Certified LabVIEW Architect Examination

Examinee _____ Date: _____

Administrator _____ Date: _____

Instructions:
If you did not receive this exam in a sealed envelope stamped "NI Certification," **DO NOT ACCEPT** this exam. Return it to the proctor immediately. You will be provided with a replacement exam.

- **Please do not detach the binding staple of any section. If any part of the exam paper is missing or detached when returned to National Instruments, you will be deemed to have failed the exam**.
- This examination may not be taken from the examination area or reproduced in any way. You may not keep any portion of this exam after you have completed it.
- Please do not ask the proctor for help. If you believe the intent of any part of the exam is not clear, you may make appropriate assumptions. Please document your assumptions on the LabVIEW block diagram of the appropriate VI.
- The exam requires you to architect a LabVIEW application based on a set of requirements.
- A computer with a standard installation of LabVIEW is the only reference allowed for the examination. Externally developed code and third party tools are not allowed in the exam.
- You may use LabVIEW design patterns, templates, and examples available in the development environment as a guide/resource for the application development.
- The application architecture must be specifically developed for the exam submission.
- Submit your LabVIEW application on the USB memory stick provided.
- Total time allocated for the exam: 4 hours
- Exam passing grade: 70%

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IMPORTANT:

- **When you have completed the exam, place the exam document, the USB memory stick with the saved application, and any deliverables in the envelope provided.**
- **Please SEAL the envelope.**
- **Give the sealed envelope to your proctor.**

Section I: Project Deliverables

For the purposes of this exam, you are required to design an architecture that covers all of the Project Specifications listed below. Your architecture should include implementations of the following key components:

- Project with hierarchy
- Main VI
- Shell (stub) modules and subVIs
- Interface for hardware
- Important data structures
- Inter-process communication mechanisms
- Application Programmers Interfaces (APIs) for all modules
- Error handling strategy
- Application shutdown strategy

Assume that specific algorithms, states, and functions will be implemented by a secondary developer. These do not need to be implemented as part of the test. However, for each requirement which is not implemented, you should include localized comments to a developer that describes a method for implementing the requirement.

Requirements Tracking

In order to demonstrate coverage of a requirement, you must include the ID of the requirement in the documentation of your architecture. Each requirement's ID precedes the requirement text in the specification below. You may cover requirements in any part of your architecture's documentation, including:

- VI Documentation Property
- Control Documentation Property
- Project or Library Documentation Property
- Comments on the front panel or block diagram

A single requirement may be covered by multiple sections of code if all of those sections are necessary to fulfill the requirement.

To cover a requirement, include the following text in the documentation of your code:

`[Covers: ID]`

A requirement tracking tool is used to verify your program, therefore, please be careful to use this exact syntax. You should also double-check that each requirement ID is correct.

> ***The provided USB memory stick contains a text file that has all of the Tags. This file is provided as a convenience for use in placing the tags in the application code.***

Grading:

The application architecture development exam consists of a total of 100 points which are allocated as follows:

- User interface and block diagram style : 10 points
- Documentation : 20 points
- Requirements coverage : 30 points
- Architecture development : 40 points

Section II: Automated Teller Machine (ATM) Project Specifications

Objective

Design a scalable, modular architecture in LabVIEW for an Automatic Teller Machine (ATM). The client has provided the following sketch of the user interface. The architecture will be distributed to a team of Certified LabVIEW Developers to work on one or multiple modules. Each module must have all of the instructions for the developer to complete the development and integration into the main project.

