all depends on the congestion on the roads and the weight and number of vehicles. And heavy and light vehicles are also diverged to their respected lane by measuring their weight by weight sensors.

V. State Diagram

The TLC state diagram shown in figure 5 illustrates that whenever cnt=00 and dir=00,then green light in north direction will be ON for few seconds and red signal light in all other directions namely west, south and east will be ON.

When cnt=01 and dir=00 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian north will be ON and then dir is incremented by one and cnt is assigned to zero. So when cnt=00 and dir=01, the green light in east direction will be ON for few seconds and all red lights in other directions be ON. Whenever cnt=01 and dir=01 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian east will be ON and then dir is incremented by one and cnt is assigned to zero. So whenever cnt=00 and dir=10, the green light in south direction will be ON for few seconds and all red lights in other directions will be ON. Whenever cnt=01 and dir=10 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian south will be ON and then dir is incremented by one and cnt is assigned to zero. So whenever cnt=00 and dir=11, the green light in west direction will be ON for few seconds and all red lights in other directions will be ON. Whenever cnt=01 and dir=11 then yellow light (y1) will be ON for few seconds and when cnt=01 yellow light (y2) and pedestrian west will be ON and then dir is assigned to 00 and cnt is assigned to zero. This sequence repeats and the traffic flow will be controlled by assigning time periods in all the four directions. Table I specifies the abbreviations used in TLC state diagram. Labeling for each lane is done by assigning the direction label in order to distinguish the outputs from each other with their states. In the traffic light controller program there will be two inputs namely clock and reset. When the two variables are „1" then the TLC will start working. Initially that is when reset is „0" then the red signal lights in all the directions will be ON and when reset is „1", then the traffic light controller system will be on assigning cnt and dir variables to 00 where cnt and dir respectively represent the states and the four directions in the state machine.

Table 1. Abbreviations used in TLC state diagram.

South	West
GS= green south RS= right south Y1S=yellow light1south Y2S= yellow light 2 south PDS=pedestrain south	GW = green west RW = right west Y1W = yellow light 2 west Y2W = yellow light 2 west PDW = pedestrain west
North	**East**
GN = green north RN = red north Y1N = yelow light 1 east Y2N = yellow light 2 north PDN = pedestrain north	GE = green east RE = red east Y1E = yellow light 2 east Y2E = yellow light 2 east PDE = pedestrain east

Now by the use of sensors we can change the delay from one state to other i.e. indirectly controlling the time for which traffic light remain green or red. E.g. if there is a congestion in traffic on the lane L1 than the timing for green light in lane L1 will be increased so as to pass the traffic through. Similarly with other lanes up and down counter will count the number of vehicles and this will tell the condition of the traffic. And the weight sensors will be diverging heavy and light vehicles to their respective lanes.

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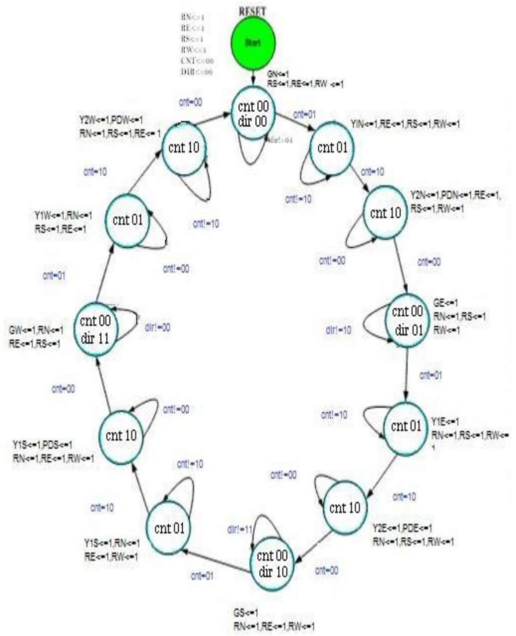

Fig. 5. state diagram.

VI. Hardware Implementation

The state machine is coded using the Hardware Description Language, VHDL. Spartan-3E trainer kit is shown in figure 6. Figure 7 shows the FPGA Implementation of TLC. Using Xilinx ISE tool, this code is dumped into Spartan-3E FPGA trainer kit and the outputs here we considered are more than the LEDs on the FPGA.

Fig. 6. Spartan-3E.

Weight sensors and Signal lights at each lane have their set of traffic light signal "Red, Yellow, and Green". Operation of this signal light is similar to common traffic light signal. Along with these specifications, each lane has sensor of the corresponding road. The first sensor detects the presence of vehicles and its weight and the second sensor determines the volume of the traffic corresponding to that lane by counting incoming and outgoing vehicles. Through the two sensors, we will know the expected time for green signal ON and when the signal light at each lane should be changed to green.

