Design and Simulation of a Specification based Vending Machine using Verilog HDL

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***Abstract*—A vending machine is a dispensing system that takes input in the form of currency or credit and dispense items such as food, beverages, consumer products and other purchasable items. Nowadays, vending machines are used in many countries as they are very useful in modern lifestyle. At present time in Bangladesh, it can only be seen in ATM booths and more application should be done for advancement in the country. Hence, this paper is based on the design of a Bus Ticket Vending Machine in Dhaka city using Verilog HDL which dispenses purchasable bus tickets when a user inputs currency in the form of Taka. The proposed concept is to convert the manual work in traditional ticket system into automation. It shall facilitate for Dhaka city passengers which will give service from Badda to Uttara one way route. As the design is based on Verilog HDL, it can be reprogrammed to incorporate the whole bus route system of Dhaka City so as to improve the current situation of public bus transport sector for passengers. Moreover, to validate the design some software tools like ModelSim and Xilinx have been used**

***Index Terms*—Vending Machine, Verilog, FSM, ModelSim, Xilinx**

I. Introduction

The first commercial coin-operated vending machines were introduced in London, England selling post cards [2][3]. Soon it advanced to many commercial use such as vending can drinks and snacks, train tickets in train stations and other consumer products. Also, the mode of vending input developed from cash to card system [5]. In Bangladesh, only one type of vending machine can be seen. It is the cash vending machine which is used in ATM booth where the input is the debit card and the output is the cash based on the selections made by the user. To facilitate more services and products, such vending machines should be implemented and interfaced in various applications of this country.

In recent times, Bangladesh is seeking technological advancement to control the systems of our country efficiently. One such advancement is essential in the transport system. In bus transport service, the exact sales of the bus tickets are not recorded in the account of the bus service company as some cash are unethically taken away by the ticket seller in the bus counters or the bus driver's helper inside bus. Some passenger purchase false tickets from the bus driver's helper which are not recorded in sales accounts of the bus company. Hence, the bus ticket system has become corrupted with unethical activities.

Therefore, to stop such unethical activities, a self-service ticket vending machine can be introduced and it's design has been implemented in this paper.The proposed algorithm for FPGA based vending machine is a sequential circuit which is based on Mealy Model [1][4][6]. This machine can take cash from the passenger and can give purchasable tickets to the passenger based on the traveling price from one station to another. The design of this vending machine can be implemented on FPGA board which has the advantage over micro controllers to re-program the whole architecture [3] if the number of stations needs to be increased.Compared to FPGA based machine, CMOS and SED based machine are more time consuming [3]. Hence, Verilog HDL language has been used to construct this self-service ticket vending machine and to validate the design some software tools like ModelSim and Xilinx have been used.

II. The Design Implementation Specifications

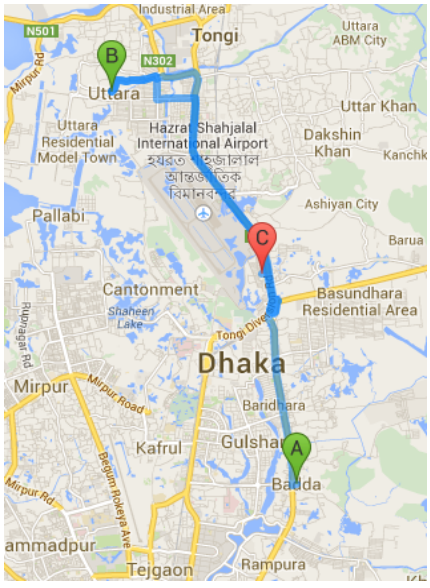

Fig. 1: Bus Route Map from Badda to Uttara (Google Map)

The self-service bus ticket vending machine has the following design specifications:

1) It shall facilitate for Dhaka city passengers which will give service from Badda to Uttara one way route.
2) The user shall input money in the form of taka.
3) The input money shall be of 2 types that is Tk 10 and Tk 20.
4) The input money of Tk 10 can be put into the machine once or twice at a time but Tk 20 can be put once only at a time.
5) The bus ticket vending machine shall be placed in Badda (as shown in Fig 1 from point A to C).
6) The items purchased shall be of 2 tickets. One ticket shall be from Badda to Khilkhet (as shown in Fig 1 from point A to C) worth Tk 10 and the other ticket shall be from Khilkhet to Uttara (as shown in Fig 1 from point A to B) worth Tk 20.
7) No money shall be returned back.

