International Journal for Modern Trends in Science and Technology
Volume 10, Issue 02, pages 394-400.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol10issue02.html
DOI: https://doi.org/10.46501/IJMTST1002052

Verilog-Based Solution for Multi-Vehicle Parking

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To Cite this Article
S Sree Chandra, Chamakura Pavani, Tammineni Thirumalarao, Perla Srilekha, Tripuraneni Sireesha, Verilog-Based Solution for Multi-Vehicle Parking, International Journal for Modern Trends in Science and Technology, 2024, 10(02), pages. 394-400.https://doi.org/10.46501/IJMTST1002052

Article Info
Received: 30 January 2024; Accepted: 21 February 2024; Published: 26 February 2024.

ABSTRACT

This work addresses the challenges faced by closed spaces, such as shopping malls and multistoried buildings, in efficiently managing parking slots and minimizing manual labor. The primary objective is to develop a sophisticated parking system with multiple slots, alleviating issues related to tight parking spaces and the substantial manual effort required for space tracking within confined areas. The core focus revolves around designing a smart car parking system implemented using Verilog. The system incorporates a sensor at the entrance to detect the presence of a vehicle. Upon sensor activation, a password is prompted for gate access. If the entered password is accurate, the gate opens, granting entry to the vehicle; otherwise, the gate remains securely locked. This innovative solution aims to streamline parking management, enhance security, and reduce the manual workload associated with monitoring parking spaces in enclosed environments.

Keywords: Parking System, Verilog Implementation, Sensor-based Access, Smart Parking, Manual Labor Reduction

1. INTRODUCTION

India is currently developing at a break-neck pace, resulting in a massive urbanization. It is home to some of the world's most populous cities, including New Delhi, Hyderabad, and Bangalore.The problem of parking spaces is becoming more acute as these cities continue to grow. The issue is straightforward: the number of cars on the road grows inexorably in proportion to the number of parking spaces available. The rising number of cars on the road does not correspond to the available parking spaces in cities. Parking spots are in high demand in today's cities, resulting in challenges such as traffic congestion, disproportionate demand and supply, and environmental risks, to name a few. India struggles with chaotic conditions such as packed walkways, illegal parking, and inadequate surveillance due to bad parking management and legislation.

Overcrowding of parking places is one of today's most common issues. The number of vehicles on the road continues to outnumber available parking spots, cluttering the roads. To alleviate the problem, most towns propose adding parking spots. Regardless of the limited land area and resources, parks and vacant plots are being exploited as potential parking spots, and multi-level facilities are being created.

Parking spaces are virtually always built in residential apartments in Indian metros because it is believed that residential plans without them will not

attract purchasers. This raises the entire building cost, which is exacerbated when parking spaces are vacant. Because parking fees are the same whether the structure is a luxurious high-rise or a row of modest apartments, lower-income tenants who are less likely to own automobiles wind up bearing the brunt of parking costs, essentially subsidizing parking for others. Commercial visitors and excessive vehicle ownership also produce a lot of spills over parking for residents.

In India's metros, the demand for parking shows no signs of abating. Because land resources are limited, it is not practical to plan parking spots in an efficient manner based on demand. Rather than increasing the number of available parking spaces, an effective technology-based solution to optimize the utilization of existing spaces must be implemented. Smart parking solutions can give both parking operators and drivers with a real-time map of available spaces using sensors and software. The traditional parking lot framework necessitates a great deal of human labour, such as guards, cash collectors, and stop teachers. To shorten the time it takes to pay the cash collection, a car parking lot system makes it simple to park cars without having to spend too much time looking for a parking spot. This project is primarily concerned with the design of a car parking system using Verilog code and the software tools Xilinx-with ISE simulator and ModelSim. The major goal of this project is to develop a proper system of car parking slots based on the Finite State Machine concept.

Drivers searching for parking are estimated to be responsible for about 30% of traffic congestion in cities. Historically, cities, businesses, and property developers have tried to match parking supply to growing demand for parking spaces.

Parking System can be defined as the use of advanced technologies for the better operation, controlling of traffic, and management of parking within an urban area. A number of technologies provide the basis for parking solutions, including vehicle sensors, wireless communications, and data analytics. Parking System is also made useful by recent technology in areas such as mobile appilcation customer services, mobile UPI payments, and in-car GPS navigation systems. At the heart of the parking system concept is the ability to access, collect, analyze, disseminate, and act on information on parking usage. Increasingly, this information is provided in real-time from intelligent devices that enable both parking managers and drivers to optimize the use of parking capacity.

