

FPGA IMPLEMENTATION OF ADAPTIVE DYNAMIC CONTROL OF TRAFFIC SIGNAL AND AMBULANCE RESCUE SYSTEM AND ANDROID APPLICATION

¹R. Mahesh, PG Scholar, Embedded System Technology, SRM University, Chennai, Tamilnadu, India

²Ms. D. Vijayalakshmi, Asst. Prof (O.G), SRM University, Chennai, Tamilnadu, India

Abstract - *The project is to make a prototype which shows a successful implementation of a Field Programmable Gate Array (FPGA) CAN bus monitor for use in a traffic signal where a traffic junction (node) can operate in three modes namely, normal mode, priority mode, the ambulance mode and also to develop an Android application to make a traffic density in each node available to the user. The traffic density along the roads are sensed using an array of IR sensor's interruption, connecting sensors to the traffic signal controller. The CAN bus is used for the communication between Traffic signal controller (nodes). In priority mode, giving priority to the most populated side of the road and in ambulance mode, paving way for the emerging ambulance resetting the current side according to the instruction sent to the controller from the main server via GSM module (in ambulance) according to the GPS co-ordinates of the ambulance marked by the main server to the path of the hospital. The traffic densities are periodically updated in the main server. The Android application is developed from the information in the main server, to make it available to the user. The nodes can be increased to N number extending the CAN bus linking the successive traffic junctions at different.*

Key Words: CAN Bus, FPGA, Android, GSM

1. INTRODUCTION

Traffic congestion and tidal flow management were recognized as major problems in urban areas, which have caused great traffic accumulation needing manual regulations at such times and mainly hindering the way for the emerging ambulance with the existing system on time basis. There is loss of life due to the delay in the arrival of ambulance to the hospital in time. This delay is mainly caused by the waiting of the ambulance in the traffic signals. It would be of great use to the

ambulance if the traffic signals in the path of the hospital are ON. The delay of respective light is hard coded in the traffic signal and it is not dependent on traffic. Therefore the need for simulating and optimizing the traffic control arises. Thus we propose a new design for automatically controlling the traffic signals with routing taking place on vehicle density basis and achieving the above mentioned tasks so that the traffic is regulated without much accumulation in traffic junctions and providing free flow for the ambulance to reach the hospitals in time without waiting at the traffic signals and thus minimising the expiration. Every traffic junction will have a controller controlling the traffic flow. The traffic junctions are referred to as nodes and each node will have a GSM modem connected to the controller. The nodes are controlled by a main server by sending the control messages to their GSM modems. When a node is controlled, its traffic signal is made to be green for the most populated side and the ambulance to pass through without waiting, it is said to be in ON STATE. For easy access the server maintains a database for each node, and hence each node will have a unique id for addressing it.

2. PROJECT DESCRIPTION

The central aim of the project is to develop a prototype, the traffic signal which operates at normal 60 seconds functioning, but when the all the IR sensors in particular side are sensed when it was green signal, the priority is assigned, the priority routing of additional 20 seconds will be extended to that side. The normal routing of signals lights take place every 2 minutes time. If the ambulance emerges, the traffic signal will be reset according to the request from the main server. In case of equal priorities sensed by two different sides, priority is given to the main road. There is a central remote server system designed to allow remote access to the recorded

data in a traffic signal, which would allow for more timely response to the traffic signal thereby monitoring and controlling the traffic flow and ambulance in the road.

Our system is divided into following units,

1. The traffic junction unit
2. The ambulance unit
3. The remote server unit
4. Android application

2.1 The Traffic Junction Unit

The system contains IR transceivers. The IR system gets activated whenever any vehicle passes on road between IR transmitter and IR receiver. Controller controls the ULTRASONIC system and counts number of vehicles stagnant on road and accordingly the traffic light functioning is controlled. CAN bus connects the next traffic signal thereby instructing heavy traffic in cases of occurrence in the main road. The priority and abort features of CAN is shown where normal priority-assigned data flow to the next traffic signal via CAN bus wherein the next traffic signal upon receiving the data, the signal begins to function at reduced time in normal mode until the sensors sense the traffic and priority mode functioning occurs till the traffic gets cleared but when ambulance arrives this data is suspended and the ambulance request is processed and this scheme is the worst case alternative of the proposed system in case of any discrepancy. The node has a GSM modem to allow the main server to establish control over it whenever needed. Along with the centralized nodes shown in the diagram, there can be many localized nodes without GSM module, with control messages being sent by CAN extensions.