III. Encoding and State Diagram Of Self-Service Bus Ticket System

The system supports the purchase of two tickets for two bus stations on the one way route from Station A which is Badda to Station B which is Uttara while passing through Station C which is Khilket. The system will be installed in station A from where the passengers can purchase bus tickets. The price of ticket1 from Station A to C is Tk 10 and of ticket2 which is from Station A to B is Taka 20. The money used as input are taka 10 which is t10 and taka 20 which is t20. If no money (t0) is given into the machine, no output will be given. The binary list of input, state and output are shown in Figure 2. After synthesizing the HDL verilog file, the Register Transfer Level (RTL) schematic diagram is shown in Figure 3.

Input	Taka[1:0]	Output	Ticket	State	Money
t0	2'b00	none	2'b00	s0	Taka 0
t10	2'b01	ticket1	2'b01	s10	Taka 10
t20	2'b10	ticket2	2'b10	s20	Taka 20

Fig. 2: Input, Output and State Encoding

The system changes it's state on every transitions of positive edge of clock cycle represented by input clock. When reset is asserted, the system returns to initial state. The state diagram is shown in Figure 4. The machine will be set to s0 at the beginning which is State 0 where the machine is reset for the passenger to use. When Taka 10 is given, the state changes from the state where there is no money in the Finite State Machine (FSM) that is s0 to the state where the FSM has taka 10 which is s10. If no more money is given, the FSM will give out ticket1 to the passenger and the state will change from s10 to s0 resetting back again. Whereas, if the user gives another Taka 10 immediately after the first input of Taka 10 into the FSM, then the state will change from s10 to s20 . On the other hand if the user gives Tk 20 after reset as the first input into the FSM, the state will change from s0 to s20 immediately. The state s20 means that the FSM has taka 20 into the system and so it will give out ticket2 to the passenger and then reset back to s0 such that other passengers can purchase bus tickets.

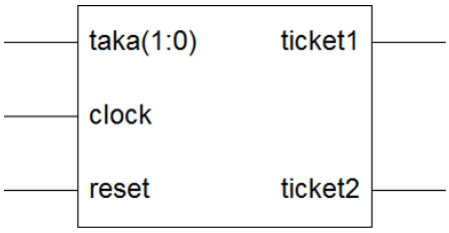

Fig. 3: RTL Schematic Diagram

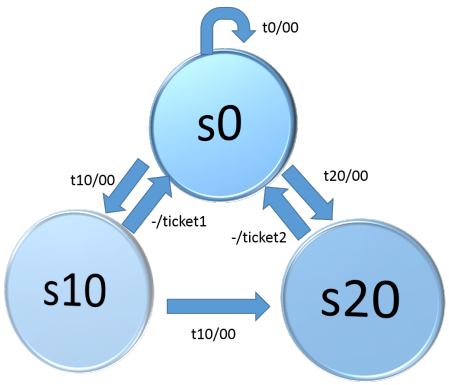

Fig. 4: State Diagram

IV. Simulation Results

The implemented design of the bus ticket vending machine is simulated using Xilinx CAD tool. The result is shown in figure 5 where after reset, in the negative edge of clock when the user gives taka 10 (2'b01) as input and then after the next clock pulse if no taka (2'b00) is given, then ticket1 is given as output. This is shown in the graph in Figure 5 where ticket1 is high. Then, the state transition occur in the FSM from s10 to s0, where the system is reset back to initial state. Hence, after the next clock pulse in negative edge of clock, when the user gives taka 20 (2b10) and no more taka is given, ticket2 is given as output which is shown in the graph as ticket2 gets high.

