Use Case and Sequence Diagram Tutorial

1 Use Case and Sequence Diagram Tutorial

This tutorial walks you through the development of a simple ATM from use cases to code. The following stages are covered:

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<td>• <strong>Identify the Use Cases</strong>: We identify the use cases that provide a good coverage to the requirements.</td>
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<td>• <strong>Writing the Use Cases</strong>: We now use textual modeling language FDL to define the use cases. The section also describes modeling of use cases with sequence diagrams. The following topics are covered:</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
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</tr>
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</table>
## Requirements

Here are the requirements for building an automated teller machine:

1. The **ATM** customer interface shall be equipped with a:
   a. **Magnetic strip card reader** for swiping ATM cards.
   b. **Keypad** for user data entry.
   c. **Display** for user feedback.
   d. **Envelope dispensing slot**
   e. **Printer** for printing customer receipts

2. The ATM keypad shall support the following keys:
   a. Numbers 0 to 9.
   b. “Enter” key to accept the transactions.
   c. “Cancel” key to cancel a transaction.

3. The ATM shall communicate to the **Bank** via the Internet.

4. The ATM **shall** perform the following authentication steps at the start of a **session**:
   a. The customer shall insert the ATM card.
   b. The ATM shall check the card integrity.
   c. The customer shall be prompted to enter the personal identification number (PIN).
   d. The ATM card number and the PIN shall be authenticated with the bank.
   e. The ATM shall abort the session if PIN authentication fails three times. (The PIN entered should match the PIN specified by the user.)

5. The ATM shall perform the following end of session steps:
   a. The ATM card shall not be released at session end if PIN authentication fails.
   b. When a transaction ends in error, appropriate error message shall be displayed on the screen and the machine shall transition to the initial menu.
   c. The ATM shall issue a printed receipt to the customer at the end of a successful session. The receipt shall contain:
      - Date and time,
      - Machine location,
      - Account information,
      - Amount of the transaction
      - Available balance

6. The ATM shall support the following **transactions**:
   a. Cash withdrawal from checking account.
   b. Cash deposit into customer checking account.

7. The ATM shall perform the following transaction verification steps:
   a. Cash withdrawal shall be allowed only after the bank permits the transaction.
   b. Presence of a cash/check envelope shall be checked before completing the bank transaction.
   c. Cash and check deposits shall be manually verified to ascertain that the amount entered by the user matches the cash/check value in the deposit envelope.
   d. The money transfer between checking and saving shall be verified by the bank.

8. The ATM shall support the following diagnostic features:
   a. **Logging** of all customer interactions
   b. Logging of all interactions with the bank
   c. The PIN for an ATM card shall not be logged.
3 Use Cases
The first step in the analysis is to develop a better understanding of the requirements by defining the use case diagrams.

3.1 Identify the Actors
Actors are entities that interact with the system under design.

The ATM is the system under design so we scan the requirements to identify entities that interact with the ATM. The actors have been marked in the requirements with bold-italics-underline.

| Customer | Customer needs to perform banking transactions using the ATM machine. |
| Bank | The bank serving this ATM. |

3.2 Identify the System Components
The requirements also give us a view into the components and entities in the system under design. We have identified the system components in the requirements with bold-underline.

| ATM | The ATM itself. |
| Card Reader | Card reader for swiping the ATM card. |
| Keypad | Keypad for entering numbers. |
| Display | Video display for the ATM. |
| Envelope Dispenser | Envelope dispenser for accepting cash and checks. |
| Printer | Printer for printing the receipt for the user session. |
| Session | A session is initiated when the user swipes the ATM card and ends when the user indicates that he or she is done. Multiple transactions may be performed in a single session. |
| Transaction | A banking operation involving the bank is defined as a transaction. A transaction might involve cash withdrawal, cash/check deposit, money transfer and balance enquiry. |
| Logger | Logs the results of all sessions for auditing transactions. |

3.3 Identify the Use Cases
Now we go through the requirements to identify the use cases that will give us a good coverage of the requirements:

- Customer withdraws cash
- Customer deposits cash
- Customer repeatedly enters invalid PIN

3.4 Writing the Use Cases
Let’s start with the customer initiated use cases. We will be writing these use cases in FDL the simple text based modeling language used in EventStudio.

