Analysis and Design with UML

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Agenda

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

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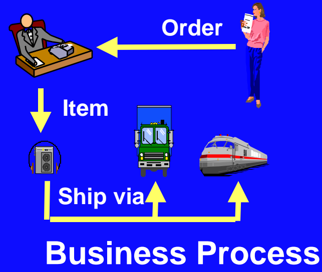
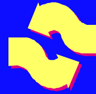
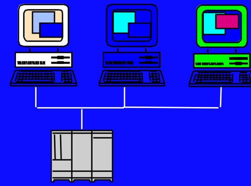
What is Visual Modeling?



Business Process

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





Computer System

Visual Modeling is modeling using standard graphical notations

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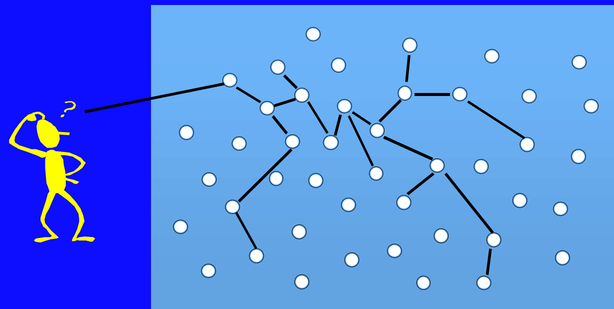
Visual Modeling Captures Business Process

Use Case Analysis is a technique to capture business process from user's perspective



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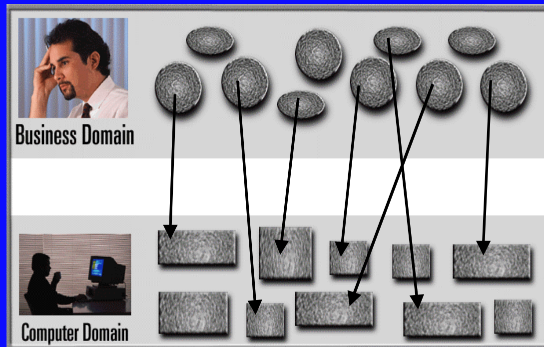
Visual Modeling is a Communication Tool

Use visual modeling to capture business objects and logic



Use visual modeling to analyze and design your application

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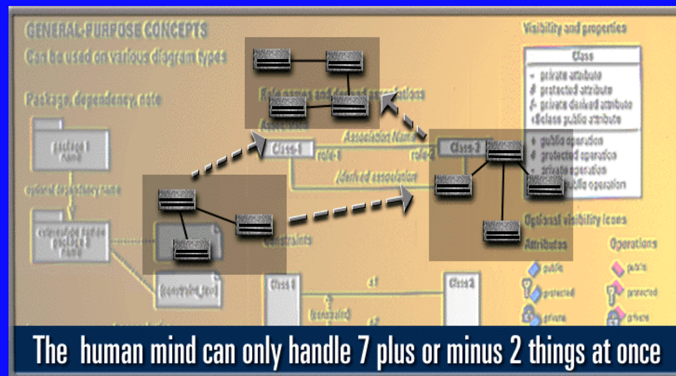
Visual Modeling Manages Complexity



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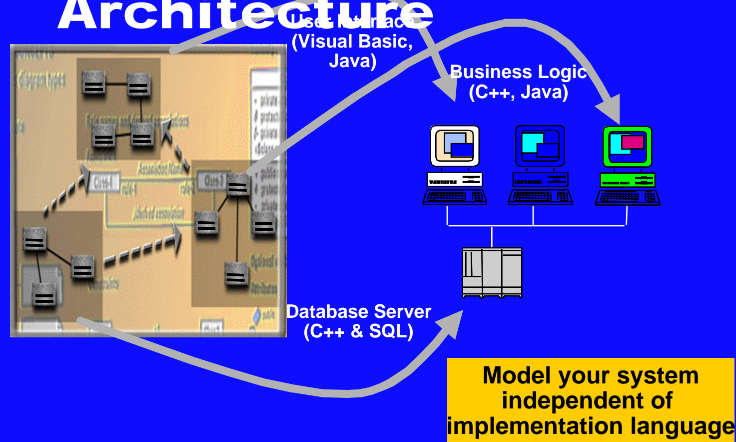
Visual Modeling Defines Software Architecture



