Properties of High Quality Software

CSE219, Computer Science III

Stony Brook University

http://www.cs.stonybrook.edu/~cse219

Software Engineering Basics

- Important Principles for creating a Software Solution:
  - First, define the problem
  - Design, then code
  - Always Provide Feedback
- Learn a methodology for constructing software systems of high quality.

What properties make a software system of *high quality*?

- Correctness
- Efficiency
- Ease of use
  - for the user
  - for other programmers using your framework
- Reliability/robustness
- Reusability (i.e., code reuse with slight or no modification)
- Extensibility
- Scalability (i.e., to handle a growing amount of work in a capable manner)
- Maintainability, Readability, Modifiability, Testability, etc.

What properties make a software system of *high quality*?

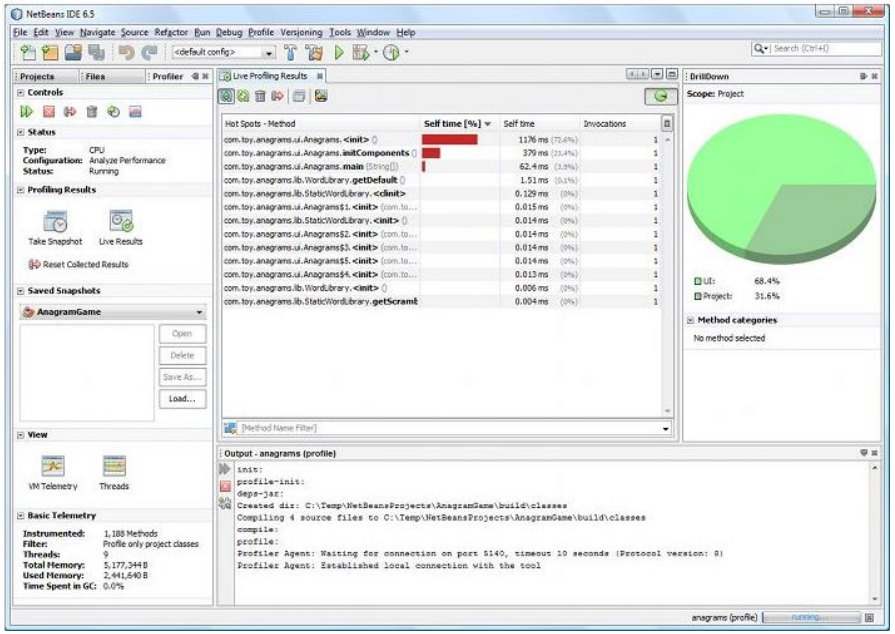
- Correctness (think of GE or IBM large engineering systems)
- Efficiency (think of Google Search)
- Ease of use
  - for the user (think of Apple UI and products)
  - for other programmers using your framework (see MS Visual…)
- Reliability/robustness (think of NASA software)
- Reusability (see Apache Software Foundation software, e.g. HTTP server)
- Extensibility (see Android OS growth to most popular mobile platform)
- Scalability (think of Oracle DBs)
- Maintainability, Readability, Modifiability, Testability, etc.

Correctness

- Does the program perform its intended function?
  - And does it produce the correct results?
- This is not just an implementation (coding) issue
  - Correctness is a function of the problem definition
- A flawed Requirements Analysis results in a flawed Design
- A flawed Design results in a flawed program
  - Garbage In – Garbage Out

Efficiency

- Plan for efficiency
  - wisely choose your data structures & algorthms (including their complexity, e.g., O(N)) in the design phase.
  - tools & technologies too.
- Does the program meet user performance expectations?
- If not, find the bottlenecks
  - done after implementation
  - called ***profiling***



Ease of Use for End User

- Is the GUI easy to learn to use?
  - a gently sloped learning curve
- What makes a GUI easy to use?
  - familiar GUI structures
  - familiar icons when possible instead of text
  - components logically organized & grouped
  - appealing to look at
    - colors, alignment, balance, etc.
  - forgiving of user mistakes
  - help, tooltips, and other cues available
  - etc.

