Analysis and Design with UML

Agenda

- Benefits of Visual Modeling
- History of the UML
- Visual Modeling with UML
- The Rational Iterative Development Process
What is Visual Modeling?

"Modeling captures essential parts of the system."
Dr. James Rumbaugh

Visual Modeling is modeling using standard graphical notations

Visual Modeling Captures Business Process

Use Case Analysis is a technique to capture business process from user’s perspective
Visual Modeling is a Communication Tool

Use visual modeling to capture business objects and logic

Use visual modeling to analyze and design your application

Visual Modeling Manages Complexity

The human mind can only handle 7 plus or minus 2 things at once
Visual Modeling Defines Software Architecture

- User Interface (Visual Basic, Java)
- Business Logic (C++, Java)
- Database Server (C++ & SQL)

Model your system independent of implementation language

Visual Modeling Promotes Reuse

Multiple Systems

Reusable Components
What is the UML?

- UML stands for Unified Modeling Language
- The UML combines the best of the best from
  - Data Modeling concepts (Entity Relationship Diagrams)
  - Business Modeling (work flow)
  - Object Modeling
  - Component Modeling
- The UML is the standard language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system
- It can be used with all processes, throughout the development life cycle, and across different implementation technologies

History of the UML

- Nov '97: UML approved by the OMG
- Sept '97
- Jan '97
- Jun '96
- Oct '95
- UML 0.9
- Bouch
- OMT
- Use Case
- St. James/Humphrey (was Rational (Oct. 1994))
- J. Jacobson (was Rational (Fall of 1994))
- Microsoft, Oracle, IBM VP & other industry leaders
UML Supports Application Development

- Objects
- Business Objects
- Relationships
- Classes
- large scale system
- application partitioning
- Scenarios
- ORDBMS
  - Oracle
- Components
  - Microsoft
- Use Cases
  - ActiveX/COM
  - Microsoft
- Business Process
- CORBA
  - OMG

UML Concepts

- The UML may be used to:
  - Display the boundary of a system & its major functions using use cases and actors
  - Illustrate use case realizations with interaction diagrams
  - Represent a static structure of a system using class diagrams
  - Model the behavior of objects with state transition diagrams
  - Reveal the physical implementation architecture with component & deployment diagrams
  - Extend your functionality with stereotypes
Putting the UML to Work

- The ESU University wants to computerize their registration system
  - The Registrar sets up the curriculum for a semester
    - One course may have multiple course offerings
  - Students select 4 primary courses and 2 alternate courses
  - Once a student registers for a semester, the billing system is notified so the student may be billed for the semester
  - Students may use the system to add/drop courses for a period of time after registration
  - Professors use the system to receive their course offering rosters
  - Users of the registration system are assigned passwords which are used at logon validation

Actors

- An actor is someone or some thing that must interact with the system under development

  - Registrar
  - Professor
  - Student
  - Billing System
Use Cases

- A use case is a pattern of behavior the system exhibits
  - Each use case is a sequence of related transactions performed by an actor and the system in a dialogue
- Actors are examined to determine their needs
  - Registrar -- maintain the curriculum
  - Professor -- request roster
  - Student -- maintain schedule
  - Billing System -- receive billing information from registration

Documenting Use Cases

- A flow of events document is created for each use case
  - Written from an actor point of view
- Details what the system must provide to the actor when the use cases is executed
- Typical contents
  - How the use case starts and ends
  - Normal flow of events
  - Alternate flow of events
  - Exceptional flow of events
Maintain Curriculum
Flow of Events

- This use case begins when the Registrar logs onto the Registration System and enters his/her password. The system verifies that the password is valid (E-1) and prompts the Registrar to select the current semester or a future semester (E-2). The Registrar enters the desired semester. The system prompts the professor to select the desired activity: ADD, DELETE, REVIEW, or QUIT.

- If the activity selected is ADD, the S-1: Add a Course subflow is performed.

- If the activity selected is DELETE, the S-2: Delete a Course subflow is performed.

- If the activity selected is REVIEW, the S-3: Review Curriculum subflow is performed.

- If the activity selected is QUIT, the use case ends.

Use Case Diagram

- Use case diagrams are created to visualize the relationships between actors and use cases.
Uses and Extends Use Case Relationships

- As the use cases are documented, other use case relationships may be discovered
  - A uses relationship shows behavior that is common to one or more use cases
  - An extends relationship shows optional behavior

Use Case Realizations

- The use case diagram presents an outside view of the system
- Interaction diagrams describe how use cases are realized as interactions among societies of objects
- Two types of interaction diagrams
  - Sequence diagrams
  - Collaboration diagrams
**Sequence Diagram**

- A sequence diagram displays object interactions arranged in a time sequence.