FSM (Finite State Machine)

In a Finite State Machine, the circuit's output is defined in a different set of states i.e. each outputis a state. A State Register to hold the state of the machine and a next state logic to decode the next state. An output register defines the output of the machine. In FSM based machines the hardware gets reduced as in this the whole algorithm can be explained in one process.

Two types of State machines are:

MEALY Machine: In this machine model, the output depends on the present state as well as on the input. The MEALY machine model is shown in figure 1.

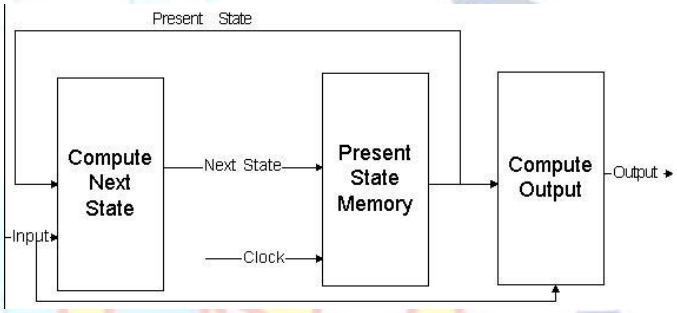

Figure 1: MEALY Machine

MOORE Machine: In Moore machine model the output only depends on the present state. The MOORE machine model is shown in figure 2.

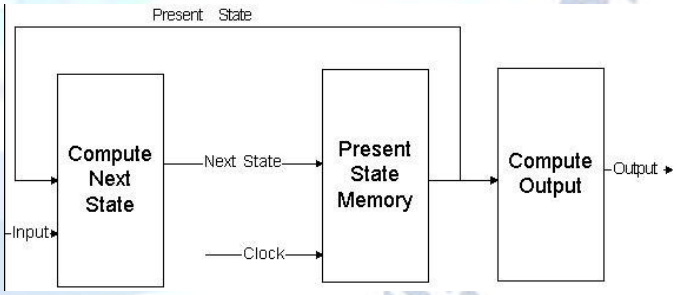

Figure 2: MOORE Machine

2. LITERATURE REVIEW

There has been lot of advances in the field of car parking system yet, there is always scope for improvement. A car parking framework has been proposed by the authors [1], which uses a Finite State Machine based on FPGA. FSM based VHSIC Hardware Description Language coding and designed on FPGA to automate parking. Works related to centralized parking system [2] have also carried out where in the driver

would be able to choose the nearest free slot for parking. Use of Fuzzy Logic Control for system design of car parking system was implemented in [3]. The system was employed to do carry out various operations that would be necessary when deploying the system in a real time environment. The authors in [4] proposed a method to curb the issue of indiscriminateparking by making use of VHDL and implemented it on a complex programmable logic device (CPLD). Methods have also been proposed in [5] to accurately predict the position of tyres of a vehicle which would prove to be helpful in identifying the space occupancy in a parking lot. There has also been advancement such as using a fast hardware-based (FPGA-based) automatic parking assistant system [6] created to aid novice drivers with parallel parking assistance. In [7] the design of IoT based parking system was carried out by deploying IR sensors to find the presence of a parked vehicle. In [8] the authors developed a 32-bit multiply and accumulate unit based on a Vedic sutra (UrdhvaTiryakbhyam sutra), an accumulation unit based on a ripple carry adder (RCA), and implemented it in a 4-tap FIR filter. The results reveal a 5% gain in area and a 9% increase in power efficiency. The possibility of solving the parking vacancy issue by harnessing the use of RFID along with VHDL have also been dealt by the authors of [9]. The system also proposed a recharge system for the RFID card which would be used at the time of entry. The distance of the preceding vehicle was calculated using a supervised learning method, YOLO (you only look once) object detector for vehicle detection in this paper [10]. In comparison to other current methods, the suggested ANN-based system estimated straight road pictures and decreased the error rate to 2%. The use of geomagnetic sensors for detecting the vacant spaces in car parking slots was also a proposed method in [11]. The idea of surveillance and monitoring for using cloud services has been mentioned in [12]. An IoT based approach was also implemented in [13] which made use of load sensors to detect the availability of slots in a parking system. The authors of [14] modeled a parking system with various sensors, stepper motors and LCD. It had modules for checking slot availability which was modeled in FPGA using HDL. A parking system using ultrasonic and magnetic sensor was implemented in [15] which was shown to have a good performance in various weather conditions also.