3.4.1 Creating a Scenario Project
Before we get started with our use cases, we need to create a scenario project for the use cases. The following steps create a starter scenario project:

1. Invoke EventStudio from the Start Menu and select the "Scenario Project from Template" option.
2. Select the "Starter Scenario Project (Simple)" from the displayed dialog. Then click "Next".

3. EventStudio will display another dialog.
   a. Change the title of the new scenario project of "ATM Example Use Cases".
   b. Change the FDL file name to "Customer_Use_Cases".

5. Now move to the EventStudio main window and double click on the “Top” icon under the "Customer_Use_Cases" icon in the left pane (See the following figure). This opens "Customer_Use_Cases.fdl" file in the main workspace. We will be replacing the contents of this file in the following steps.
3.4.2 Representing the Actors and System Components

FDL allows you to partition your model into a three level hierarchy. At the highest level are modules. The system consists of modules. Modules contain processors and processors contain eternal and dynamic objects. We will be taking advantage of the hierarchical decomposition in the definition of the actors and the system.

We will decompose the use case entities into a three level hierarchy. At the highest level we have Actors and the System.

The second level further decomposes the system into smaller subdivisions. The Actors are further classified as Primary and Secondary Actors. The System is split into Input, Output and Controller.

At the third level we will define eternal and dynamic objects. Eternal objects represent entities that exist throughout the use case life time. Entities that are instantiated during the use case are modeled as dynamic objects. Actors identified in section 3.1 are modeled as eternal objects in the Primary_Actors and Secondary_Actors processors. System components identified in section 3.2 are modeled as eternal and dynamic objects. Note that Session and Transaction are defined as dynamic objects as they will be created during the use case.

The final use case entity organization is shown below:

<table>
<thead>
<tr>
<th>Actors</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Actors</td>
<td>Input</td>
</tr>
<tr>
<td>Customer</td>
<td>Card Reader</td>
</tr>
<tr>
<td>Bank</td>
<td>Keypad</td>
</tr>
<tr>
<td>Secondary Actors</td>
<td>Output</td>
</tr>
<tr>
<td>ATM</td>
<td>Display</td>
</tr>
<tr>
<td>Keypad</td>
<td>Printer</td>
</tr>
<tr>
<td>Card Reader</td>
<td>ATM</td>
</tr>
<tr>
<td>Display</td>
<td>Session</td>
</tr>
<tr>
<td>Printer</td>
<td>Transaction</td>
</tr>
<tr>
<td>Envelope Dispenser</td>
<td>Logger</td>
</tr>
</tbody>
</table>

Now let's map this into FDL:
/** Customer Use Cases */
module : Actors, System
processor : Primary_Actors in Actors
processor : Secondary_Actors in Actors
processor : Output in System
processor : Controller in System
eternal : Customer in Primary_Actors
eternal : Bank in Secondary_Actors
eternal : Card_Reader in Input
eternal : Keypad in Input
eternal : Envelope_Dispenser in Input
eternal : Display in Output
eternal : Printer in Output
eternal : ATM in Controller
dynamic : Session in Controller
dynamic : Transaction in Controller
eternal : Logger in Controller
feature "ATM Example: Customer Initiated Use Cases"
endfeature

Now replace the contents of Customer_Use_Cases.fdl (see section 3.4.1) with the FDL shown above.

The next step is to click the "Quick Save and Display" icon (Control-Q is the keyboard shortcut).
Click the "Quick Save and Display" icon. (Control-Q key shortcut may be used.)

EventStudio parses the FDL and generates a sequence diagram similar to the one shown below. Note that this diagram defines the entities organized hierarchically. An axis is drawn for each eternal object.

We have defined the architecture of the use case components. The next section describes modeling of the interactions in the use case diagram.