**Collaboration Diagram**

- A collaboration diagram displays object interactions organized around objects and their links to one another.
Class Diagrams

- A class diagram shows the existence of classes and their relationships in the logical view of a system
- UML modeling elements in class diagrams
  - Classes and their structure and behavior
  - Association, aggregation, dependency, and inheritance relationships
  - Multiplicity and navigation indicators
  - Role names

Classes

- A class is a collection of objects with common structure, common behavior, common relationships and common semantics
- Classes are found by examining the objects in sequence and collaboration diagram
- A class is drawn as a rectangle with three compartments
- Classes should be named using the vocabulary of the domain
  - Naming standards should be created
  - e.g., all classes are singular nouns starting with a capital letter
**Classes**

- RegistrationForm
- RegistrationManager
- ScheduleAlgorithm
- Course
- Student
- Professor
- CourseOffering

**Operations**

- The behavior of a class is represented by its operations
- Operations may be found by examining interaction diagrams

```plaintext
RegistrationManager.addCourse(Student, Course)
```
Attributes

- The structure of a class is represented by its attributes
- Attributes may be found by examining class definitions, the problem requirements, and by applying domain knowledge

Each course offering has a number, location and time

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Classes

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<th>Classes</th>
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<td></td>
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<tr>
<td>RegistrationManager</td>
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<tr>
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Relationships

- Relationships provide a pathway for communication between objects
- Sequence and/or collaboration diagrams are examined to determine what links between objects need to exist to accomplish the behavior -- if two objects need to “talk” there must be a link between them
- Three types of relationships are:
  - Association
  - Aggregation
  - Dependency

An association is a bi-directional connection between classes
  - An association is shown as a line connecting the related classes

An aggregation is a stronger form of relationship where the relationship is between a whole and its parts
  - An aggregation is shown as a line connecting the related classes with a diamond next to the class representing the whole

A dependency relationship is a weaker form of relationship showing a relationship between a client and a supplier where the client does not have semantic knowledge of the supplier

A dependency is shown as a dashed line pointing from the client to the supplier
Finding Relationships

- Relationships are discovered by examining interaction diagrams
  - If two objects must “talk” there must be a pathway for communication

Relationships

- RegistrationManager
- Math 101
- Course
- StudentInfo

RegistrationManager
- addStudent (joe)

RegistrationForm
- RegistrationManager
- ScheduleAlgorithm
- Professor
- CourseOffering
- Course

Professor
- name
- tenureStatus

CourseOffering
- open

Course
- name
- credit

ScheduleAlgorithm
- open

StudentInfo
- name
- major

RegistrationManager
- addStudent(Course, StudentInfo)
Multiplicity and Navigation

- Multiplicity defines how many objects participate in a relationship.
  - Multiplicity is the number of instances of one class related to ONE instance of the other class.
  - For each association and aggregation, there are two multiplicity decisions to make: one for each end of the relationship.

- Although associations and aggregations are bi-directional by default, it is often desirable to restrict navigation to one direction.

- If navigation is restricted, an arrowhead is added to indicate the direction of the navigation.
Inheritance

- Inheritance is a relationship between a superclass and its subclasses.
- There are two ways to find inheritance:
  - Generalization
  - Specialization
- Common attributes, operations, and/or relationships are shown at the highest applicable level in the hierarchy.
The State of an Object

- A state transition diagram shows
  - The life history of a given class
  - The events that cause a transition from one state to another
  - The actions that result from a state change

- State transition diagrams are created for objects with significant dynamic behavior

State Transition Diagram

- Initialization
  - Add student / Set count = 0
  - Open
    - Add student[ count < 10 ]
    - Closed
      - Close

- Canceled
  - Cancel
    - Cancel
      - Cancel[ count = 10 ]
The Physical World

- Component diagrams illustrate the organizations and dependencies among software components
- A component may be
  - A source code component
  - A run time components or
  - An executable component

Component Diagram

- Billing.exe
- Register.exe
- Course.dll
- People.dll
- Course
- Offer
- User
- Student
- Professor
Deploying the System

- The deployment diagram shows the configuration of runtime processing elements and the software processes living on them.
- The deployment diagram visualizes the distribution of components across the enterprise.
Extending the UML

- Stereotypes can be used to extend the UML notational elements
- Stereotypes may be used to classify and extend associations, inheritance relationships, classes, and components
- Examples:
  - Class stereotypes: boundary, control, entity, utility, exception
  - Inheritance stereotypes: uses and extends
  - Component stereotypes: subsystem

What the Iterative Life Cycle Is Not

- It is not hacking
- It is not a playpen for developers
- It is not unpredictable
- It is not redesigning the same thing over and over until it is perfect
- It is not an excuse for not planning and managing a project
- It is not something that affects only the developers on a project
What the Iterative Life Cycle Is

- It is planned and managed
- It is predictable
- It accommodates changes to requirements with less disruption
- It is based on evolving executable prototypes, not documentation
- It involves the user/customer throughout the process
- It is risk driven

Three Important Features of the Iterative Approach

- Continuous integration
  - Not done in one lump near the delivery date
- Frequent, executable releases
  - Some internal; some delivered
- Attack risks through demonstrable progress
  - Progress measured in products, not documentation or engineering estimates
Resulting Benefits

- Releases are a forcing function that drives the development team to closure at regular intervals
  - Cannot have the “90% done with 90% remaining” phenomenon
- Can incorporate problems/issues/changes into future iterations rather than disrupting ongoing production
- The project’s supporting elements (testers, writers, toolsmiths, CM, QA, etc.) can better schedule their work

Risk Profile of an Iterative Development
Risk Management Phase-by-Phase

- Inception
  - Bracket the project’s risks by building a proof of concept

- Elaboration
  - Develop a common understanding of the system’s scope and desired behavior by exploring scenarios with end users and domain experts
  - Establish the system’s architecture
  - Design common mechanisms to address system-wide issues

Risk Management Phase-by-Phase (cont.)