Ease of Use for other Programmers

- In particular for frameworks and tools
  - the Java API is developed to be easy to use
- Should you even build a framework?
  - Yes, you will be a software developer.
- What makes a framework easy to use?
  - logical structure
  - naming choices (classes, methods, etc.)
  - flexibility (usable for many purposes)
  - feedback (exceptions for improper use)
  - documentation (APIs & tutorials)
  - etc.

Reliability/Robustness

- Does your program:
  - anticipate erroneous input?
  - anticipate all potential program conditions?
  - handle erroneous input intelligently?
    - think about this in the design stage
  - provide graceful degradation?
    - *Graceful degradation* (or *Fault-tolerance*) is the property that enables a system to continue operating properly in the event of the failure of (or one or more faults within) some of its components.
      - If an error condition occurs in your program, should your program:
        - crash?, exit?, notify the user and exit?, provide an approximated service? Not always possible to save it.
      - For example: What should Web Browsers do with poorly formatted HTML?

Feedback

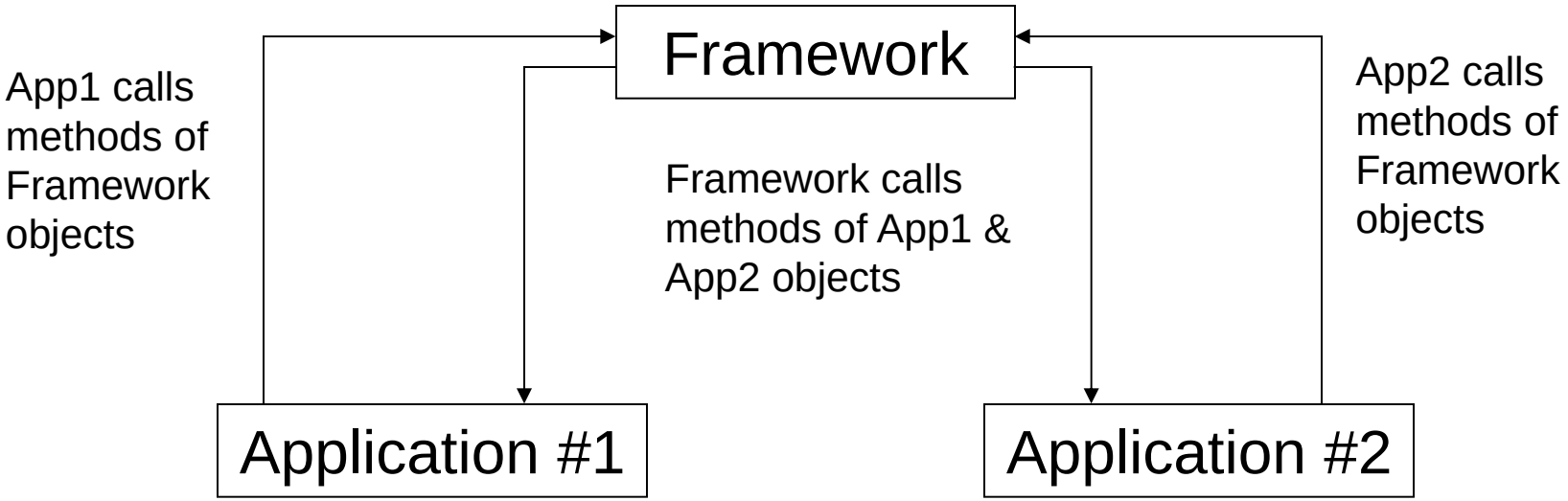
- Provide feedback to End users due to: bad input, equipment failure, missing files, etc.
  - How?
    - popup dialogs, highlighting (red text in Web form), etc.
- Provide feedback to other programmers using your framework due to: passing bad data, incorrect initialization, etc.
  - How?
    - exception throwing, error value returning, etc.

Flexibility in a Framework

- Programmers need to know:
  - when and why things in a framework might go wrong AND
  - when and why things in a framework do go wrong
- How?
  - customized response:
    - **`System.out.println`** notifications
    - **`GUI`** notifications
    - Web page generated and sent via Servlet notification
    - etc.