3.IMPLEMENTATION OF PROPOSED ARCHITECTURE

The system to be designed is a very simple one and its purpose is to design an FSM using VHDL. The FSM has four states: A, B, C, and D. The system has one input signal called P, and the value of P determines what state the system moves to next. The system changes state from A to B to C to D as long as the input P is high (1). If P is low, and the system is in state A, B, or C, the state is not changed. If the system is in state D, it changes to B if P is high and to A if P is low. The system also has an output called R which is 1 if in state D, otherwise it is a 0. Figure 3shows he state diagram of the FSM. The circles represent the states. Arrows between the circles represent the rules for changing from state to state. For example, in this system, the state machine moves from state A to state B if the input P is equal to 1 (otherwise it remains in state A. The information underneath the line in the circle represents the output value when in each state.The arrow coming from "nowhere" to the A indicates that A is the initial state.

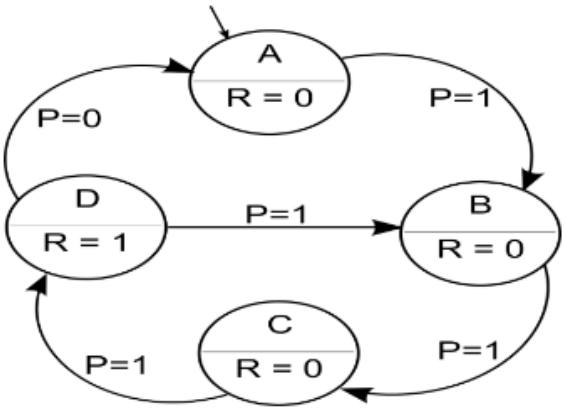

Figure 3: State Diagram of the FSM

In the proposed multi-car parking system5 states have been considered. They are IDLE, WAIT PASSWORD, RIGHT PASS, WRONG PASS, STOP. The main idea is that when a car enters the car parking arena, one has to give his username and password for the verification of entry. So, in this case two variables named password_1 and password_2 is taken where password_1 refers to username and password_2 refers to password. In case the password is incorrect, the redlight glows and one has to keep entering the password and username as long as the password and username matches with the system. If it matches with the system then the green light glows and the person will be allowed to park the car. So, to track whether the car is entering or exiting, the work

uses two sensors known as sensor entrance and sensor exit. Initially when the car is in idle state, sensor_entrance is made to 1 and when right password is entered then sensor entrance is made to 0 ensuring that car is parked. When the car exits, the sensor_exit is made to 0 and the sensor_entrance is made to 1.

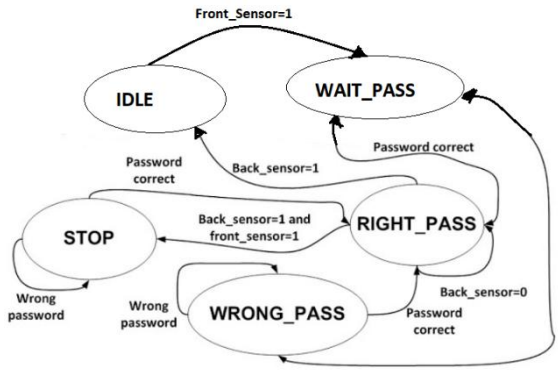

Figure 4: Proposed Parking System as FSM

But the problem with the existing design is that it does not address the issue of multiple parking slots. The above design addresses only a single car parking slot. Hence to Figure 4. FSM Representation of the Proposed System address this issue, a 'car count' is created which keeps tracks on how many cars can enter. So, in our project, the number of parking slots available is taken to be 4. This is done for easier simulation purpose. The number of car parking slots can be taken any number. Correspondingly the car_count has to changed to a suitable register in order to hold register values. The password and username of the system is given a fixed value ie username is given as 01 with password as 10. If the car is entering the parking slot and user enters 01 as username and password as 10 then the car is allowed for further states otherwise for example if user enters 11 as both password and username then the car doesn't match with the parking slot system hence car will not be permitted. Aslong as car parking count i.e., the car count, is less than 4, cars may be allowed to park. Once it reaches the limit of 4 the other entering cars are sent out at STOP point. But there will also be a case where a car may want to leave when other car enters. Whenever a car leaves from the slot, based on the sensor_exit, sensor_entrance parameter car count is decreased.

Motivation to use Parking System:

1. New Revenue Streams – Many new revenue streams are possible with smart parking technology. For example, lot owners can enable tiered payment options dependent on parking space location. Also, reward programs can be integrated into existing models to encourage repeat users.

2.Integrated Payments and POS – Returning users can replace daily, manual cash payments with account invoicing and application payments from their phone.This could also enable customer loyalty programs and valuable user feedback.

3. Real-Time Data and Trend Insight – Over time, a smart parking solution can produce data that uncovers correlations and trends of users and lots. These trends can prove to be invaluable to lot owners as to how to make adjustments and improvements to drivers.

