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12.1 Case Study Introduction

Now we begin the *optional* portion of our object-oriented design and implementation case study. In this chapter and Chapter 13, you'll design and implement an object-oriented automated teller machine (ATM) software system. The case study provides you with a concise, carefully paced, complete design and implementation experience. In Sections 12.2–12.7 and 13.2–13.3, you'll perform the steps of an object-oriented design (OOD) process using the UML while relating these steps to the object-oriented concepts discussed in Chapters 2–10. In this chapter, you'll work with six popular types of UML diagrams to graphically represent the design. In Chapter 13, you'll tune the design with inheritance, then fully implement the ATM in a 673-line Java application (Section 13.4).

This is not an exercise; rather, it's an end-to-end learning experience that concludes with a detailed walkthrough of the complete Java code that implements our design. It will begin to acquaint you with the kinds of substantial problems encountered in industry.

These chapters can be studied as a continuous unit after you've completed the introduction to object-oriented programming in Chapters 8–11. Or, you can pace the sections one at a time after Chapters 2–8 and 10. Each section of the case study begins with a note telling you the chapter after which it can be covered.

12.2 Examining the Requirements Document

[*Note:* This section can be taught after Chapter 2.]

We begin our design process by presenting a **requirements document** that specifies the purpose of the ATM system and *what* it must do. Throughout the case study, we refer often to this requirements document.

Requirements Document

A local bank intends to install a new automated teller machine (ATM) to allow users (i.e., bank customers) to perform basic financial transactions (Fig. 12.1). Each user can have only one account at the bank. ATM users should be able to view their account balance, withdraw cash (i.e., take money out of an account) and deposit funds (i.e., place money into an account). The user interface of the automated teller machine contains:

- a screen that displays messages to the user
- a keypad that receives numeric input from the user
- a cash dispenser that dispenses cash to the user and
- a deposit slot that receives deposit envelopes from the user.

The cash dispenser begins each day loaded with 500 $20 bills. [*Note:* Owing to the limited scope of this case study, certain elements of the ATM described here do not accurately mimic those of a real ATM. For example, a real ATM typically contains a device that reads a user's account number from an ATM card, whereas this ATM asks the user to type the account number on the keypad. A real ATM also usually prints a receipt at the end of a session, but all output from this ATM appears on the screen.]

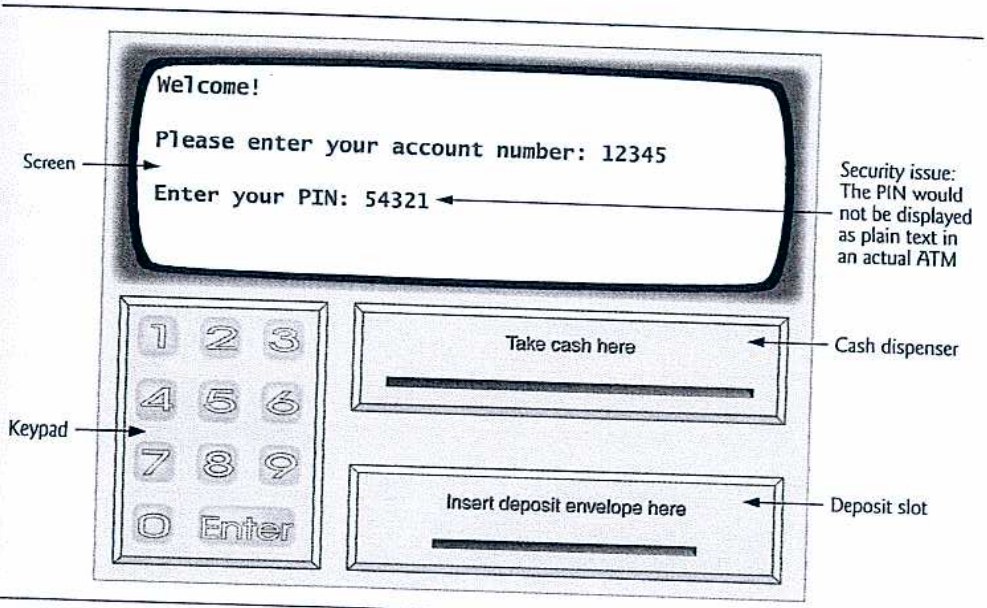

Fig. 12.1 | Automated teller machine user interface.

The bank wants you to develop software to perform the financial transactions initiated by bank customers through the ATM. The bank will integrate the software with the ATM's hardware at a later time. The software should encapsulate the functionality of the hardware devices (e.g., cash dispenser, deposit slot) within software components, but it need not concern itself with how these devices perform their duties. The ATM hardware has not been developed yet, so instead of writing your software to run on the ATM, you should develop a first version to run on a personal computer. This version should use the computer's monitor to simulate the ATM's screen, and the computer's keyboard to simulate the ATM's keypad.