Applications Using Frameworks

- Making a framework is much more difficult than making a single application



Reusability

- Code serving multiple purposes.
- Who cares?
  - management does
    - avoid duplication of work (save $)
  - software engineering does
    - avoid duplication of work (save time & avoid mistakes)
- How can we achieve this?
  - careful program decomposition (from methods to classes and packages)
  - separate technology-dependent components

Extensibility

- Can the software easily be extended?
  - can it be used for other purposes
    - plug-ins,
    - exporters,
    - add-ons,
    - etc
- Extensibility Example:
  - In NetBeans, Tools → Plugins
    - Anyone can make a plugin
    - Download, install, and use
  - In Eclipse IDE, Help → Install New Software plugin

Scalability

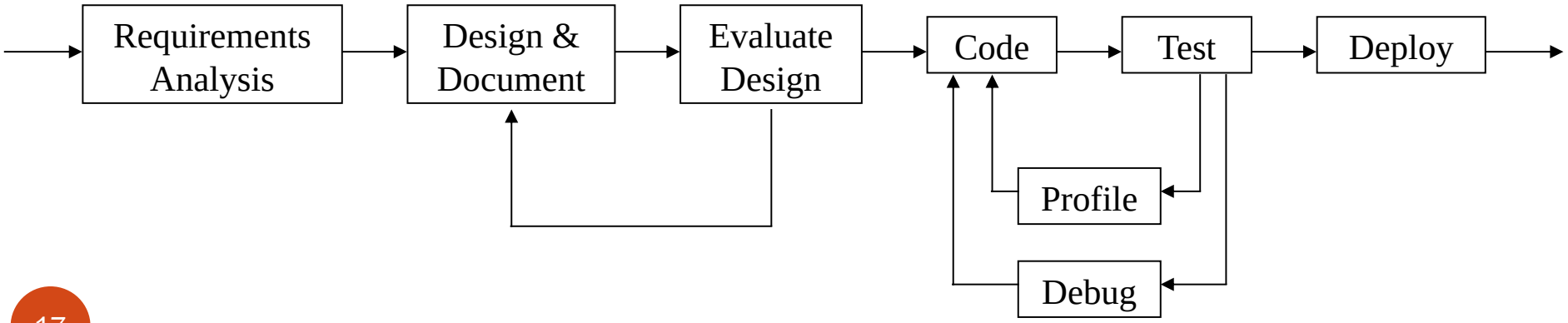
- How will the program perform when we increase:
  - # of users/connections
  - amount of data processed
  - # of geographic locations users are from
- A function of design as well as technology

More Software Engineering steps

- Maintainability
- Readability
- Modifiability
- Testability
- etc.
- All of these, as with the others, must be considered early in design

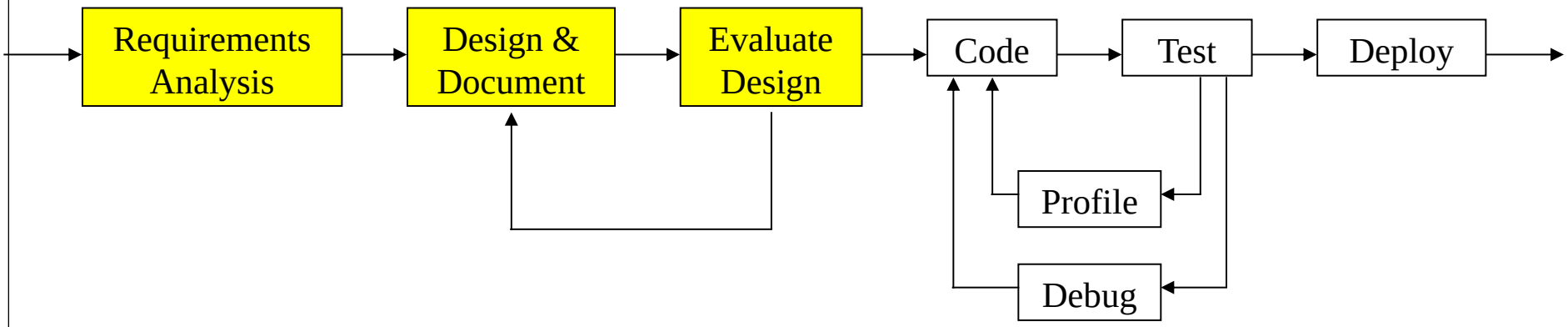
How can these properties be achieved?