- Construction
  - Refine the architecture
  - Risk-driven iterations
  - Continuous integration

- Transition
  - Facilitate user acceptance
  - Measure user satisfaction

- Post-deployment cycles
  - Continue evolutionary approach
  - Preserve architectural integrity
Initial Project Risks
Initial Project Scope

Revise Overall Project Plan
• Cost
• Schedule
• Scope/Content

Plan Iteration N
• Cost
• Schedule

Develop Iteration N
• Collect cost and quality metrics

Assess Iteration N

Risks Eliminated

Revise Project Risks
• Reprioritize

Plan Iteration N

Assess Iteration N

Risks Eliminated

Revise Overall Project Plan

Initial Project Risks
Initial Project Scope

Iteration N

Risk Reduction Drives Iterations

Inception Elaboration Construction Transition

Use Cases Drive the Iteration Process

“Mini-Waterfall” Process

Iteration Planning
Requirements Capture
Analysis & Design
Implementation
Test
Prepare Release

Iteration 1 → Iteration 2 → Iteration 3
The Iteration Life Cycle: A Mini-Waterfall

Selected scenarios:
- Results of previous iterations
- Up-to-date risk assessment
- Controlled libraries of models, code, and tests

Iteration Planning
- Requirements Capture
- Analysis & Design
- Implementation
- Test
- Prepare Release

Release description
- Updated risk assessment
- Controlled libraries

Detailed Iteration Life Cycle Activities

- Iteration planning
  - Before the iteration begins, the general objectives of the iteration should be established based on
    - Results of previous iterations (if any)
    - Up-to-date risk assessment for the project
  - Determine the evaluation criteria for this iteration
  - Prepare detailed iteration plan for inclusion in the development plan
    - Include intermediate milestones to monitor progress
    - Include walkthroughs and reviews
**Detailed Iteration Life Cycle Activities (cont.)**

- **Requirements Capture**
  - Select/define the use cases to be implemented in this iteration
  - Update the object model to reflect additional domain classes and associations discovered
  - Develop a test plan for the iteration

- **Analysis & Design**
  - Determine the classes to be developed or updated in this iteration
  - Update the object model to reflect additional design classes and associations discovered
  - Update the architecture document if needed
  - Begin development of test procedures

- **Implementation**
  - Automatically generate code from the design model
  - Manually generate code for operations
  - Complete test procedures
  - Conduct unit and integration tests
Detailed Iteration Life Cycle Activities (cont.)

- Test
  - Integrate and test the developed code with the rest of the system (previous releases)
  - Capture and review test results
  - Evaluate test results relative to the evaluation criteria
  - Conduct an iteration assessment

- Prepare the release description
  - Synchronize code and design models
  - Place products of the iteration in controlled libraries

Work Allocation Within an Iteration

- Work to be accomplished within an iteration is determined by
  - The (new) use cases to be implemented
  - The rework to be done

- Packages make convenient work packages for developers
  - High-level packages can be assigned to teams
  - Lower-level packages can be assigned to individual developers

- Use Cases make convenient work packages for test and assessment teams

- Packages are also useful in determining the granularity at which configuration management will be applied
  - For example, check-in and check-out of individual packages
Iteration Assessment

- Assess iteration results relative to the evaluation criteria established during iteration planning:
  - Functionality
  - Performance
  - Capacity
  - Quality measures
- Consider external changes that have occurred during this iteration
  - For example, changes to requirements, user needs, competitor’s plans
- Determine what rework, if any, is required and assign it to the remaining iterations

Selecting Iterations

- How many iterations do I need?
  - On projects taking 18 months or less, 3 to 6 iterations are typical
- Are all iterations on a project the same length?
  - Usually
  - Iteration length may vary by phase. For example, elaboration iterations may be shorter than construction iterations
The First Iteration

- The first iteration is usually the hardest
  - Requires the entire development environment and most of the development team to be in place
  - Many tool integration issues, team-building issues, staffing issues, etc. must be resolved
- Teams new to an iterative approach are usually overly-optimistic
- Be modest regarding the amount of functionality that can be achieved in the first iteration
  - Otherwise, completion of the first iteration will be delayed,
  - The total number of iterations reduced, and
  - The benefits of an iterative approach reduced

There Is No Silver Bullet

- Remember the main reason for using the iterative life cycle:
  - You do not have all the information you need up front
  - Things will change during the development period
- You must expect that
  - Some risks will not be eliminated as planned
  - You will discover new risks along the way
  - Some rework will be required; some lines of code developed for an iteration will be thrown away
  - Requirements will change along the way