The Gate Level Schematic of Self-Service Bus Ticket Vending Machine is shown in figure 6. This can be implemented in hardware for physical implementation which can then be used for final simulation which is the final

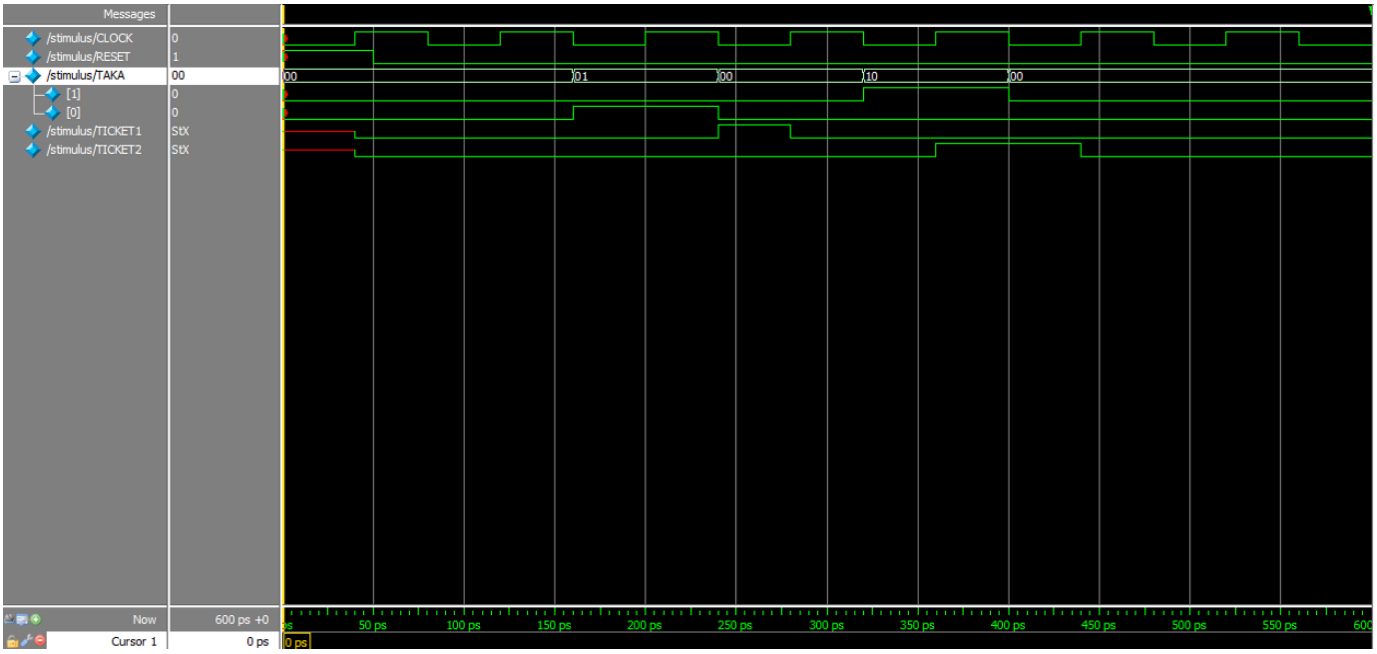

Fig. 5: ModelSim Simulation Graph

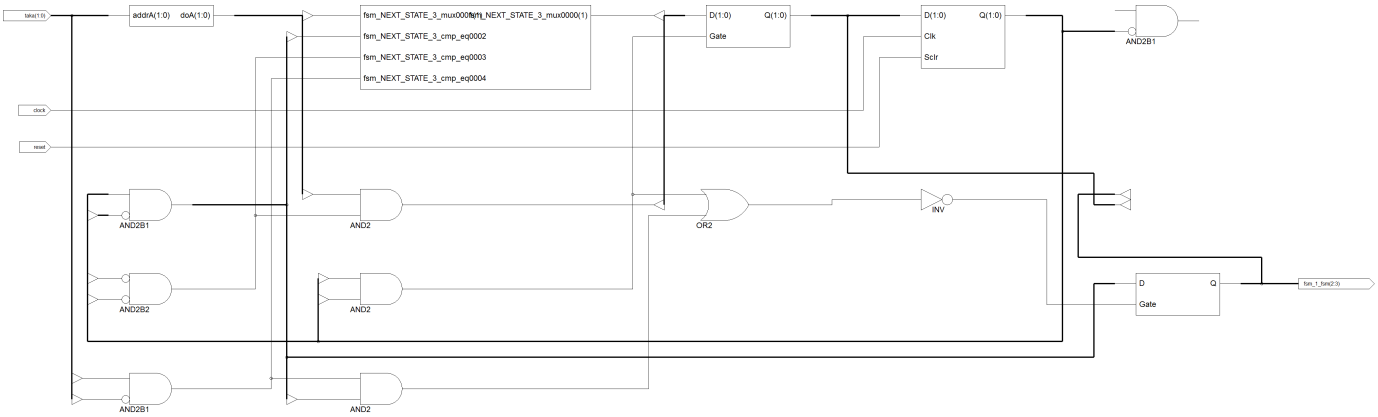

Fig. 6: Gate Level Schematic of Self-Service Bus Ticket Vending Machine

product analysis in real life application .