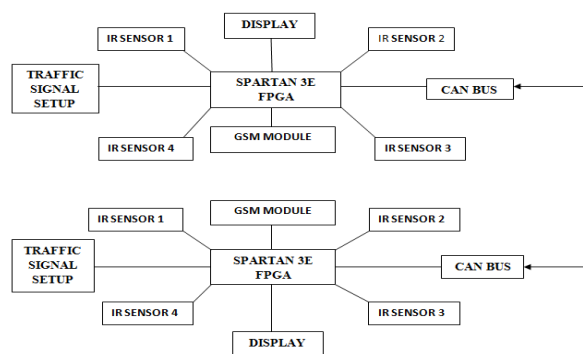


Fig 1: Model of the traffic signal setup

Other important properties defined in the CAN standard are:

- Message prioritization - Critical devices or messages have priority on the network. This is done through the media arbitration protocol.
- Guaranteed latency - Real time messaging latency utilizes a scheduling algorithm which has a proven worst case and therefore can be reliable in all situations.
- Configuration flexibility - The standard is robust in its handling of additional nodes, nodes can be added and removed without requiring a change in the hardware or software of any device on the system.
- Global data consistency - Messages contain a consistency flag which every node must check to determine if the message is consistent.
- Automatic Retransmission - Corrupted messages are retransmitted when the bus becomes idle again, according to prioritization.
- Reduced power consumption - Nodes can be set to sleep mode during periods of inactivity. Activity on the bus or an internal condition will awaken the nodes

2.2 The Ambulance Unit

The ambulance unit has a GPS system and a GSM MODEM for transmitting GPS data to the main server. The server receives the GPS data sent by the ambulance at regular intervals of time. The server sends the coordinates of all the nodes in the path to the ambulance. The ambulance unit on receiving the coordinates, plots them on to the map to get the shortest path to the hospital. The GSM MODEM communicates to the traffic signal controller via the main server, thereby controlling it in the path. In the worst case of suggested system failure, a communication between the traffic signal and ambulance directly is suggested, where the code is written for the ambulance to take control over the traffic signal, switching ON the Green light in it's wanted (N-north, S-South, W-west, E-east).

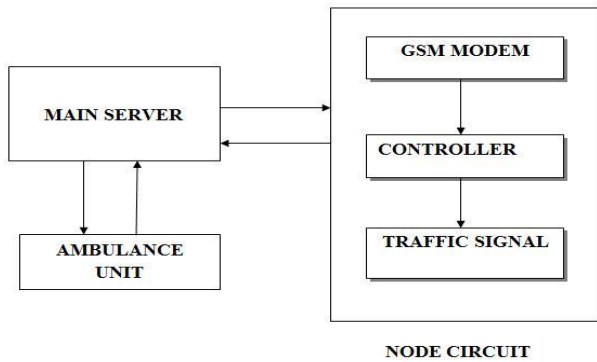


Fig 2: The Ambulance Unit

Alternative:

Here the control over the node is directly done by the ambulance. The control message from the Ambulance N/S/W/E (N-north, S-south, W-west, E-east direction) is sent to node via GSM, the node upon receiving the data resets the lights switching ON the green light in its wanted direction and loses the ambulance hold only after the Ambulance releases it by sending STOP message.