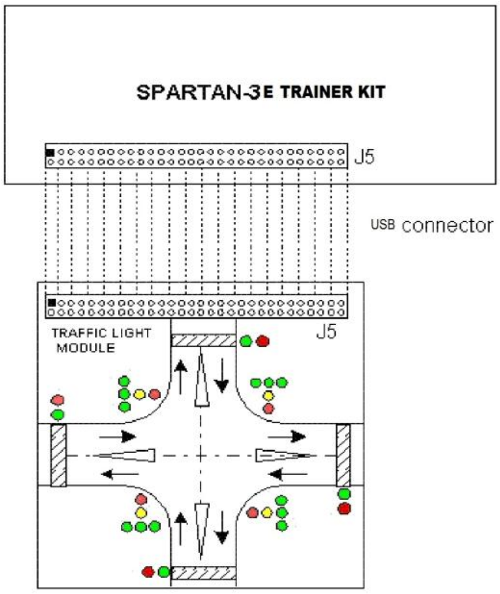

Fig. 7. FPGA Implementation.

VII. Observations

As compare to other methods the implementation of traffic light system using FPGA is cost effective moreover the time delay can be changed simply by manipulating the software part. Also as weight and count sensors are also connected to the FPGA board so the traffic congestion can be measured in the real time and this information is then used by TCC (traffic control centre) to control vehicles by the use On-board Units (OBUs) Road-side Units (RSUs) communicating through GPS.

VIII. Conclusion

In this paper we have proposed a new adaptive traffic light system and a new traffic light green-wave control algorithm that takes into account the driver's behavior. According to our approach, it is clear that in this case traffic flow will be improved by reducing stop number and each car's delay. Xilinx tool gives the flexibility in verification for the design with large number of inputs & outputs, also used for easy implementation of the design into the FPGA Spartan-3E. Also, to allow the user to assign the time for each traffic light (i.e. minimum time to be Green), adding more sensors on each road to count the number of cars in each road and check for the longer queue to increase the timer for that road. This method will help reduce congestion on roads and would help in coping with accidents as the heavy vehicles and light vehicles will be in different lanes. Resultantly, a solution to a much critical problem of traffic congestion and fatal accidents is possible using this system. Thus the proposed system would make our roads a safer place to travel.

References

[1] M. Voinescu, A. Udrea, and S. Caramihal, "On urban traffic modelling and control," *CEAI*, vol. 11, no. 1, pp. 10-18, 2009.

[2] C. M. Mwangi, S. M. Kang'ethe, and G. N. Nyakoe, "Design and simulation of a fuzzy logic traffic signal controller for a signalized

intersection," *Proceedings of JKUAT Scientific Technological and Industrialization Conference*, pp. 210-219, 2010.

[3] O. Tomescu, I. M. Moise, A. E. Stanciu, and I. Băţroş, "Adaptive traffic light control system using ADHOC vehicular communications network," *U.P.B. Sci. Bull.*, Series D, vol. 74, issue 2, pp. 68-78, 2012.

[4] T. Han, C. Lin, "Design of an intelligence traffic light controller (ITLC) with VHDL" *Proceedings IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering*, vol. 3, pp. 1749 – 1752, 2002.

[5] S. Nath, C. Pal, S. Sau, S. Mukherjee, A. Roy, A. Guchhait, and D. Kandar, "Design of an FPGA based intelligence traffic light controller with VHDL," *IEEE International Conference on Radar, Communication and Computing (ICRCC)*, pp. 92 – 97, 2012.

[6] W. M. El-Medany and M. R. Hussain, "FPGA-based advanced real traffic light controller system design," *4th IEEE Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS)*, pp. 100 – 105, 2007.

[7] A. C. Soh, L. G. Rhung, and H. Md. Sarkan, "MATLAB simulation of fuzzy traffic controller for multilane isolated intersection," *International Journal on Computer Science and Engineering (IJCSE)*, vol. 02, no. 04, pp. 924-933, 2010.

[8] H. Dong, X. Xiong and X. Zhang, "Design and implementation of a real-time traffic light control system based on FPGA," *ASEE Zone I Conference*, University of Bridgeport, Bridgpeort, CT, USA, April 3-5, 2014.

[9] A. Mallik, S. Kundu, Md. A. Rahman, "An FPGA based semi automated traffic control system using verilog HDL," *Proceeding of the International Conference on Electrical, Computer and Telecommunication Engineering (ICECTE2012)*, RUET, Rajshahi-6204, Bangladesh, 2012.

[10] M. Voinescu, A. Udrea, and S. Caramihai, "On urban traffic modelling and control," *Control Engineering and Applied Informatics (CEAI)*, vol. 11, no. 1, pp. 10-18, 2009.

[11] Rashmi and Anurag Sharma, "VHDL based multiple traffic lights controller," *International Journal of Electronics & Communication Technology* (*IJECT*), vol. 2, issue 3, pp. 259-262, 2011.

[12] W. Wen, "A dynamic and automatic traffic light control expert system for solving the road congestion problem," *An International Journal: Expert Systems with Applications (Elsevier)*, vol. 34, issue 4, pp. 2370–2381, 2008.

Sahil Gupta, "VHDL based FPGA implemented advanced traffic light controller system", *Journal of Scientific and Technical Advancements*, Volume 1, Issue 3, pp. 313-317, 2015.