V. Associated Benefits, Drawbacks and Adjustments

The benefits of installing ticket vending machine in a country are numerous which has been supported by the present use of such systems in cities like New York, Singapore, Austin etc. Using automatic ticket systems helps in avoiding confrontation between the supervisors and passengers, handling of data becomes safer and easier, also it saves personnel costs of transportation authorities [9]. Moreover, this bus ticket vending machine can be frequently updated with new routes and price rates by simply adjusting the Verilog HDL description that has been used to design the system.

Compared to food vending machine, ticket vending machine are less likely for theft or hack. However, the fact that thieves are very attentive towards the deposited money in the machine cannot be overlooked. Thus, smart card can be substituted [7] as payment method into the system. As it is an external input, there will not be any significant change in the Verilog HDL description that has been used in designing the system but some changes will be required in the external design of the vending machine. Moreover, smart card usage can eliminate the extra provision required for cash back facility. Nonetheless, environmental pollution can be reduced by avoiding paper tickets. All these positive benefits made the incorporation of smart card in vending machine common in almost all the developed countries of the world. Additionally, recent research made RFID printable smart card more cost effective, economically feasible and user friendly [9] than the

available smart card.

On the other hand, to avoid lining up to purchase tickets and to eliminate paper tickets, cities like Austin in Texas have implemented mobile ticketing rather than using vending machine. The use of such system in countries like Bangladesh will require advanced information technology system and all the present public bus have to be replaced with technology incorporated bus. This may be expensive in the short run and thus ticket vending machine is comparatively more suitable in terms of investment cost in our country.

As the technological literacy of Bangladesh is not strong, which includes the ability to use computers and other consumer electronics products, the user interface should be kept simple and should contain both English and Bangla as language of content on the display screen. This user friendly interface becomes more relevant among older generation people. When developing the new layout, it will be important to ensure that people who are nervous of the ticket machines are given the feeling that they can master the task easily and without the help of others. As initial steps, the choice of options could be better structured and a clearer visual demarcation introduced between higher level menu elements[8]. Nevertheless, one drawback of the ticket vending machine is the lack of alternative to the touchscreen which makes it impossible to be used by the blind and visually impaired people.

VI. Conclusion

Therefore, it can be concluded that this Bus Ticket Vending Machine is executable into a user friendly system in countries like Bangladesh, as the simulation analysis validates the design specifications. The user can use this design to purchase two possible tickets based on two installed routes. However, the design in this paper can be advanced and expanded with the incorporation of other stations and two way route into the system. This can be done by adding the bus routes in the Verilog HDL description that has been used in the system design of this paper. Also, the bus fares can be updated in the system design whenever required. A prototype can be implemented on an FPGA board to analyze field observations and make possible adjustments in the HDL description before making the final product.

The designed bus ticket vending machine can contribute to solve a major management public transportation problem in Bangladesh. The conversion from manual ticketing to automation can help the transportation authority to manage accurate sales data and can reduce forgery. As purchase records are made internally by the vending machine, maintaining accounts will become easy and less time consuming. The transportation authority will be able to cut down the expense of ticket salesman and bus helper but on the other hand will have to employ a technician who will be responsible to maintain and repair these bus ticket vending machine. Additionally, if a bar code can be printable on the tickets which shall be read by the scanning machine fixed into the entrance and exit doors of the bus, then a passenger cannot enter or exit from the bus without a valid ticket. Furthermore, the bus can be technologically advanced where if all the seats are filled then the entrance door will not open even if a ticket is scanned. Thus, the system will become more efficient by assuring the customer requirement of getting a bus seat rather than standing on motion bus. This will improve the current scenario of the bus transport system in Dhaka city as overloading can be completely eliminated.

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