- By using well proven, established processes:
  - preferably while taking advantage of good tools
    - Software Development Life Cycle



Software Development Life Cycle

- Requirements Analysis & design stages:



- Correctness, Efficiency, Ease of use, Reliability/robustness, Reusability, Maintainability, Modifiability, Testability, Extensibility, Scalability
  - do we consider these properties in the implementation stages?
    - Little because it is too late to make a big impact.

Where to begin?

- Understand and Define the problem
  - the point of a requirements analysis
  - What are system input & output?
  - How will users interact with the system?
  - What data must the system maintain?
- Generate a problem specification document
  - defines the problem
  - defines what needs to be done to solve the problem

Requirements Analysis

- i.e. Software Specification (spec.)
  - A textual document
  - It serves two roles. It:
    - defines the problem to be solved
    - explains how to solve it
  - This is the input into the software design stage
- **What goes in a requirements analysis (RA)?**
  - The why, where, when, what, how, and who:
    - Why are we making this software?
    - Where and when will it be created?
    - What, exactly, are we going to make?
    - How are we going to make it?
    - Who will be performing each role?

Requirements Analysis

- **What really goes in a RA?**
  - Detailed descriptions of all:
    - necessary data (including how to query it, views, forms, inserts)
    - program input and output
    - GUI screens & controls
    - user actions and program reactions
- **Where do you start?**
  - Interviews with the end users
    - What do they need?
    - What do they want?

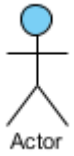
UML Use Case Diagrams

- A set of scenarios that describe an interaction between a user and a system
- Done first in a project design
  - helps you to better understand the system requirements
- To draw a Use Case Diagram:
  - List a sequence of steps a user might take in order to complete an action.
  - Example actor: a user placing an order with a sales company

UML Use Case Diagrams

- Human Actor: Stick figure with name underneath.

Name usually identifies type of actor.

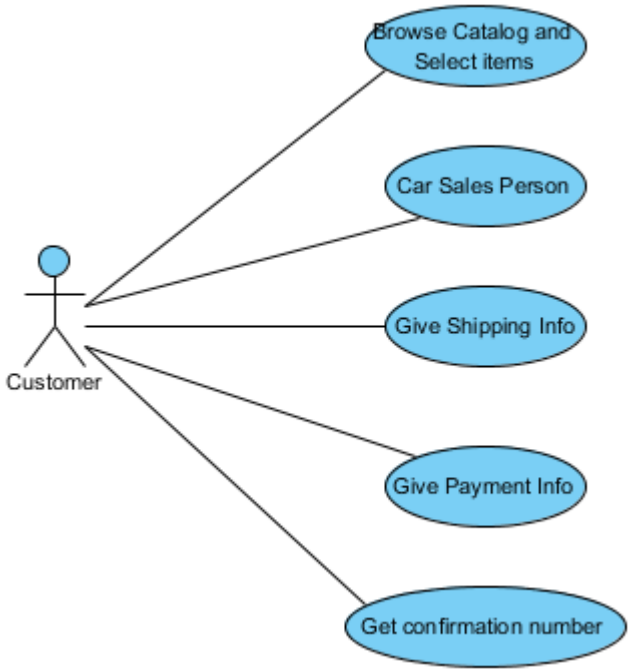


- Use Case: Oval enclosing name of use case.

- Non-Human Actor: Stick figure, or a rectangle enclosing the stereotype <<actor>> and the name of the actor. A stereotype indicates the type of UML element (when it isn't evident from the shape).