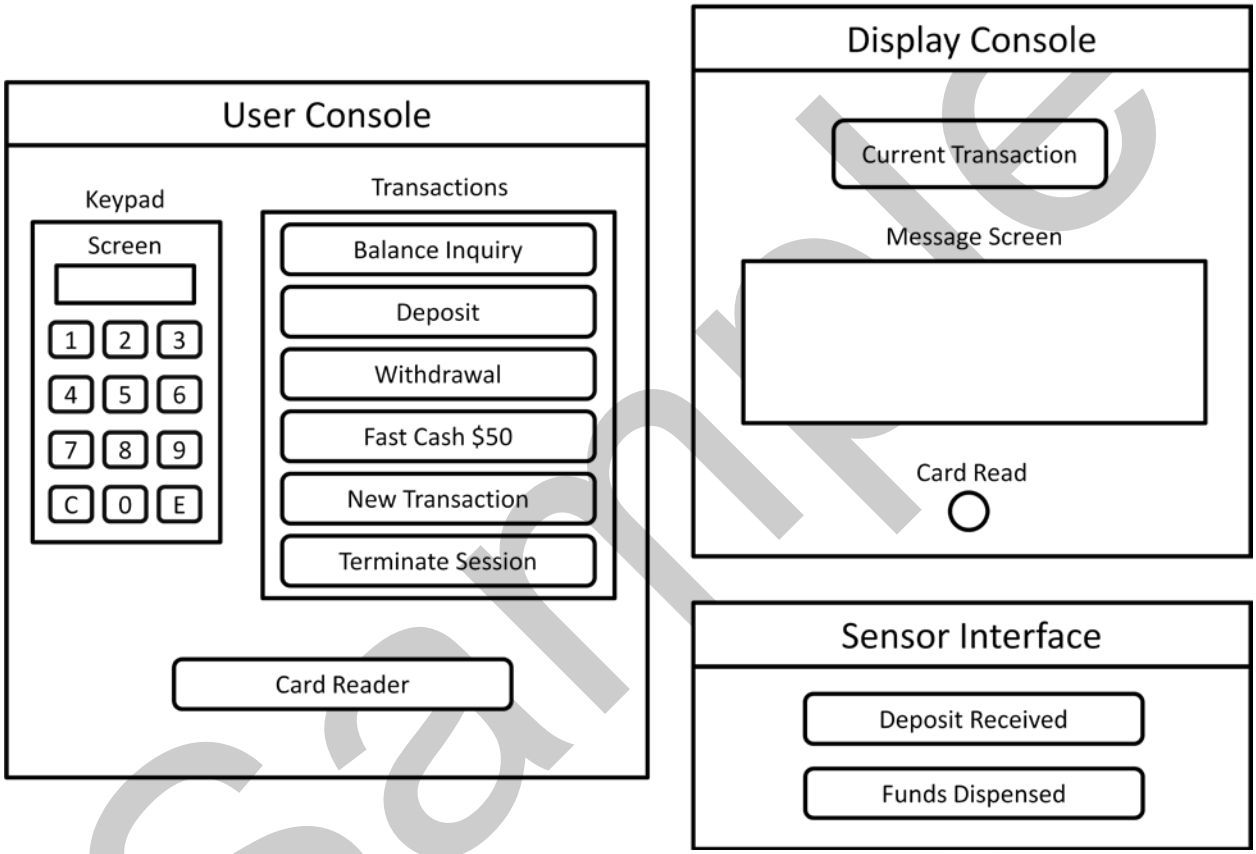

Figure 1: User Interface Sketch

Overview

The ATM processes transactions for balance inquiries, deposits, and cash withdrawals. The **User Console** is used to enter digits on the **Keypad**, initiate transactions, and recognize the insertion of a user's Bank Card. The **Display Console** displays the current transaction, ATM messages, and indicates a successful read of the Bank Card. The **Sensor Interface** is used to dispense cash and detect cash or check deposits. After completing one transaction, the ATM is ready to process another transaction.

Definitions

Application Simulation Interface
A program that is run to test ATM algorithms in a software-only environment.

ATM Controller
A software component that monitors and controls the transactions by interacting with the **User Console**, **Display Console**, and **Sensor Interface**. The ATM Controller module controls the transactions and performs the following main functions:

- Reads the Configuration Database to retrieve the user's identifying information and account balances.
- Verifies security by comparing **Keypad** inputs of the Account Number with the Configuration Database.
- Processes the following types of transactions:
  - Balance Inquiry
  - Deposit
  - Withdrawal
  - Fast Cash $50
  - New Transaction
  - Terminate Session
- Updates the **Display Console** and **Sensor Interface** while executing transactions.
- Gets transaction commands and data from the **User Console**.
- Displays messages on the **Message Screen**.

User Console
The interface where a user enters information and responds to system prompts. All references to the **User Console** apply to a Simulated or Physical User Console.

Simulated User Console

A software interface that simulates a Physical User Console.

Physical User Console

A hardware interface that includes physical controls that allows a user to interact with the ATM.

Display Console
The interface where a user receives status updates from the Controller. All references to the **Display Console** apply to a Simulated or Physical Display Console.

Simulated Display Console

A software interface that simulates a Physical Display Console.

Physical Display Console

A hardware interface that includes a physical display that allows a user to receive status updates from the Controller.

Sensor Interface

The interface where a user simulates the depositing of checks or cash and the dispensing of cash. All references to the **Sensor Interface** apply to a Simulated or Hardware Sensor Interface.

