Khulna University of Engineering & Technology

Department of Computer Science and Engineering

Report Title: Design and Simulation of a Vending Machine in Verilog

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Project Title: Design and Simulation of a Vending Machine in Verilog.

Objectives

1. To design and simulate a digital vending machine system.
2. To implement a state-based mechanism for product selection, payment, and change return.
3. To ensure user-friendly features, including canceling transactions and returning change.

Introduction

A vending machine is a convenient and automated device for dispensing products after receiving appropriate payment. In this project, we designed and simulated a digital vending machine using verilog in Active-HDL. The vending machine supports:

- Multiple product selections based on unique codes.
- Acceptance of any amount of money.
- Dispensation of products and returning change.
- Transaction cancellation functionality.

The project is modeled using a finite state machine (FSM) to ensure a structured transition between states and accurate handling of inputs and outputs.

Project Description

The vending machine system is capable of performing the following tasks:

1. **Product Selection:** Customers select a product using a unique code.
2. **Money Acceptance:** Accepts any amount of money.
3. **Customized Product Selection:** Allows customers to choose from three products with distinct prices.
4. **Returning Change:** Dispenses change if the inserted money exceeds the product's price.
5. **Cancel Transaction:** Returns inserted money if the transaction is canceled.

Features Implemented:

- **Input Parameters:**
  - Price (P) — Price of the product.
  - Quantity (Q) — Quantity to be purchased.
  - Money (M) — Inserted amount.
- **Outputs:**
  - Dispensed product (1 or 0).
  - Returned change (difference between money inserted and total cost).

The system's operations are modeled using a state diagram and flowchart, ensuring logical and error-free transitions.

State Diagram

The state diagram of the vending machine is structured as follows:

1. **T0 (Initial State):**
    - The system initializes, setting all variables (e.g., x = 1).
    - Awaits product selection.
2. **T1 (Product Selection):**
    - User selects a product by entering the unique product code.
    - Transitions to the payment state.
3. **T2 (Input Money):**
    - The user inputs the required amount (M).
    - Calculates the total cost ('price * quantity').
4. **T3 (Cost Verification):**
    - Compares the inserted amount (M) with the total cost:
        - **Condition:** If money >= total, transitions to state T5.
        - **Else:** Transitions to T4 for cancellation or adjustment.
5. **T5 (Change Return):**
    - Returns change if money > total (i.e., return = money - total).
    - Proceeds to product dispensing state.
6. **T6 (Dispense Product):**
    - The selected product is dispensed to the user.
    - Transitions to the final state.
7. **T4 (Transaction Cancel):**
    - Returns the entire inserted money to the user if money < total or the user cancels the transaction.
8. **T7 (Final State):**
    - The machine resets for the next transaction.