### 3.4.3 Entering the Use Case Interactions

Now let's define the core use case that handles a customer session and transactions. This use case will define the basis for the customer-initiated use cases identified in section 3.3.
We scan the requirements in section 1 to specify the interactions involved in setting up an ATM session followed by a single generic transaction.

The FDL representation of the use case is shown below. We have highlighted some of the important statements.

```fdl
feature "ATM Example: Customer Initiated Use Cases"
heading "Session start handling"
  "Insert Credit Card" : Customer -> Card_Reader
  (* The customer inserts the ATM card to start the ATM session. *)
  "Credit Card Swipe" ("ATM Card Number", PIN) : Card_Reader -> ATM
  (* The Card Reader in the ATM detects the credit card. *)
  ATM creates Session
  (* The ATM object has detected the start of a new session and creates a new Session object. *)
  Initialize ("ATM Card Number", PIN) : ATM -> Session
  (* Update the Session object with the ATM card number and PIN stored on the ATM card. *)
  chain
    "Welcome Message" : Display <- Session
    "Welcome Message" : Customer <- Display
  endchain
  (* A welcome message is displayed to the user. *)
  chain
    "Request PIN" : Display <- Session
    "Request PIN Box Display" : Customer <- Display
  endchain
  (* Request the user to enter the PIN. *)
  chain
    "Enter PIN" : Customer -> Keypad
    "Handle PIN Entry" : Keypad -> Session
  endchain
  (* The Customer enters the PIN. *)
  Session takes action "Compare PIN read from the card with the entered PIN"
  (* Does the PIN entered by the user match the PIN stored on the card? *)
  chain
    "Display Transaction Menu" : Display <- Session
    "Display Transaction Menu" : Customer <- Display
  endchain
  (* The PIN has matched, so give the transaction choices to the user. *)
  chain
    "Select Transaction Menu" : Customer -> Keypad
    "Handle Transaction Selection" : Keypad -> Session
  endchain
  (* User selects the transaction. *)
heading "General handling for a transaction"
Session creates Transaction
  (* The Session creates the Transaction object. *)
Transaction takes action "Perform Transaction"
  (* Transaction is processed. *)
  "Transaction Log" : Transaction -> Logger
  "Transaction Complete" : Session <- Transaction
  (* Notify the session object that the transaction has been completed. *)
```
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**Session deletes Transaction**

(* Delete the transaction object as the transaction has been completed. *)

chain
  "Display Transaction Menu" : Display <- Session
  "Display Transaction Menu" : Customer <- Display
endchain

(* Again display the transaction menu, giving the user the option to initiate 
another transaction. *)

chain
  "Select Transaction Menu" : Customer -> Keypad
  "Handle Transaction Selection" : Keypad -> Session
endchain

(* The user makes a selection. In this case, the user decides to end the 
session. *)

heading 'Session end handling'

**Session takes action 'Ending Session'**

"Eject ATM Card" : Card_Reader <- Session
  (* Eject the ATM card as the session has been completed successfully. *)

"Session Log" : Session -> Logger
  (* Update the session level log. *)

"Session Complete" : ATM <- Session
  (* Notify the ATM object. *)

ATM deletes Session
  (* ATM deletes the Session object. *)

endfeature

The next step is to click the "Quick Save and Display" icon (Keyboard: Control-Q). EventStudio will generate a PDF sequence diagram similar to the one shown below. You can see the representation of the highlighted FDL statements in the sequence diagram.
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ATM Example: Customer Initiated Use Cases (Hello Goodbye)

Primary Actors
- Customer
- Bank

Secondary Actors
- Card Reader
- Keypad
- Envelope Dispenser
- Display
- Printer
- ATM

System Designer 4.0

EventStudio System Designer 4.0

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Session start handling:

1. Insert Card

   - The customer inserts the ATM card to start the ATM session.

2. Credit Card Swipe

   - The Card Reader in the ATM detects the credit card and sends a message to the ATM object.

3. Create Session

   - The ATM object has detected the start of a new session. The ATM object creates a new Session object.

4. Initialize Card Number, PIN

   - Update the Session object with the ATM card number and PIN stored on the ATM card.

