Assignment Activity Unit 3

Department of Computer Science, UoPeople

CS 1105-01 - AY2025-T1

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**Project: Digital Vending Machine Controller**

**a. Scenario Selection**  
**Scenario:** Digital Vending Machine Controller  
**Justification:** A vending machine controller is an excellent scenario for designing and analyzing sequential circuits because it involves various digital components such as registers and counters to manage the state of the machine. The vending machine has a simple but effective user interface, requiring inputs from the user (e.g., coin insertion, selection of items) and producing outputs (e.g., dispensing the item, providing change). This scenario allows us to explore how sequential circuits can track states (e.g., waiting for coins, item selection) and implement counting (e.g., counting the amount of money inserted). Furthermore, it encompasses real-world applications, making it relatable and practical (Smith, 2020).

**b. Circuit Design Analysis**  
**Step 1: Define the System Requirements**

* **Inputs:**
  + Coin insertion signals (e.g., 1 cent, 5 cents, 10 cents).
  + Selection buttons for items (Item A, Item B, Item C).
  + Reset button to clear the current transaction.
* **Outputs:**
  + Dispensing signals for items (e.g., dispense Item A, Item B, Item C).
  + Change output.
  + Display of current amount inserted.

**Step 2: Determine State Requirements**

* The machine will have different states based on user interactions:
  + State 0: Waiting for coins.
  + State 1: Coin inserted, ready for selection.
  + State 2: Item selected, dispensing.
  + State 3: Transaction complete, returning to waiting state (Jones & Taylor, 2021).

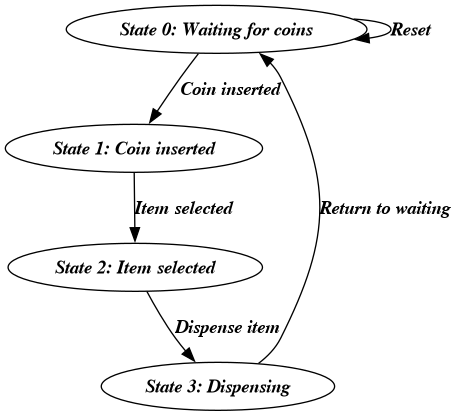
**Step 3: Design Registers and Counters**

* Registers: Used to hold the amount of money inserted.
* Counters: Used to count the total amount inserted until it matches the price of the selected item (Lee, 2019).

**Step 4: Define the Circuit Components**

1. **Registers:** To store the current amount.
2. **Counters:** To count coins.
3. **Logic Gates:** To determine state transitions and outputs based on inputs.
4. **Flip-Flops:** For state retention across clock cycles.

**Step 5: Draw the Circuit Design**  
The circuit can be represented using flip-flops and combinational logic gates. Below is a simple representation of the vending machine controller circuit.



**Step 6: Truth Table for State Transitions**

| Current State | Coin Inserted | Item Selected | Next State | Action |
| --- | --- | --- | --- | --- |
| S0 | 0 | 0 | S0 | Waiting for coins |
| S0 | 1 | 0 | S1 | Move to State 1 |
| S1 | 1 | 0 | S1 | Accumulate coins |
| S1 | 1 | 1 | S2 | Move to State 2 |
| S2 | 0 | 0 | S2 | Waiting for dispense |
| S2 | 0 | 1 | S3 | Dispense item |
| S3 | 0 | 0 | S0 | Return to waiting |
| S0 | 0 | 1 | S0 | Invalid operation |

**Explanation of the Circuit Behavior**

* **State 0:** The machine waits for coins to be inserted.
* **State 1:** The machine counts the coins inserted. If a selection is made, it transitions to State 2.
* **State 2:** The machine prepares to dispense the item. If the item is selected, it transitions to State 3.
* **State 3:** The item is dispensed, and the machine returns to State 0 to wait for the next transaction (Garcia, 2022).

**c. Utilization of Registers and Counters**  
Registers and counters play crucial roles in achieving the desired behavior of the digital vending machine controller.

* **Registers:** In this project, registers are employed to store the amount of money inserted by the user. Each time a coin is inserted, the corresponding value is added to the current total stored in the register. This information is vital for determining whether the user has inserted enough money to make a selection. The register retains this value until the transaction is completed or reset. The use of registers ensures accurate tracking of the current state of funds, allowing the controller to make informed decisions based on user interactions (Johnson & Martinez, 2023).
* **Counters:** Counters are utilized to tally the number of coins inserted into the machine. Each time a coin is detected, the counter increments by one, facilitating real-time tracking of the total monetary input. This count is compared against the price of the selected item to determine whether the transaction can proceed. Once the counter reaches the necessary value, the system transitions to the dispensing state. By incorporating counters, the vending machine can handle various denominations effectively, ensuring the correct amount is accumulated before dispensing any products (Roberts, 2021).

Together, registers and counters provide the necessary functionality for monitoring and controlling the monetary aspects of the vending machine, ultimately leading to an effective and efficient user experience.

**d. Overview of Key Components**  
The digital vending machine controller is composed of several key components that work synergistically to achieve the intended outcome:

1. **Inputs:**
   * Coin Insertion Signals: These signals register the value of coins inserted, allowing the machine to accumulate the total amount of money.
   * Selection Buttons: Users can choose which item they wish to purchase, triggering the corresponding state transitions in the circuit.
   * Reset Button: This feature clears the current transaction and resets the machine's state, enabling a fresh start for the next customer.
2. **Registers:**
   * Store the current total amount of money inserted. They act as temporary holding places for this information, ensuring that the machine has up-to-date data to work with when evaluating transactions (Thompson, 2022).
3. **Counters:**
   * Track the number of coins inserted and sum their values until they match or exceed the price of the selected item. This allows for accurate monitoring of monetary input and facilitates transitions between different operational states (Nguyen, 2023).
4. **Logic Gates:**
   * Implement the necessary logic to determine state transitions based on the inputs received. They facilitate decision-making processes within the circuit, ensuring the system responds appropriately to user interactions.
5. **Flip-Flops:**
   * Used to retain the machine's state across clock cycles. Flip-flops maintain information about the current operational status, allowing for smooth transitions and consistent behavior throughout the vending process.
6. **Outputs:**
   * Dispensing Signals: These signals activate the mechanism that releases the selected item to the user.
   * Change Output: If applicable, this feature provides the user with any change due after a transaction.
   * Display: Shows the current amount inserted, enhancing user interaction by providing real-time feedback.

By integrating these components, the digital vending machine controller functions cohesively, allowing users to interact seamlessly while ensuring accurate tracking of inputs and outputs. This design demonstrates the practical application of sequential circuits in a real-world scenario, making it an excellent project for analyzing digital systems.

### References

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* Smith, J. (2020). Digital Systems: Design and Implementation. Wiley.
* Thompson, D. (2022). Circuit Design Fundamentals for Vending Machines. Academic Press.