An ATM session consists of authenticating a user (i.e., proving the user's identity) based on an account number and personal identification number (PIN), followed by creating and executing financial transactions. To authenticate a user and perform transactions, the ATM must interact with the bank's account information database (i.e., an organized collection of data stored on a computer; we study database access in Chapter 28). For each bank account, the database stores an account number, a PIN and a balance indicating the amount of money in the account. [*Note:* We assume that the bank plans to build only one ATM, so we need not worry about multiple ATMs accessing this database at the same time. Furthermore, we assume that the bank does not make any changes to the information in the database while a user is accessing the ATM. Also, any

business system like an ATM faces complex and challenging security issues that are beyond the scope of a first or second programming course. We make the simplifying assumption, however, that the bank trusts the ATM to access and manipulate the information in the database without significant security measures.]

Upon first approaching the ATM (assuming no one is currently using it), the user should experience the following sequence of events (shown in Fig. 12.1):

1. The screen displays `Welcome!` and prompts the user to enter an account number.
2. The user enters a five-digit account number using the keypad.
3. The screen prompts the user to enter the PIN (personal identification number) associated with the specified account number.
4. The user enters a five-digit PIN using the keypad.[1]
5. If the user enters a valid account number and the correct PIN for that account, the screen displays the main menu (Fig. 12.2). If the user enters an invalid account number or an incorrect PIN, the screen displays an appropriate message, then the ATM returns to *Step 1* to restart the authentication process.

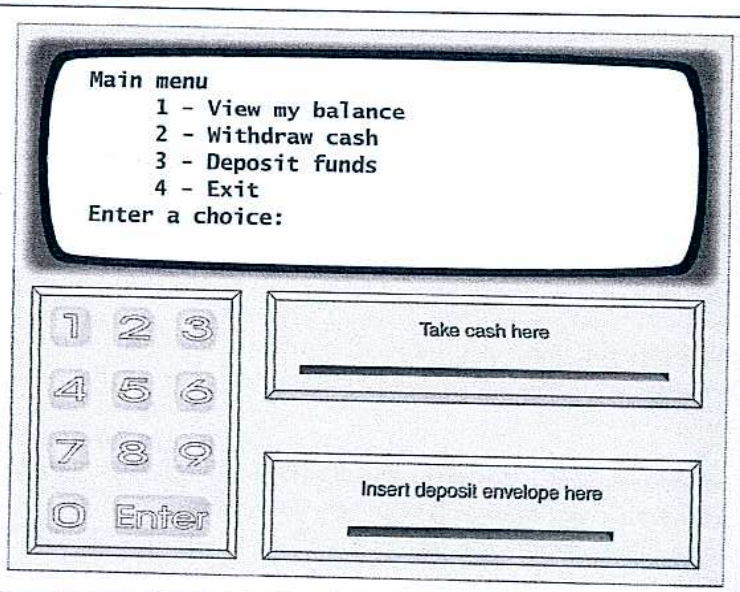

Fig. 12.2 | ATM main menu.

After the ATM authenticates the user, the main menu (Fig. 12.2) should contain a numbered option for each of the three types of transactions: balance inquiry (option 1),

1. In this simple, command-line, text-based ATM, as you type the PIN, it appears on the screen. This is an obvious security breach—you would not want someone looking over your shoulder at an ATM and seeing your PIN displayed on the screen. In Chapter 14, we introduce the `JPasswordField` GUI component, which displays asterisks as the user types—making it more appropriate for entering PIN numbers and passwords. Exercise 14.18 asks you to build a GUI-based version of the ATM and to use a `JPasswordField` to obtain the user's PIN.

withdrawal (option 2) and deposit (option 3). It also should contain an option to allow the user to exit the system (option 4). The user then chooses either to perform a transaction (by entering 1, 2 or 3) or to exit the system (by entering 4).

If the user enters 1 to make a balance inquiry, the screen displays the user's account balance. To do so, the ATM must retrieve the balance from the bank's database. The following steps describe what occurs when the user enters 2 to make a withdrawal:

1. The screen displays a menu (Fig. 12.3) containing standard withdrawal amounts: $20 (option 1), $40 (option 2), $60 (option 3), $100 (option 4) and $200 (option 5). The menu also contains an option to allow the user to cancel the transaction (option 6).