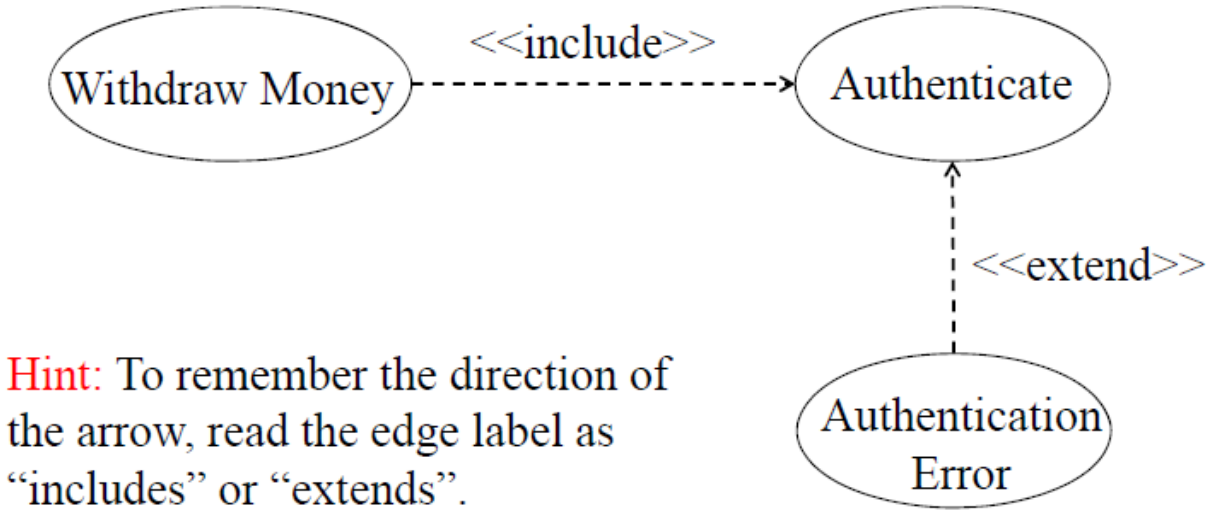
UML Use Case Diagrams

- Relationships Between Actors and Use Cases:
  - Solid edge between an actor A and a use case U means that actor A participates in use case U.



UML Use Case Diagrams

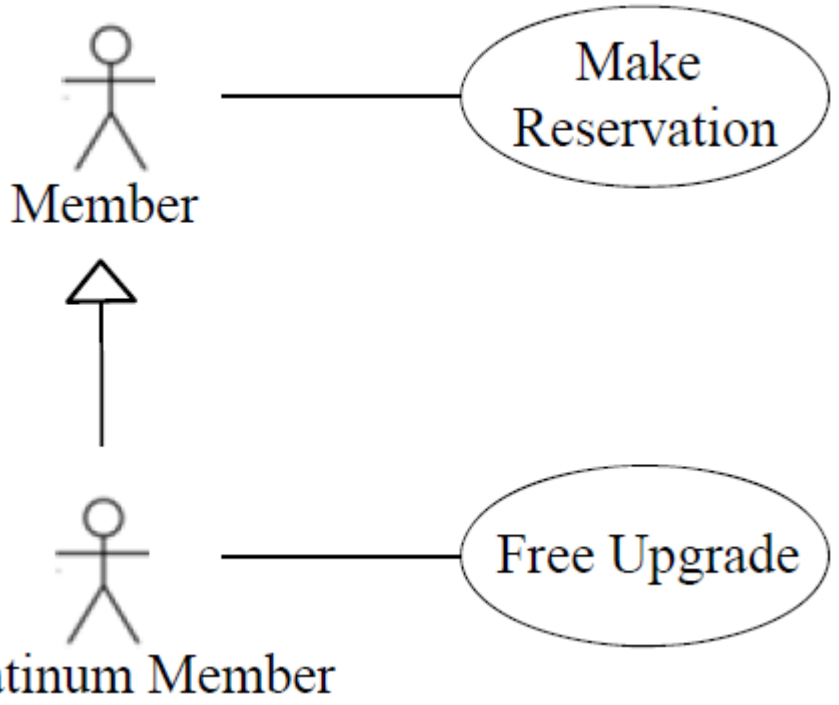
- Relationships Between Use Cases:
  - Include: dashed arrow labeled <<include>> from use case U1 to use case U2 means U2 is part of the primary flow of events of U1.
  - Extend: dashed arrow labeled <<extend>> from use case U2 to use case U1 means U2 is part of a secondary flow of events of U1.