4. Reduced pollution – Searching for parking burns around one million barrels of oil a day. An optimal parking solution will significantly decrease driving time, thus lowering the amount of daily vehicle emissions and ultimately reducing the global environmental footprint.

5. Enhanced User Experience – A smart parking solution will integrate the entire user experience into a unified action. Driver's payment, spot identification, location search and time notifications all seamlessly become part of the destination arrival process.

6. Optimized parking – Users find the best spot available, saving time, resources and effort. The parking lot fills up efficiently and space can be utilized properly by commercial and corporate entities.

7. Reduced traffic – Traffic flow increases as fewer cars are required to drive around in search of an open parking space.

8. Increased Safety – Parking lot employees and security guards contain real-time lot data that can help prevent parking violations and suspicious activity. License plate recognition cameras can gather pertinent footage. Also, decreased spot searching traffic on the streets can reduce accidents caused by the distraction of searching for parking.

9. Real-Time Data and Trend Insight – Over time, a smart parking solution can produce data that uncovers correlations and trends of users and lots. These trends can prove to be invaluable to lot owners as to how to make adjustments and improvements to drivers.

10. Decreased Management Costs – More automation and less manual activity saves on labor cost and resource exhaustion.

he smart parking system is considered beneficial for the car park operators, car park patrons as well as in environment conservation.

4. RESULTS& DISCUSSION

Simulation results provide a comprehensive understanding of how the designed circuit behaves under different conditions. They are crucial for verifying the functionality, identifying and resolving issues, and ensuring that the circuit meets the desired specifications before physical implementation. Figure 5shows the simulation wave of multi-car parking system.

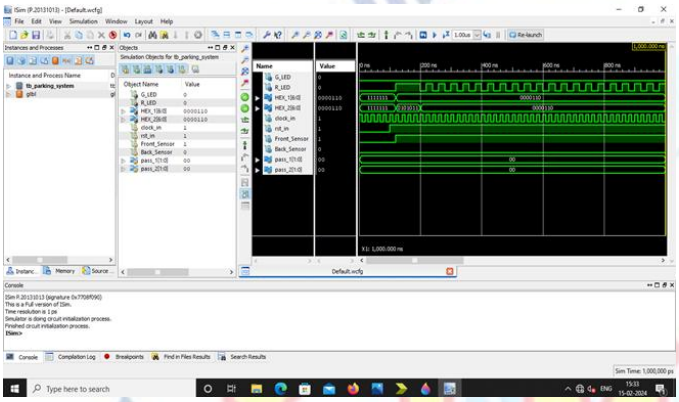

Figure 5: Simulation results of the proposed system

The block diagram offers a high-level representation of the entire system, illustrating the functional blocks and their interconnections. It serves as a visual guide for system architecture, aiding designers in conceptualizing and communicating the design structure and functionality. Figure 6 shows the block diagram of the parking system.In this PASS_1 and PASS_2 represents Password and User name. Back sensor and Front sensor represent the entry vehicle or exit vehicle. G_LED and R_LED represents the vehicle parking.

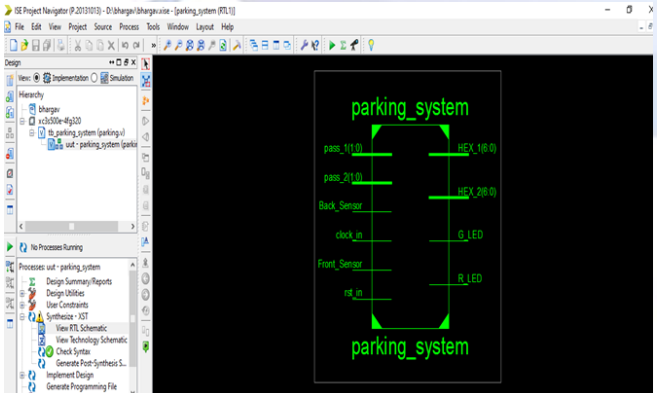

Figure 6: Block diagram of the proposed system

RTL schematics depict the digital logic at a higher abstraction level, showing the flow of data between registers and logic elements. This representation is vital for understanding the data flow within the circuit, facilitating optimization, synthesis, and ensuring proper mapping of the design to hardware. Figure 7 shows the RTL schematic of the proposed parking system.