5. Welcome Message

6. Request PIN

7. Enter PIN

   - The Customer enters the PIN.

8. Handle PIN Entry

   - Compare PIN read from the card with the entered PIN.

9. Display Transaction Menu

10. Select Transaction Menu

11. Display Transaction Menu

12. Select Transaction Menu

13. Display Transaction Menu

14. Handle Transaction Selection

General handling for a transaction:

15. Transaction

   - The Session creates the Transaction object.

   - Transaction is processed.

   - Notify the session object that the transaction has been completed.

   - Delete the transaction object as the transaction has been completed.
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Use Cases

3.4.4 Understanding Scenarios

Before we move further, let's look at Scenarios in EventStudio. A single FDL file supports definition of multiple scenarios. The differences in the scenarios are identified using the `case-` `endcase` and `if-else-endif` statements (covered later). We have not used these statements as we have only covered one scenario.

The scenario is represented in the left side scenario bar as shown below. EventStudio template we used created a default scenario called "Hello Goodbye". Let's rename this scenario to "Valid PIN" by right-clicking on the Scenario and selecting the "Rename Scenario" command.

This scenario will serve as our successful case scenario. Addition of `case-leg-endcase` statements will result in modification to this scenario to select the `case-legs` that apply to this scenario.
3.4.5 Adding an Alternative Scenario to the Use Case

We have defined a use case for a successful ATM session. We will now add an alternative scenario. The new scenario will cover the handling of an ATM session when the user enters an invalid PIN.

The new scenario is added by simply introducing a `case-endcase` block with `leg` statements for valid and invalid PIN scenarios.

```plaintext
feature "ATM Example: Customer Initiated Use Cases"
heading 'Session start handling"

"Insert Credit Card" : Customer -> Card_Reader
(* The customer inserts the ATM card to start the ATM session. *)

"Credit Card Swipe" (*ATM Card Number", PIN) : Card_Reader -> ATM
(* The Card Reader in the ATM detects the credit card and sends a message to the ATM object. *)

ATM creates Session
(* The ATM object has detected the start of a new session. The ATM object creates a new Session object. *)

Initialize (*ATM Card Number", PIN): ATM -> Session
(* Update the Session object with the ATM card number and PIN stored on the ATM card. *)

chain
"Welcome Message" : Display <- Session
```
Now let's save and regenerate the use case diagram by Control-Q (Quick Save and Display). EventStudio senses the new case statement and asks us to make the leg selection for the existing Scenario ("Valid PIN"). We select "Valid PIN" leg for the "Valid PIN" Scenario.
Select the case leg for the existing "Valid PIN" scenario.

Once the selection is made, EventStudio associates the case leg "Valid PIN" with the "Valid PIN" scenario.

We will now add a second scenario for the case where the user enters an invalid PIN. The steps involved here are:

1. Click on the "Add Scenario" (Control-R).

   Click "Add Scenario" to define a new scenario to represent the "Invalid PIN" leg.

2. Enter the Scenario title "Customer Enters an Invalid PIN" and click "Next".
3. Select the "Customer_Use_Cases.fdl" file and click "Next".

4. Now select the "Invalid PIN" leg and click "Next".
5. Click "Finish" to complete the addition of the Scenario.

6. EventStudio now displays two Scenarios in the left pane. The legs uniquely identifying the Scenarios are also listed.
7. Now click the "Review All Scenarios" icon (Control-W) to look for design errors.

8. We fix the problem by moving the exit label.

EventStudio had detected that the Session object was not being deleted in the "Invalid PIN" leg. We fix the problem by moving the exit label. This ensures that the Session is deleted correctly in all cases.
9. Now click **Control-Q** to save and generate the documents. EventStudio generates a combined use case diagram that includes two Scenarios.

The generated use case diagram lists bookmarks for the new Scenarios.

### 3.4.6 Adding More Scenarios

We now expand the use case by adding the implementation for the "cash withdrawal" and "cash deposit" scenarios.