Hint: To remember the direction of the arrow, read the edge label as "includes" or "extends".

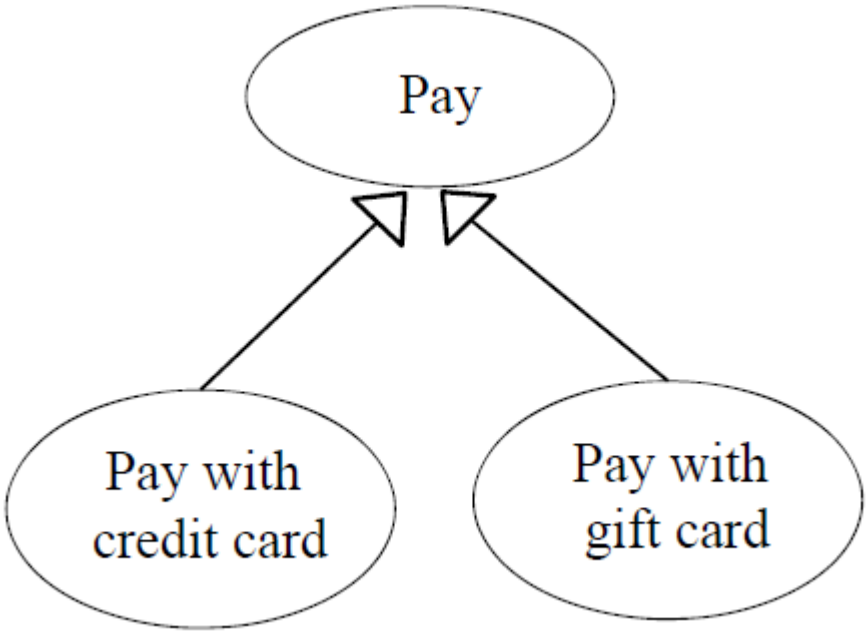
Relationships Between Actors

- Generalization: Solid line with triangular arrowhead from actor A1 to actor A2 means that A2 is a generalization of A1. This implies that A1 participates in all use cases that A2 participates in. Generalization is similar to inheritance.