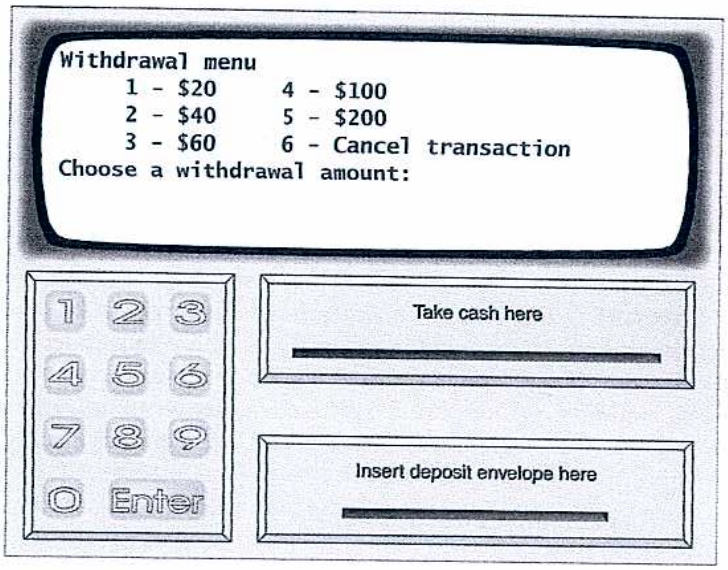

Fig. 12.3 | ATM withdrawal menu.

2. The user enters a menu selection using the keypad.
3. If the withdrawal amount chosen is greater than the user's account balance, the screen displays a message stating this and telling the user to choose a smaller amount. The ATM then returns to *Step 1*. If the withdrawal amount chosen is less than or equal to the user's account balance (i.e., an acceptable amount), the ATM proceeds to *Step 4*. If the user chooses to cancel the transaction (option 6), the ATM displays the main menu and waits for user input.
4. If the cash dispenser contains enough cash, the ATM proceeds to *Step 5*. Otherwise, the screen displays a message indicating the problem and telling the user to choose a smaller withdrawal amount. The ATM then returns to *Step 1*.
5. The ATM debits the withdrawal amount from the user's account in the bank's database (i.e., subtracts the withdrawal amount from the user's account balance).
6. The cash dispenser dispenses the desired amount of money to the user.

7. The screen displays a message reminding the user to take the money.

The following steps describe the actions that occur when the user enters 3 (when viewing the main menu of Fig. 12.2) to make a deposit:

1. The screen prompts the user to enter a deposit amount or type 0 (zero) to cancel.
2. The user enters a deposit amount or 0 using the keypad. [*Note:* The keypad does not contain a decimal point or a dollar sign, so the user cannot type a real dollar amount (e.g., $27.25). Instead, the user must enter a deposit amount as a number of cents (e.g., 2725). The ATM then divides this number by 100 to obtain a number representing a dollar amount (e.g., 2725 ÷ 100 = 27.25).]
3. If the user specifies a deposit amount, the ATM proceeds to *Step 4*. If the user chooses to cancel the transaction (by entering 0), the ATM displays the main menu and waits for user input.
4. The screen displays a message telling the user to insert a deposit envelope.
5. If the deposit slot receives a deposit envelope within two minutes, the ATM credits the deposit amount to the user's account in the bank's database (i.e., adds the deposit amount to the user's account balance). [*Note:* This money is *not* immediately available for withdrawal. The bank first must physically verify the amount of cash in the deposit envelope, and any checks in the envelope must clear (i.e., money must be transferred from the check writer's account to the check recipient's account). When either of these events occurs, the bank appropriately updates the user's balance stored in its database. This occurs independently of the ATM system.] If the deposit slot does not receive a deposit envelope within this time period, the screen displays a message that the system has canceled the transaction due to inactivity. The ATM then displays the main menu and waits for user input.

After the system successfully executes a transaction, it should return to the main menu so that the user can perform additional transactions. If the user exits the system, the screen should display a thank you message, then display the welcome message for the next user.

Analyzing the ATM System

The preceding statement is a simplified example of a requirements document. Typically, such a document is the result of a detailed process of **requirements gathering**, which might include interviews with possible users of the system and specialists in fields related to the system. For example, a systems analyst who is hired to prepare a requirements document for banking software (e.g., the ATM system described here) might interview banking experts to gain a better understanding of what the software must do. The analyst would use the information gained to compile a list of **system requirements** to guide systems designers as they design the system.

The process of requirements gathering is a key task of the first stage of the software life cycle. The **software life cycle** specifies the stages through which software goes from the time it's first conceived to the time it's retired from use. These stages typically include: analysis, design, implementation, testing and debugging, deployment, maintenance and retirement. Several software life-cycle models exist, each with its own preferences and specifications for when and how often software engineers should perform each of these stages.