The scenario support is added in the FDL is via a case-endcase statement. An important point to note here is the use of #includes and #define-macros to simplify the FDL.

Once the scenarios have been added type "**Control+Q**" to update the sequence diagram.

```fdl
/* == inc.fdl == */
/* -- Colors -- */
#include "colors_inc.fdl"
/* -- Useful Macros -- */
define TRANSACTION_INPUT(_command, _via)
  chain;
  _command : Customer -> _via;
  _command : _via -> Transaction;
endchain
define TRANSACTION_OUTPUT(_command, _via)
  chain;
  _command : _via <- Transaction;
  _command : Customer <- _via;
endchain
#include "inc.fdl"
/* Customer Use Cases */
module : Actors, System
...Other Declarations...```

C preprocessor type macros are defined to handle repetitive patterns. Multi-line macros can be defined by separating lines with \\.

Include the "inc.fdl" defined above.
3.4.7 Choose the Level of Detail in Sequence Diagrams

EventStudio lets you control the level of detail in the generated sequence diagrams. The different levels of detail are listed below.

<table>
<thead>
<tr>
<th>Diagram type</th>
<th>Level of Detail</th>
<th>How to Generate</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence Diagram</td>
<td>Sequence diagram with full detail.</td>
<td>Right Click on the &quot;Sequence Diagram&quot; in the Left Pane and select &quot;Generate Document&quot;.</td>
<td>3.4.7.1</td>
</tr>
<tr>
<td>Processor Interaction Sequence Diagram</td>
<td>Intra processor details are hidden. Only inter processor interactions are shown.</td>
<td>Right Click on the &quot;Processor Level Sequence Diagram&quot; in the Left Pane and select &quot;Generate Document&quot;.</td>
<td>3.4.7.2</td>
</tr>
<tr>
<td>Module Interaction Sequence Diagram</td>
<td>Intra module details are hidden. Only inter module interactions are shown.</td>
<td>Right Click on the &quot;Module Level Sequence Diagram&quot; in the Left Pane and select &quot;Generate Document&quot;.</td>
<td>3.4.7.3</td>
</tr>
</tbody>
</table>
3.4.7.1 Sequence Diagram

ATM Example: Customer Initiated Use Cases (Cash Deposit into Checking)

<table>
<thead>
<tr>
<th>Actors</th>
<th>System</th>
<th>Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Actors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer</td>
<td>Bank</td>
<td></td>
</tr>
<tr>
<td>Secondary Actors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Card Reader</td>
<td>Keypad</td>
<td></td>
</tr>
<tr>
<td>Envelope Slot</td>
<td>Display</td>
<td></td>
</tr>
<tr>
<td>Cash Dispenser</td>
<td>Printer</td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>Session</td>
<td></td>
</tr>
<tr>
<td>Transaction Logger</td>
<td>Logger</td>
<td></td>
</tr>
</tbody>
</table>

Session start handling

1: Insert Card
2: Credit Card Swipe
   ATM Card Number, PIN
3: Create Session
4: Initialize
   ATM Card Number, PIN
5: Welcome Message
6: Welcome Message
7: Request PIN
8: Request PIN Box Display
9: Enter PIN
10: Handle PIN Entry
11: Display Transaction Menu
12: Display Transaction Menu
13: Select Transaction Menu
14: Handle Transaction Selection
15: Create Transaction
16: Enter Cash Amount for deposit
17: Enter Cash Amount for deposit
18: Cash Amount
19: Cash Amount
20: Request Cash in Envelope