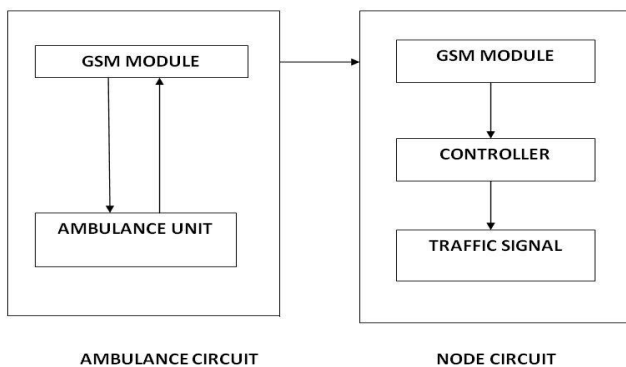


Fig 3: Direct ambulance control

2.3 The Remote Server Unit

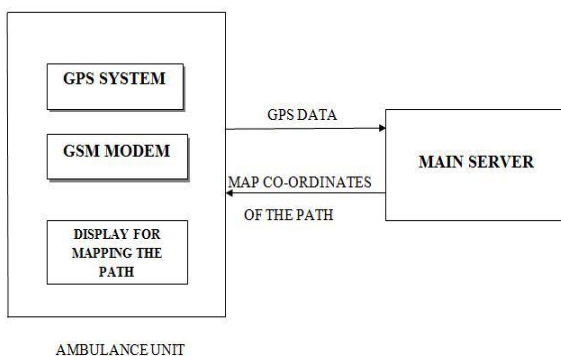


Fig 4: Remote Server System

The server is the central brain of our system, the server performs the communication as well as controls every node in the path of the ambulance and also interrupt service. The server receives the GPS data from the ambulance unit and matches the location and marks the nearest traffic node, nearest hospital to the ambulance, and establishes the control over the node. As soon as the ambulance enters the geographical zone of the traffic signal, the main server establishes control over the traffic signal by switching ON green light in the path of ambulance. It releases the hold over the traffic signal after the ambulance has crossed the signal. In addition the details of the traffic flow are fed in the database of the server and timely changes could be done to the nodes and thus an effective traffic light control and monitoring system is established providing a rescue of ambulance in the traffic signal.

The server objectives can be mainly classified into:

1. locating the nearest hospital
2. sending co-ordinates to the ambulance
3. controlling the nodes in the shortest path

2.4 Android Application

Android application is developed by making use of records available in the data base. Since, traffic is getting updated periodically in database, using android application we can get the current status. So Android application is available to each and every user and they can get the update and density of the traffic in the city.

3. CONTROLLING THE NODES

A node can possibly operate in three modes namely,

- The normal mode
- The priority mode
- The ambulance mode

Normal mode is the usual traffic control by a controller in a junction, (the 60 seconds direction change).

In normal mode, traffic flow in each direction of the mode will be given equal importance.

In priority-based mode, importance is given to the most populated side of the road.

In the ambulance mode, the direction in which the ambulance heads is given importance and is kept in the ON state, till the ambulance leaves the junction (node).

This is done by,

- The node will receive a START SIGNAL from the main server as a control message which contains the direction that must be kept in ON state so that the ambulance can pass through the junction without waiting.
- The direction retrieved from the control message is given to the controller.
- The particular direction is kept in the ON state as long as another message (STOP SIGNAL) is received from the main server.
- The STOP SIGNAL is generated when the GPS coordinates of the ambulance and the node matches i.e. when the ambulance crosses the node. The node then will return to its normal mode of operation.

4. INTERRUPT SERVICE ROUTINE ALGORITHM

4.1 Ambulance Mode

- WAIT FOR THE RECEPTION OF START MESSAGE ALONG WITH THE DATA.
- RETRIEVE THE DATA ABOUT THE SIGNAL TO BE MADE GREEN.
- MAKE THE CORRESPONDING SIGNAL TO BE GREEN.
- WAIT FOR THE RECEPTION OF NEXT MESSAGE (THE STOP SIGNAL)
- IF THE MESSAGE IS RECEIVED RETURN TO NORMAL MODE

By this way each node in the path to the hospital is controlled by the server.

4.2 Priority Mode

- WAIT FOR THE RECEPTION OF START MESSAGE ALONG WITH PRIORITY DATA OF ALL NODES
- RETRIEVE THE DATA ABOUT THE SIGNAL TO BE MADE GREEN
- IN CASE OF EQUAL PRIORITIES BEING ASSIGNED IN IR SENSOR TRIGGERING TO ANY TWO NODE, PRIORITY IS GIVEN TO THE MAIN ROAD
- MAKE THE CORRESPONDING SIGNAL TO BE GREEN
- MAKE THE OCCURANCE OF NORMAL ROUTING CYCLE EVERY 2 MINUTES
- WAIT FOR THE RECEPTION OF THE STOP

SIGNAL SOON THE IR INTERRUPTION GETS CLEARED

- RETURN TO NORMAL MODE

5. NODE ACCESS AND CONTROL

The nodes in the path are accessed and controlled only when the ambulance reaches a distance of around say 1km from the node. These locations are stored as the 1km markings. Since the signal should not be kept in ON state for a long time.