Simulated Sensor Interface

A software interface that simulates physical sensors.

Hardware Sensor Interface

The hardware interface that includes physical sensors and a data acquisition device.

Configuration Database

An interface that stores Account Number, Name, and Account Balance parameters for each user. All references to the Configuration Database apply to both the Simulated and Embedded Configuration Database.

Simulated Configuration Database Module

A software interface connected to a database that simulates an Embedded Configuration Database.

Embedded Configuration Database Module

A software interface that accesses the Embedded Configuration Database.

Terminology

The following is a description of the ATM terminology and operation. Specific details for timing, control and indicator behavior, database access, data calculations, and error handling are described in the *Requirements* section of this specification.

Session

A session begins when an ATM user inserts a Bank Card and finishes when the user completes their transactions with the ATM.

Verification Process

The Controller compares the Account Number entered with the available Account Numbers in the Configuration Database. If no match is found, the user is provided another opportunity. After 3 tries, the ATM terminates their session.

Simulation Interface

Due to the unavailability of a physical setup, the client has requested the application have simulations of each module. The simulated modules will be used to validate the ATM Controller logic and algorithms.

The simulated modules will be replaced with physical modules in a subsequent project phase. For each module, the client must have the ability to choose either a simulated or hardware module.

Requirements

Simulation Interface Requirements

SI1. The components of the Simulation Interface are separated from the ATM Controller by defined interfaces that simulate communication with the physical modules.

SI2. The Simulation Interface automatically loads the **User Console**, **Display Console**, **Sensor Interface**, Controller, and other modules upon startup.

User Interface Requirements

Develop the front panels using appropriate control types in order to meet requirements.

UI1. The Simulation User Interface mimics the *Figure 1* sketch.

The **User Console** is used to select transactions and interact with the ATM.

UI2. The ATM includes a **User Console** component.

UI2A. **Card Reader**. Pressing this control simulates the insertion of a Bank Card and the associated reading of the Account Number.

UI2B. **Keypad**. This control allows the user to enter Account Numbers and withdrawal or deposit amounts. Pressing a numeric key on the **Keypad** causes the number to display on the **Keypad Screen**.

- Pressing the **E** button on the **Keypad** signals to the ATM Controller that numeric entry is complete.
- Pressing the **C** button on the **Keypad** clears any entered numbers.

UI2C. **Transactions**. These controls allow a user to select a transaction.

The **Display Console** uses indicators to display the **Current Transaction**, messages on the **Message Screen**, and a successful reading of a Bank Card.

UI3. The ATM includes a **Display Console** component.

UI3A. **Card Read**. This indicator turns ON when a Bank Card is detected.

- This indicator turns ON when the **Card Reader** control is pressed on the **User Console**.
- The indicator turns OFF when the current session ends.

UI3B. **Current Transaction**. This indicator displays the most recent **Transaction**.

UI3C. **Message Screen**. This indicator displays messages for the user, as specified in *Table 1*.

The **Sensor Interface** simulates a user making a deposit or withdrawal from the ATM.

UI4. The ATM includes a **Sensor Interface** component.

UI4A. **Deposit Received**. Pressing this control simulates a sensor confirming a successful cash or check deposit.

UI4B. **Funds Dispensed**. Pressing this control simulates a sensor confirming successful cash dispense.

Initial State Requirements

This section defines how the ATM application is initialized when the Run button is pressed.

IS1. **User Console**:

- **Card Reader** control is enabled.
- **Keypad** control is disabled.
- All **Transactions** are disabled.

IS2. **Display Console**:

- **Card Read** indicator is OFF.
- **Current Transaction** indicator display is blank.
- **Message Screen** indicator displays the Welcome Message, as specified in *Table 1*.

IS3. **Sensor Interface**:

- All controls are disabled.

User Message Requirements

UM1. The ATM Controller stores a list of messages, as specified in *Table 1* below.

UM1A. Some messages contain parameters in *italics* that are dynamically replaced with data from the Configuration Database, or **Keypad** when displayed.

Message Name	Message Text
Welcome Message	Welcome to Acme Bank. Please insert your card.
Login Message	Please enter your Account Number on the keypad. Press Enter (E) when done. Account Number: [User-Entered]
Idle Message	Welcome to Acme Bank *First Name from DB, Last Name from DB* Please select a transaction by using the buttons.
Invalid Login Message	Account Information Incorrect Please re-enter your Account Number. Press Enter (E) when done. Account Number: [User-Entered]
Terminate Session Message	Your session has been terminated due to due to inactivity or menu selection. Goodbye!