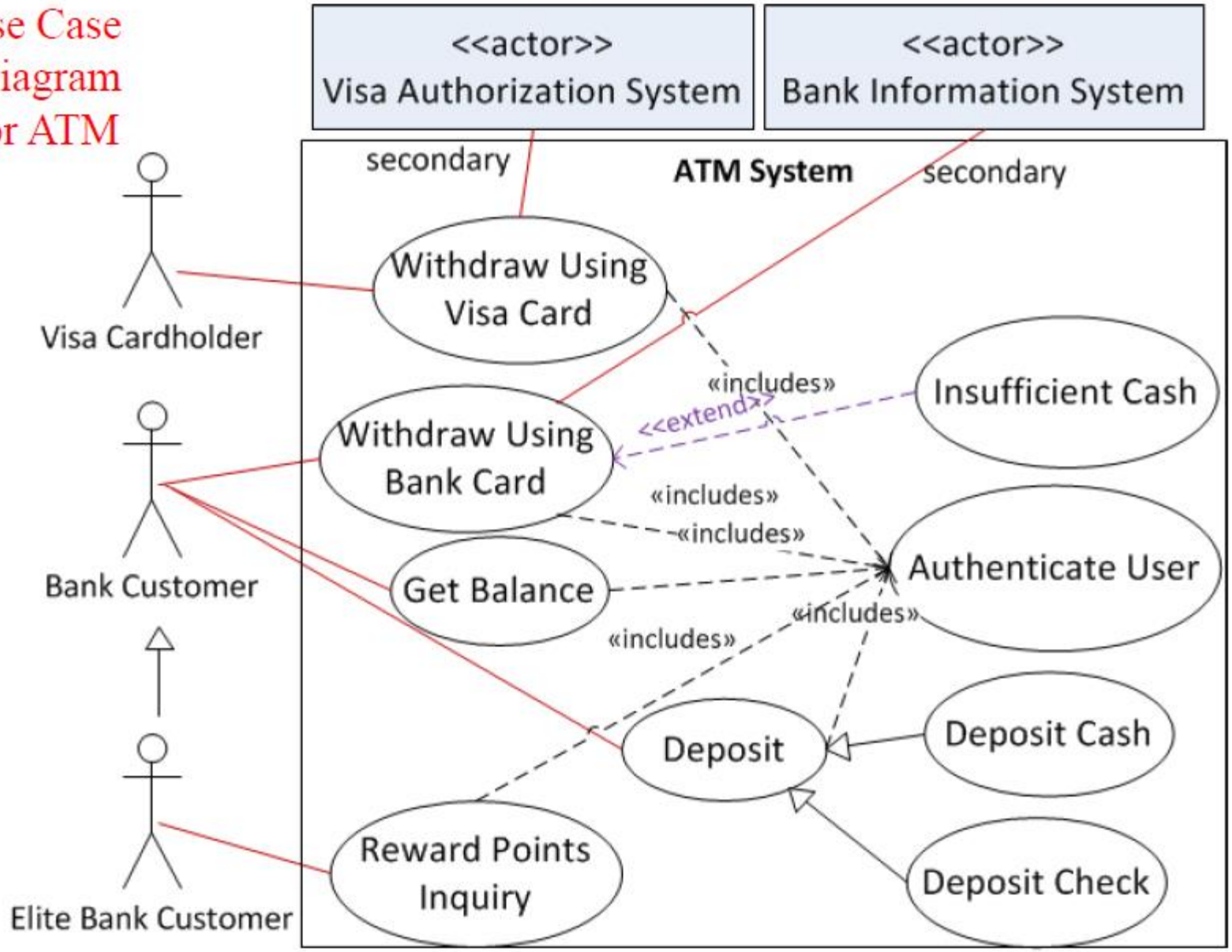


Relationships Between Use Cases

- Generalization: Solid line with triangular arrowhead from use case U1 to use case U2 means that U2 is a generalization of U1 (equivalently, U1 is a specialized version of U2). Generalization is similar to inheritance.