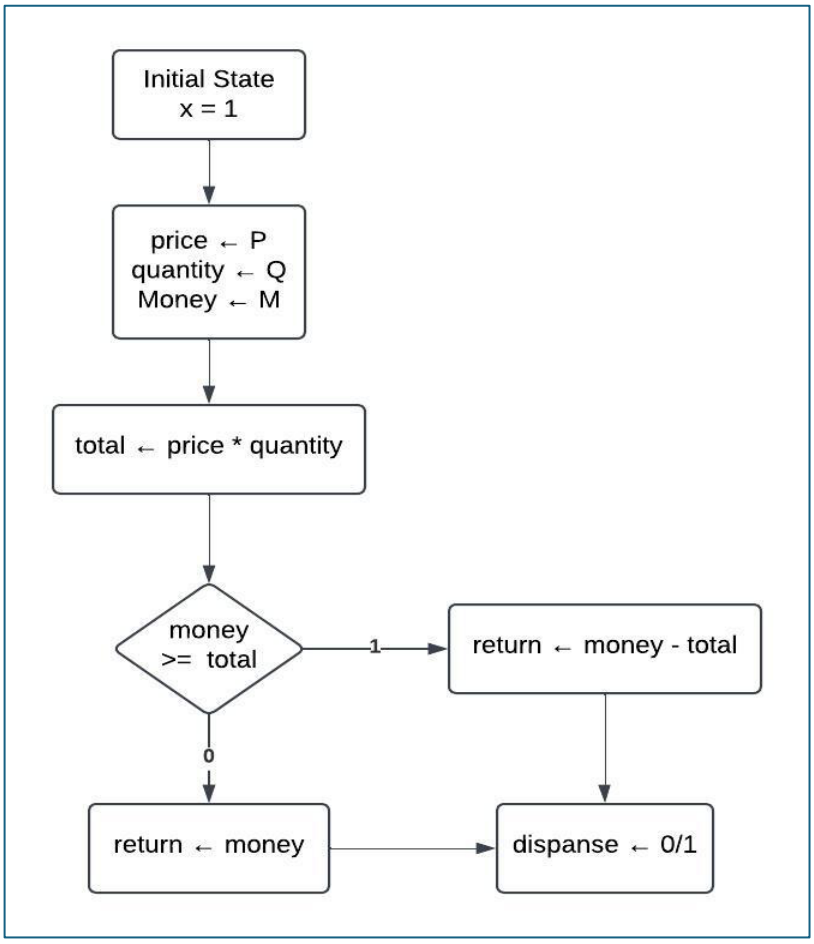

Figure 1: Flow Diagram

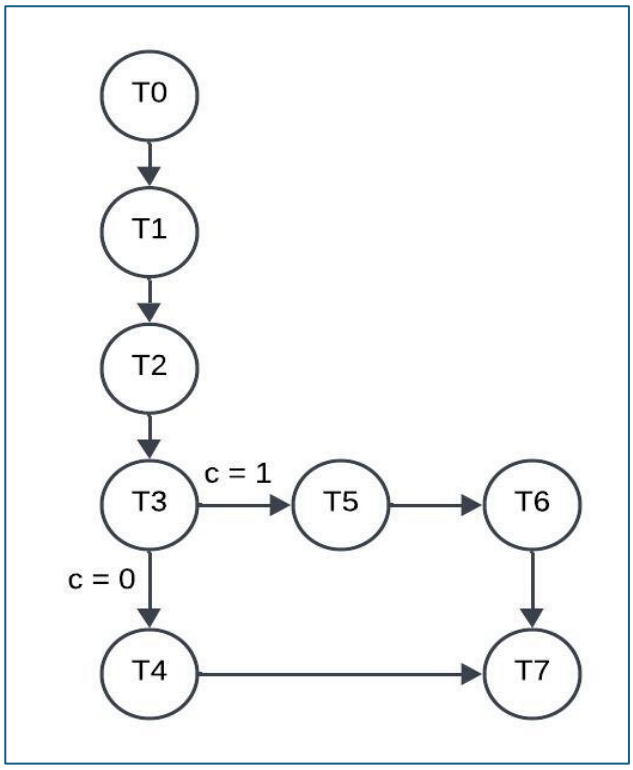

Figure 2: State Transition Table

State Transition Table:

Present State Q2 Q1 Q0	C	Next State Q2 Q1 Q0	D2 D1 D0
0 0 0	x	0 0 1	0 0 1
0 0 1	x	0 1 0	0 1 0
0 1 0	x	0 1 1	0 1 1
0 1 1	0	1 0 0	1 0 0
0 1 1	1	1 0 1	1 0 1
1 0 0	x	1 1 1	1 1 1
1 0 1	x	1 1 0	1 1 0
1 1 0	X	1 1 1	1 1 1

Equations:
D2 = Q2'Q1Q0C' + Q2'Q1Q0C + Q2Q1'Q0' + Q2Q1'Q0 + Q2Q1Q0'
D1 = Q2'Q1'Q0 + Q2'Q1Q0' + Q2Q1'Q0' + Q2Q1'Q0 + Q2Q1Q0'
D0 = Q2'Q1'Q0' + Q2'Q1Q0' + Q2'Q1Q0C + Q2Q1'Q0' + Q2Q1Q0'

After simplification:
D2 = Q1 (Q2 ^ Q0) + Q2Q1'
D1 = Q1Q0
D0 = Q0' + (Q2'Q1Q0C)

Discussion

The state-based design of the vending machine ensures an efficient and logical flow of operations, seamlessly handling user inputs and delivering appropriate outputs. By utilizing a finite state machine (FSM), the project demonstrates structured state transitions that simplify debugging and enhance system reliability. The ability to manage edge cases—such as insufficient funds or canceled transactions—reflects the robustness of the design. Furthermore, features like change return and product dispensing add significant convenience for users. However, during the design phase, challenges were encountered in handling simultaneous inputs and ensuring smooth transitions between states. These challenges were mitigated by thorough testing and systematic debugging. While the current system performs its intended tasks effectively, potential improvements include adding more sophisticated payment options (e.g., credit cards or digital wallets) and expanding the product range. This project highlights the practical application of digital design principles to solve real-world automation challenges, demonstrating the versatility and efficiency of FSM-based approaches.

Conclusion

The vending machine design successfully demonstrates the application of FSM in solving practical problems. The implemented features, such as product selection, change return, and transaction cancellation, make the machine user-friendly and reliable. Future improvements can include support for advanced payment options and additional product categories. The project illustrates how digital system design principles can be applied to real-world automation systems.