21: Request Cash in Envelope

The customer inserts the ATM card to start the ATM session.
The Card Reader in the ATM detects the credit card and sends a message to the ATM object.
The ATM object has detected the start of a new session. The ATM object creates a new Session object.
Update the Session object with the ATM card number and PIN stored on the ATM card.
A welcome message is displayed to the user.
Request the user to enter the PIN.
The Customer enters the PIN.
Does the PIN entered by the user match the PIN stored in the card?
LEG: Valid PIN
The PIN has matched, so give the transaction choices to the user.
User selects the transaction.
The Session creates the Transaction object.
LEG: Cash Deposit into Checking Account
Ask the user to enter the cash amount for deposit.
The customer enters the cash amount.
Request the user to prepare an envelope with cash.
**3.4.7.2 Processor Interaction Sequence Diagram**

**Session start handling**

**Session end handling**
1. Print Session Details → 2. ATM Transaction Receipt → 3. Eject ATM Card

**LEG: Valid PIN**
The PIN has matched, so give the transaction choices to the user.

**3.4.7.3 Module Interaction Sequence Diagram**

**Session start handling**

**Session end handling**
1. ATM Transaction Receipt

**LEG: Cash Deposit into Checking Account**
Ask the user to enter the cash amount for deposit.

The customer inserts the ATM card to start the ATM session.

A welcome message is displayed to the user.

Request the user to enter the PIN.

The customer enters the PIN.

The PIN has matched, so give the transaction choices to the user.

User selects the transaction.

User enters the cash amount.

Request the user to prepare an envelope with cash.

Customer inserts the envelope.

Envelope Slot informs the Transaction object that the Envelope has been successfully received.

Inform the user that the deposit envelope has been accepted by the ATM.

Again display the transaction menu, giving the user the option to initiate another transaction.

The user makes a selection. In this case, the user decides to end the session.

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3.4.8 Complete Example

The complete example can be downloaded from:
4 Detailed Design

The first phase of analysis and design has been completed with the generation of detailed use case diagrams. We will now focus on the detailed design.

4.1 Object Sequence Diagrams

The first step in class design is to convert the use case diagrams into object sequence diagrams. The sequence diagrams will add method level detail. The design steps are:

1. Navigate to the "EventStudio Documents" folder in your "My Documents" folder.
2. Make a copy of the "ATM Example Use Cases".
3. Rename the copied folder as "ATM Object Sequence Diagrams" and navigate to the folder.
4. Inside the folder rename the scenario project "ATM Example Use Cases.scn" to "ATM Object Sequence Diagrams.scn".
5. Double click on the "ATM Object Sequence Diagrams.scn" file to launch EventStudio.

6. We go through the use case diagram and convert the message interactions into method invocation. The structure of the FDL is also changed. More details are added. The new FDL file is shown below:

```fdl
#include "inc.fdl"
module : System
processor : ATM.Controller in System
eternal : Bank in ATM.Controller
eternal : Card_Reader in ATM.Controller
eternal : Keypad in ATM.Controller
dynamic : Session in ATM.Controller
eternal : ATM in ATM.Controller
eternal : Logger in ATM.Controller
feature "ATM Example: Customer Initiated Use Cases"
  "Insert Credit Card" : env_l -> Card_Reader
  (* The customer inserts the ATM card to start the ATM session. *)
  Card_Reader invokes ATM.HandleCardSwipe(cardNumber, pin)
  (* The Card Reader in the ATM detects the credit card and sends a message to the ATM object. *)
```

The customer has been represented as an environment. FDL supports env_l and env_r as the left and right environment.

The complete example can be downloaded from [TBD].

---

EventStudio System Designer 4.0
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ATM creates Session
(* The ATM object has detected the start of a new session. The ATM object creates a new Session object. *)

ATM invokes Session.Start (cardNumber, pin)
(* Update the Session object with the ATM card # and PIN stored on the ATM card. *)
Session invokes Display.Print("Welcome to the XYZ Bank ATM")
(* A welcome message is displayed to the user. *)
Display.Print returns
Session invokes Display.Print("Please enter the PIN")
(* Request to the user to enter the PIN. *)
Display.Print returns
Session.Start returns

ATM.HandleCreditCardSwipe returns

"Enter PIN" : env_l -> Keypad (* The Customer enters the PIN. *)
Keypad invokes Session.HandlePIN(pin)

Session takes action "Compare PIN read from the card with the entered PIN"
(* Does the PIN entered by the user match the PIN stored in the card? *)
case
  leg "Valid PIN":
  leg "Invalid PIN":
  [* Begin Loop: Retry PIN expired *]
  Session invokes Display.Print("Collect your ATM card from the bank")
  Display.Print returns
  Session invokes Card_Reader.SwallowCard
  Card_Reader.SwallowCard returns
  Session invokes Session.End(InvalidATM)
  Session invokes ATM.HandleSessionComplete
  ATM takes action "Mark Session for Deletion"
  ATM.HandleSessionComplete returns
  Session.End returns
  Session deletes Session
  goto exit
endcase
Session invokes Display.Print("(1) Deposit (2) Withdraw (3) Quit")
(* The PIN has matched, so give the transaction choices to the user. *)
Display.Print returns
Session.HandlePIN returns

"Select Transaction Menu" : env_l -> Keypad (* User selects the transaction. *)
Keypad invokes Session.HandleTransactionSelection(transaction_type)
case
  leg "Cash Withdrawal from Checking Account":
  Session creates Transaction
  (* The Session creates the WithdrawCashTransaction object. *)
  Session invokes Transaction.Start
  Transaction invokes Display.Print("Enter the Amount to be Withdrawn")
  (* Request the customer to enter the amount to be withdrawn. *)
  Display.Print returns
  Transaction.Start returns
  Session.HandleTransactionSelection returns
  "Dollar Amount" : env_l -> Keypad
  (* The customer enters the dollar amount that he or she wishes to withdraw. *)
  Keypad invokes Transaction.HandleAmountEntry(amount)
  Transaction invokes Bank.RequestWithdrawalAuthorization(CardNumber, Pin, amount)
  (* Request the Bank to authorize the cash withdrawal. *)
  Bank.RequestWithdrawalAuthorization returns
  Transaction.HandleAmountEntry returns
  "Withdrawal Accepted" (Amount) : env_l -> Bank
  (* Bank allows the cash withdrawal. *)
  Bank invokes Transaction.HandleBankReply(result)
  Transaction invokes Cash_Dispenser.DispenseCash(amount)
  (* Dispense the cash to the user. *)
  Cash_Dispenser.DispenseCash returns
7. Click Control-Q to regenerate the sequence diagram. A page from the generated sequence diagram is shown below:
### 4.2 Class Roles and Responsibilities

The next step in the analysis process is to scan the use case diagrams to identify the roles and responsibilities of individual classes. We will use the following diagrams to aid in the analysis:

<table>
<thead>
<tr>
<th>Diagram Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface Sequence Diagrams</td>
<td>A sequence diagram that just lists the interactions involving one module, processor or object.</td>
</tr>
<tr>
<td>Summary Document</td>
<td>Object wise summary of the interactions. The HTML document lists the interactions on a per object basis.</td>
</tr>
<tr>
<td>Interface Collaboration Diagrams</td>
<td>A collaboration diagram that just lists the interactions involving one module, processor or object.</td>
</tr>
</tbody>
</table>

#### 4.2.1 Interface Sequence Diagram

Use the interface sequence diagram to and role of important entities in the use case diagrams. The following steps define the interface collaboration diagram:

1. Click on the “Add Document” icon (Shortcut Control+D).