Deposit Message	`Please enter amount to deposit and press Enter (E) when done.`
	
	`Deposit Amount: $[User-Entered]`

Withdrawal Message	`Please enter amount to withdraw and press Enter (E) when done.`
	
	`Withdrawal Amount: $[User-Entered]`

Fast Cash $50 Message	`Fast Cash $50 withdrawal processing`
Withdrawal Complete Message	`Please remove cash from the ATM.`
Withdrawal Failed Message	`Insufficient funds in account. Please check your account balance and try again.`
Balance Inquiry Message	`Your Balance is:` `$ (`*`Balance Amount from Database`*`)`

Table 1: ATM Messages

Idle State Requirements

ID1. The ATM process after login or after the user presses **New Transaction**.

ID1A. **User Console**:

- The **Card Reader** remains ON and is disabled.
- The **Keypad** is disabled.
- All **Transactions** are enabled.

ID1B. **Display Console**:

- The **Current Transaction** indicator displays `New Transaction`.
- The M**essage Screen** displays the Idle Message, as specified in *Table 1*.

ID1C. Wait for a **Transaction** to be pressed.

- Pressing **Balance Inquiry** starts the *Balance Inquiry State*.
- Pressing **Deposit** starts the *Deposit State*.
- Pressing **Withdrawal** starts the *Withdrawal State*.
- Pressing **Fast Cash $50** starts the *Fast Cash State*.
- Pressing **New Transaction** starts the *Idle State*.
- Pressing **Terminate Session** starts the *Terminate State*.
- If no **Transaction** is pressed within 10 seconds, the ATM starts the *Terminate State.*

Login State Requirements

LO1. The login process begins when the **Card Reader** control is pressed, simulating a Bank Card has been read by the **Card Reader**.

LO1A. **User Console**:

- The **Card Reader** control remains ON and is disabled.
- The **Keypad** is enabled.
- **Terminate Session** is enabled.
- All other **Transactions** are disabled.

LO1B. **Display Console**:

- The **Current Transaction** indicator display is blank.
- The **Message Screen** displays the Login Message, as specified in *Table 1*.
- **Card Read** indicator turns ON.

LO2. Controller waits for the user to enter their Account Number and press **E**.

- Pressing **E** starts the Verification process.
- Pressing **Terminate Session** starts the *Terminate State*.

LO2A. If no control pressed within 10 seconds, the ATM starts the *Terminate State*.

LO3. The Controller queries the Configuration Database for the entered Account Number.

LO3A. If the Account Number is found in the database start the *Idle State*.

LO3B. If a user enters an incorrect Account Number, the **Message Screen** displays the Invalid Login Message, as specified in *Table 1*.

LO3C. The Controller tracks the number of invalid login attempts.

LO3C1. After the 3rd consecutive invalid login, start the *Terminate State*.

LO3C2. After the 1st or 2nd invalid login attempt:

- The **Message Screen** displays the Login Message, as specified in *Table 1*
- Return to LO2 requirement.

Balance Inquiry State Requirements

BI1. The ATM process when the user selects **Balance Inquiry**.

BI1A. **Display Console**:

- The **Current Transaction** indicator displays `Balance Inquiry`.
- The **Message Screen** displays the Balance Inquiry Message, as specified in *Table 1*.

BI1B. Return to the *Idle State* if **New Transaction** is not pressed within 5 seconds.

Deposit State Requirements

DP1. The ATM process when the user selects **Deposit**.

DP1A. **User Console**:

- The **Keypad** is enabled.
- The **New Transaction** and **Terminate Session** controls are enabled.
- All other **Transaction** controls are disabled.

DP1B. **Display Console**:

- The **Current Transaction** indicator displays `Deposit`.
- The **Message Screen** displays the Deposit Message, as specified in *Table 1*.

DP1C. Enter the deposited amount on the **Keypad**.

DP1C1. A **Keypad** entry of **E** triggers a deposit.

DP1C2. The ATM waits for the **Deposit Received** control to be pressed. If not pressed within 10 seconds, start *Terminate State*.

DP1C3. The deposit amount entered on the **Keypad** is added to the user's Balance.

DP1D. Return to the *Idle State* if **New Transaction** is not pressed within 5 seconds.

Withdrawal State Requirements

WD1. The ATM process when the user selects **Withdrawal**.