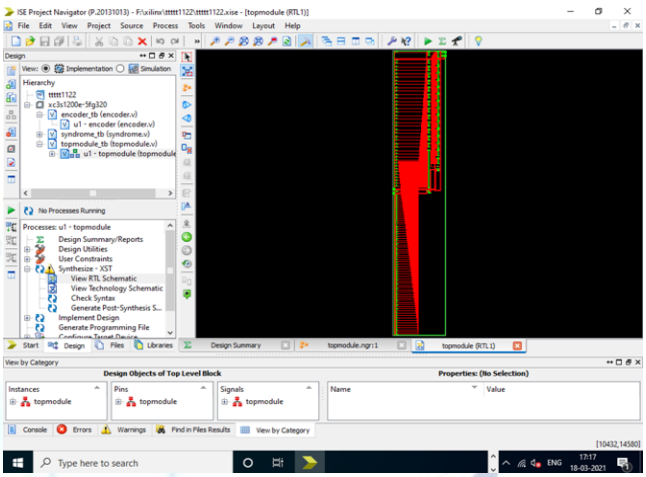

Figure 7: RTL Schematic of the proposed system

Delay estimation is essential for ensuring that the designed circuit meets timing requirements. It helps identify and address timing issues such as setup and hold time violations, ensuring that signals propagate through the circuit within the specified time constraints. Figure 8 presents the delay estimation of the proposed system. The delay in the circuit is 5.44ns.

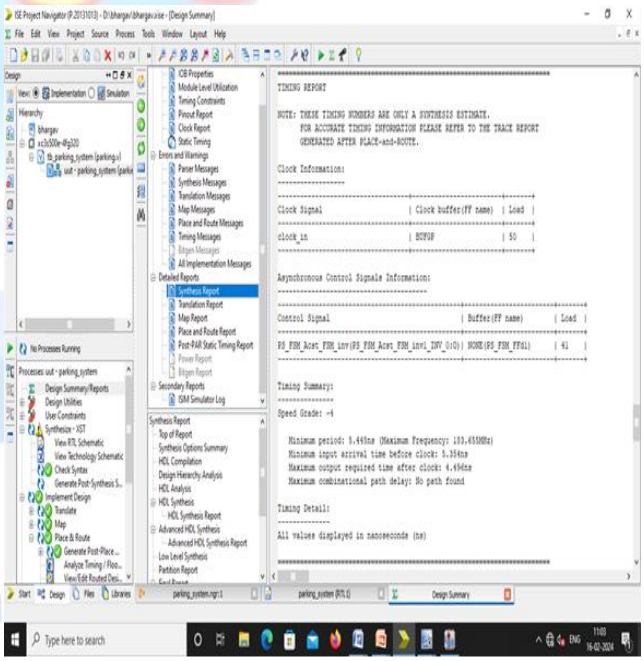

Figure 8: Delay estimation of the proposed system

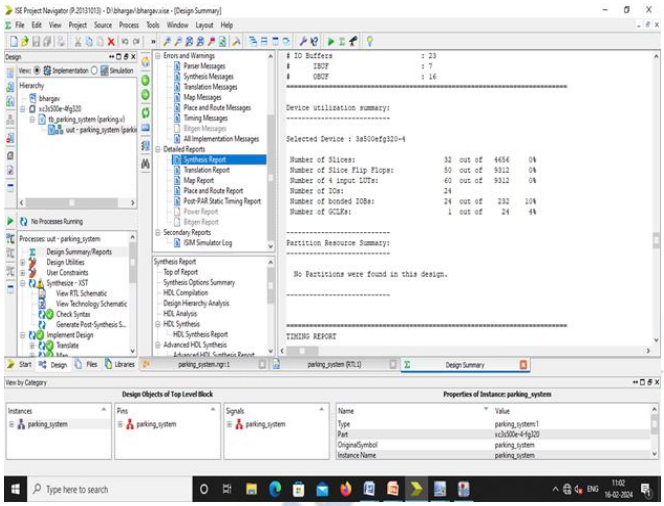

Figure 9: Device utilization summaryof the proposed parking system

Area estimation provides insights into the physical space occupied by the designed circuit on the semiconductor. It is crucial for optimizing the use of resources and determining the overall size of the chip. Efficient area utilization contributes to cost-effectiveness and manufacturability. Figure 9 presents the area estimation of the proposed system. The area report shows that it contains 60 look up tables.

5. CONCLUSIONS

This design aimed to solve the issue of car parking system by proposing a simulation-based approach with the feature of identifying the availability for multiple slots. The system caters to a wide range of issues. Device utilization was found to be much lower in comparison to the existing models. It is a safe and cost-effective personalized parking solution that focuses on the fundamental principle of saving time while parking. Because the majority of the operation is hardware based, maintaining the network of incoming and outgoing cars is also relatively simple. The concept also promotes quick parking..

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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