2. Now select the "Interface Sequence Diagram" and click "Next".

3. Set the "Document Interface Filter" as "Session" and click "Next".
Set the document interface filter as "Session".

4. Change the "Object Spacing" to Medium and click "Next".

5. Enter the Document Name and click "Next".
6. Click **"Finish"** to complete the addition of the document.

7. Now right click on the "Session Sequence Diagram" in the left pane and select "Generate Document" from the popup menu.
8. EventStudio generates the document and opens the document. One of the pages of the generated document is shown below.

EventStudio System Designer 4.0
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### Session Interfaces (Cash Withdrawal from Checking)

<table>
<thead>
<tr>
<th>System</th>
<th>Bank</th>
<th>Card Reader</th>
<th>Keypad</th>
<th>Envelope Slot</th>
<th>Display</th>
<th>Cash Dispenser</th>
<th>Printer</th>
<th>ATM</th>
<th>Session</th>
<th>Transaction</th>
<th>Logger</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. The ATM object has detected the start of a new session. The ATM object creates a new Session object.
2. **Start()**
   - cardNumber, pin
   - Update the Session object with the ATM card # and PIN stored on the ATM card.
3. **Print()**
   - Welcome to the XYZ Bank ATM
   - A welcome message is displayed to the user.
4. **returns**
5. **Print()**
   - Please enter the PIN
   - Request the user to enter the PIN.
6. **returns**
7. **HandlePIN()**
   - Does the PIN entered by the user match the PIN stored in the card?
   - LEG: Valid PIN
     - The PIN has matched, so give the transaction choices to the user.
9. **Print()**
   - (1) Deposit (2) Withdraw (3) Quit
   - The PIN has matched, so give the transaction choices to the user.
10. **returns**
11. **returns**
12. **HandleTransactionSelection()**
    - transaction_type
    - LEG: Cash Withdrawal from Checking Account
    - The Session creates the WithdrawCashTransaction object.
13. **create**
    - The Session creates the WithdrawCashTransaction object.
### 4.2.2 Object Wise Summary

The object-wise summary document lists the interactions for each object. This aids in identifying the roles and responsibilities of individual classes. Generate this document by just right clicking on the "Objectwise Summary".

The first page of the generated document is shown below.

<table>
<thead>
<tr>
<th>Objectwise Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>EventStudio System Designer 4.0</td>
</tr>
<tr>
<td>Generated on 29-Sep-07 08:58</td>
</tr>
</tbody>
</table>

#### Cash Withdrawal from Checking

**Legs Taken:**
- Valid PIN
- Cash Withdrawal from Checking Account

**Bank Actions**

1. Transaction invokes Bank.RequestWithdrawalAuthorization() (CardNumber, pin, amount)
2. Send Authorize Cash Withdrawal (ATM card #, PIN, Amount) to env_l
4. Receive Withdrawal Accepted (Amount) from env_l
5. Bank invokes Transaction.HandleBankReply() (result)
6. Transaction.HandleBankReply returns

**Card_Reader Actions**

1. Receive Insert Credit Card from env_l
2. Card_Reader invokes ATM.HandleCreditCardSwipe() (cardNumber, pin)
3. ATM.HandleCreditCardSwipe returns
4. Session invokes Card_Reader.EjectCard()
5. Card_Reader.EjectCard returns

**Keypad Actions**

1. Receive Enter PIN from env_l
2. Keypad invokes Session.HandlePIN() (pin)
3. Session.HandlePIN returns
4. Receive Select Transaction Menu from env_l
5. Keypad invokes Session.HandleTransactionSelection() (transaction_type)
6. Session.HandleTransactionSelection returns
7. Receive Dollar Amount from env_l
8. Keypad invokes Transaction.HandleAmountEntry() (amount)
9. Transaction.HandleAmountEntry returns
10. Receive Select Transaction Menu from env_l
11. Keypad invokes Session.HandleTransactionSelection() (transaction_type)
12. Session.HandleTransactionSelection returns

**Display Actions**

1. Session invokes Display.Print() (Welcome to the XYZ Bank ATM)
2. Display.Print returns
3. Session invokes Display.Print() (Please enter the PIN)
4. Display.Print returns
5. Session invokes Display.Print() ((1) Deposit (2) Withdraw (3) Quit)
6. Display.Print returns
7. Transaction invokes Display.Print() (Enter the Amount to be Withdrawn)
8. Display.Print returns
9. Session invokes Display.Print() ((1) Deposit (2) Withdraw (3) Quit)
4.2.3 Interface Collaboration Diagram

4.3 Class Diagrams
Now we have all the information for drawing the class diagrams for the classes implementing the ATM. We have generated these class diagrams with Visual Studio 2005. You may use any freeware of commercial UML tool to generate the class diagrams.
4.4 Skeleton Source Code in C#

The VisualStudio 2005 project containing the skeleton source code for the project can be downloaded from:


The ZIP file also contains the Use Case and Detailed Design Scenario Projects.