The node access control is done in the following steps:

- The server plots a 1km marking for each node.
- The locations of 1km markings (latitude and longitude) are taken from the map and stored in the NODES database.
- **When the ambulance's GPS location of any one of the 1km markings matches, the corresponding GSM ID with the signal direction from the map is taken by the server and is compared with the path nodes' GSM IDs.**
- If that node is present in the path, the START SIGNAL is sent to that GSM ID.
- Now, the node is kept in ON state till the ambulance crosses the node. Once it crosses the node, the server sends a STOP signal to the node which brings the node to normal mode of operation.
- The resolution of the GPS coordinates is that 1 second represents a 101.2ft in latitude and 61.6ft in longitude. Thus in every comparison with respect to ambulance unit, it is enough to note the GPS co-ordinate till the accuracy of second's.

6. RESULT



Fig 5: Communication between two traffic nodes

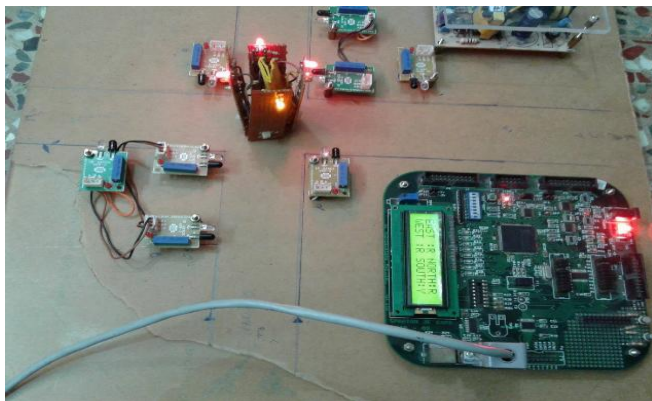


Fig 6: Transmitter Section

CONCLUSION

In this paper, a successful implementation of a monitoring system for a CAN bus sensor network in a hardware design on an FPGA development board is shown and a novel idea is proposed for controlling the signals in favour of the most populated side of road when a exceeding amount of traffic is felt along a direction so as to have a smooth flow of traffic and in favour of emerging ambulances. Traffic light optimization is a complex problem. Even for single junctions there might be no obvious optimal solution. With multiple junction. The problem becomes even more complex, as the state of one light influences the flow of traffic towards many other lights. Another complication is the fact that flow traffic constantly changes, depending on the time of day, the day of the week, and the time of

year. Road work and accidents further influence complexity and performance. Thus our design is a good solution to this issue. It seems to be a matter of when rather than if a priority based traffic routing is possible in a busy traffic signal junction. The system works on the **real time data, not mere stored data or previous cycle's data** and thus it is best in its kinds of proposed design. The proposed design is flexible, in the sense, modifications to the design can be done quick and easy when needed, saving both time and money. It is of reduced development time and risk and reduced complexity of logistics with long time availability in real time applications, fast and efficient. The normal mode execution taking places every 2 minutes time, avoid the accumulation of traffic in other sides of roads. The system proposed is highly efficient and automated thereby saving manual efforts of controlling the junctions which has proven to be unreliable and tedious task in a heavily populated urban city. Thus if this set up is implemented in countries with large population like INDIA, it can produce better results. The automatic ambulance rescue system is more accurate with no loss of time. Traffic lights can be increased to N number and traffic light control can be done whole city by sitting on a single place. With the FPGA, modifications to be design can be done quick and easy when needed, saving both time and money. The proposed system will be flexible enough to be enhanced in order to handle future traffic aspects using FPGAs based Microelectronics chips to control traffic signals.

FUTURE ENHANCEMENTS

The project can be extended further

To detect other VIP vehicles, providing rescue at traffic signals. Same system can be used for other applications like automatic gate opening. It could be extended to other emergency vehicles.

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