Use Case Diagram For ATM



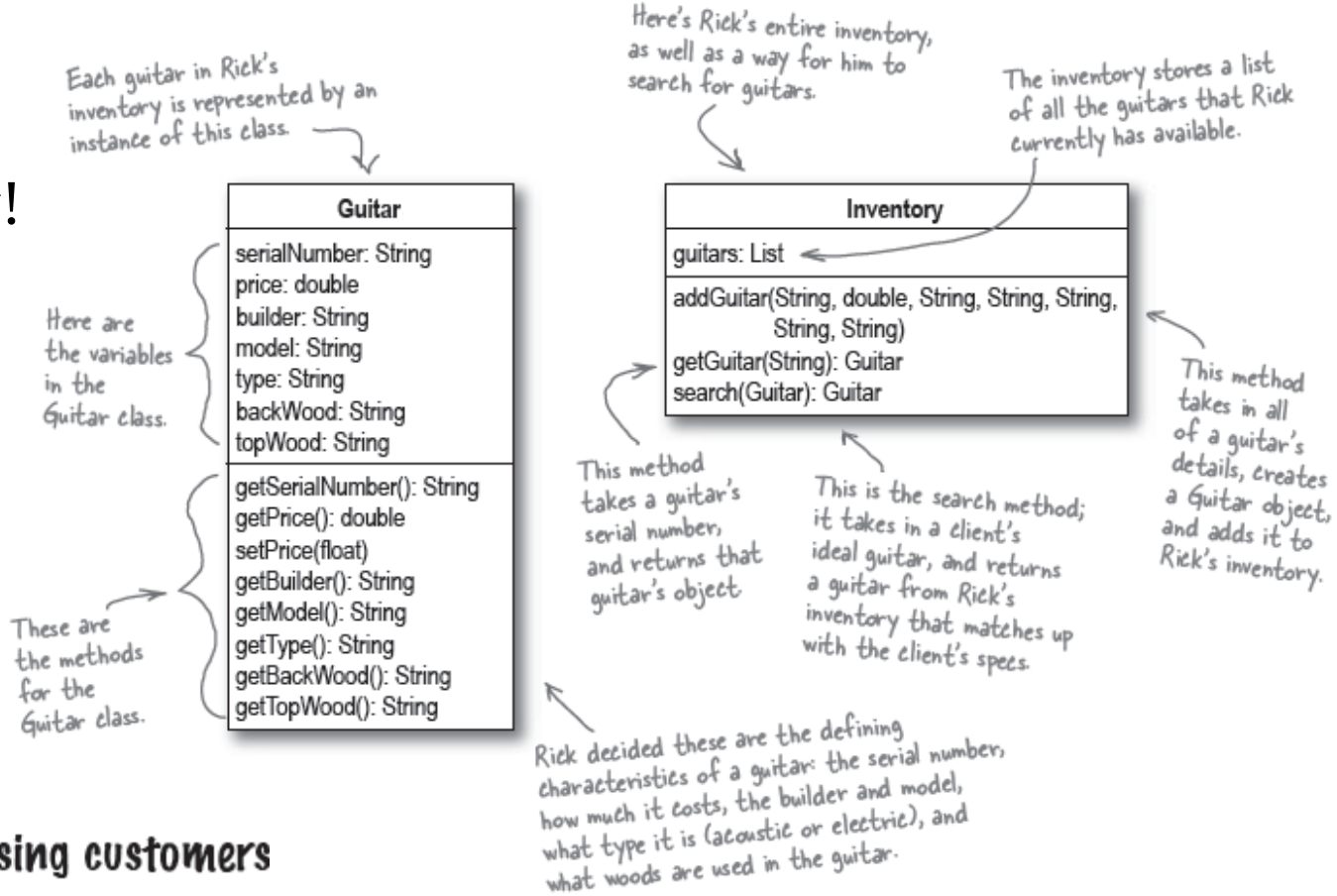
Use-case:	ApplicationSearch
Primary actor:	Undergraduate Secretary, Admin
Goal in context:	Display a list of applications that match the secretary's search term and criteria.
Preconditions:	The actor has been authenticated and identified as an undergraduate secretary.
Trigger:	The undergraduate secretary clicks on the "Application Search" button.
Scenario:	1. UG secretary: observes search page. 2. UG secretary: selects 'Search by ID', 'Search by Name', or 'Search by Matriculation Date' radio button. 3. UG secretary: enters the ID number, first and last name, or date range in the text fields corresponding to the selected radio button. 4. UG secretary: clicks the 'Search' button. 5. UG secretary: observes all the records in the database that match the given search terms and criteria in a table below the search fields.
Exceptions:	1. 'Search by ID' button is selected: if the ID is not provided in the correct format, and error message is displayed that contains the correct format. 2. There are no records that match the given search terms and criteria (the message 'No matching records could be found' will be displayed below the search fields) : UG secretary enters different search terms and clicks the 'Search' button
Priority:	Essential, must be implemented.
When available:	First increment.
Frequency of use:	Many times per day.
Channel to actor:	Via web browser interface.
Secondary actors:	Admin, server
Channels to secondary actors:	Admin: web browser interface, program modification server: network and local interface
Open issues:	1. Where on the web interface will the search fields and buttons be displayed? 2. What other criteria will the UG secretary want to search by? 3. Should we have a 'Clear Fields' button that clears all entered text in the search fields?

Formal UML Use Case Diagram

Textbook example: Design well, Then code.

- Head First Object Oriented Analysis and Design (chapter 1):
  "*Rick decided to throw out his paper-based system for keeping track of guitars, and start using a computer-based system to store his inventory.*"

Down and dirty! Company produced:



AND

Rick started losing customers

More design needed to meet the user demands

Eliminate Strings and add enumerations of types