WD1A. **User Console**:

- The **Keypad** is enabled.
- The **New Transaction** and **Terminate Session** controls are enabled.
- All other **Transaction** controls are disabled.

WD1B. **Display Console**:

- The **Current Transaction** indicator displays `Withdrawal`.
- The **Message Screen** displays the Withdrawal Message, as specified in *Table 1*.

WD1C. A **Keypad** entry of **E** triggers a withdrawal. The Controller:

- Reads the amount displayed on the **Keypad**.
- Compares the balance of the database record to the displayed amount.

WD1D. If there are sufficient funds:

- Modify the user's Balance in the Configuration Database.
- The **Message Screen** displays the Withdrawal Complete Message, as specified in *Table 1*.

- Wait for the **Funds Dispensed** control to be pressed, return to *Idle State*.
- If the **Funds Dispensed** control is not pressed within 5 seconds, return to *Idle State*.

WD1E. If there are NOT sufficient funds:

- Make no change to the Configuration Database.
- The **Message Screen** displays the Withdrawal Failed Message, as specified in *Table 1*.
- Return to the *Idle State* if **New Transaction** is not pressed within 5 seconds.

Fast Cash State Requirements

FC1. The ATM process when the user selects **Fast Cash**.

FC1A. **User Console**:

- The **New Transaction** and **Terminate Session** controls are enabled
- All other **Transactions** are disabled.

FC1B. **Display Console:**

- The **Current Transaction** indicator displays `Fast Cash $50`.
- The **Message Screen** displays the Fast Cash $50 Message, as specified in *Table 1*.

FC1C. Check if the Balance from the database record is sufficient.

FC1C1. If there are sufficient funds:

- Subtract $50.00 from the user's Account Balance in the Configuration Database.
- The **Message Screen** displays the Withdrawal Complete Message, as specified in *Table 1*.
- Wait for **Funds Dispensed** control to be pressed, and return to *Idle State*.
- Return to the *Idle State* if **New Transaction** is not pressed within 5 seconds.

FC1C2. If there are NOT sufficient funds:

- Make no change to the Configuration Database.
- The **Message Screen** displays the Withdrawal Failed Message, as specified in *Table 1*.
- Return to the *Idle State* if **New Transaction** is not pressed within 5 seconds.

Terminate State Requirements

TS1. The ATM process when the user selects **Terminate Session** or an error requires a termination to occur.

TS1A. Disable all **User Console** controls.

TS1B. **Display Console:**

- The **Current Transaction** indicator displays `Terminate Session`.
- The **Message Screen** displays the Terminate Session Message for 5 seconds.

TS1C. Return to *Initial State*.

Inactivity Timeout Requirements

IT1. If user activity is not detected after 15 seconds, the machine starts *Terminate State*.

Configuration Database Requirements

CD1. The file format of the database is appropriately chosen to support the following records:

CD1A. **Account Number**. 5 Digit Integer number

CD1B. **First Name**. Text, maximum of 256 characters

CD1C. **Last Name**. Text, maximum of 256 characters

CD1D. **Balance**. Fractional number with at least 9 integer digits and 2 decimal digits

CD2. The Controller reads and updates the Configuration Database.

CD2A. The ATM updates the Account Balance after a transaction.

CD3. The Configuration Database provides a mechanism to search for a record based upon an Account Number.

CD4. If the Configuration Database is not found, the Controller reads and uses default parameters.

CD5. The Configuration Database has an interface used by the Controller to read and update records.

Error Handling Requirements

The ATM has centralized error handling with three categories of errors.

EH1. **Console Error**. Provides a warning to the user. The user is notified of the error and the ATM continues operations without interruption.

EH1A. If an error occurs in the **Display Console**, the centralized error handler displays a notification dialog to the user. When the user clicks OK, the error clears and the ATM continues the last operation or process step.

EH1B. If an error occurs in the **User Console**, the centralized error handler displays a notification dialog to the user with the choice to clear or continue with the error.

EH1B1. If the error is cleared, the ATM continues the last operation or process step.

EH1B2. If the user continues, without clearing the error, the error is handled as a Process Step Error.

EH2. **Sensor Interface IO Error**. The Controller executes a *Terminate State.*

EH3. **Process Step Error**. The Controller executes a *Terminate State*.

EH4. **Error Log**. The error handling system maintains a log file. All errors are logged with the following data.

- The error log includes a description of each error that occurs.
- The error log includes the level of the error.
- The error log includes the time and date at which the error occurred.