Model your system independent of implementation language

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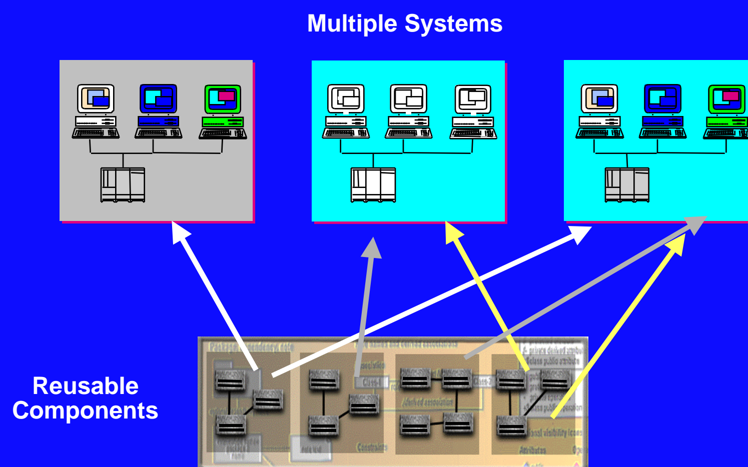
Visual Modeling Promotes Reuse

Multiple Systems



Reusable Components

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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

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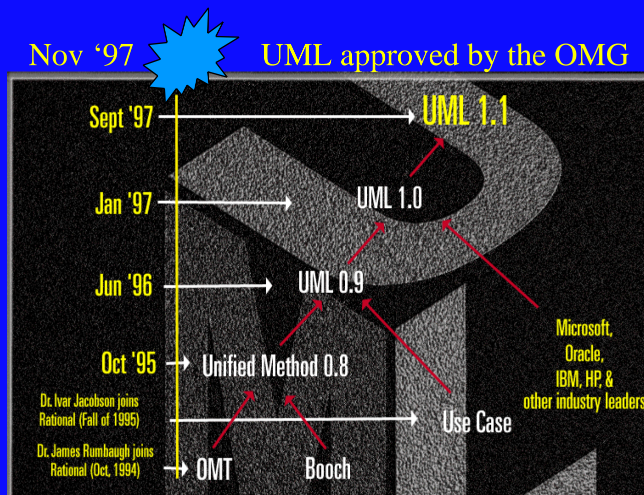
History of the UML



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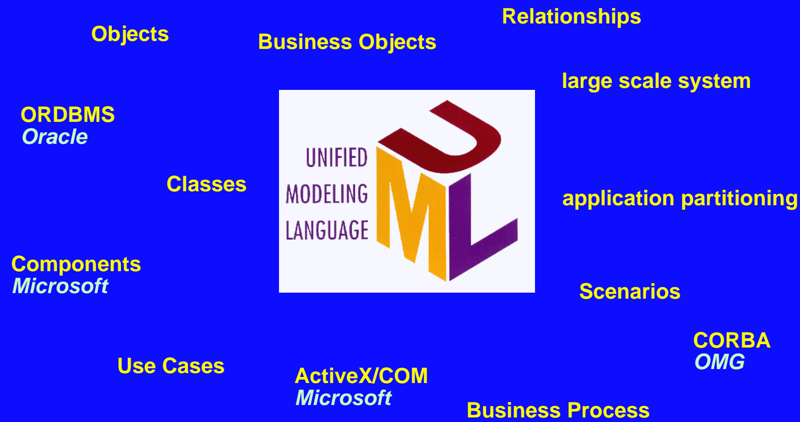
UML Supports Application Development



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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

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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

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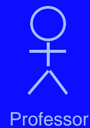
Actors

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



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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

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Documenting Use Cases

- A flow of events document is created for each use cases
  - 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

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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.
- ...

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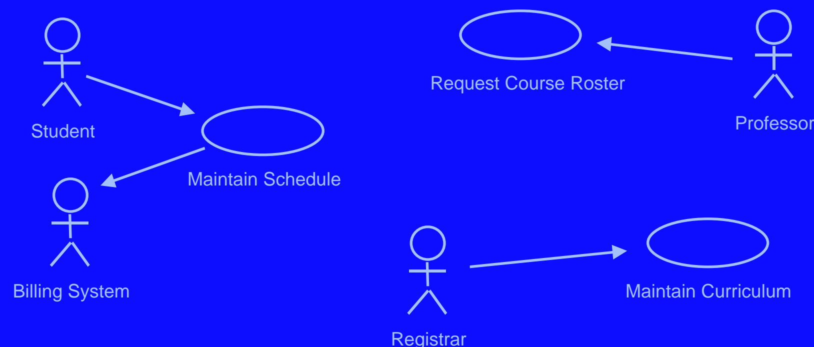
Use Case Diagram

- Use case diagrams are created to visualize the relationships between actors and use cases



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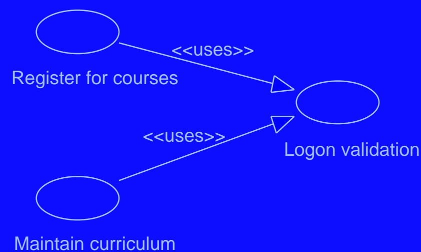
Uses and Extends Use Case Relationships

- 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



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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

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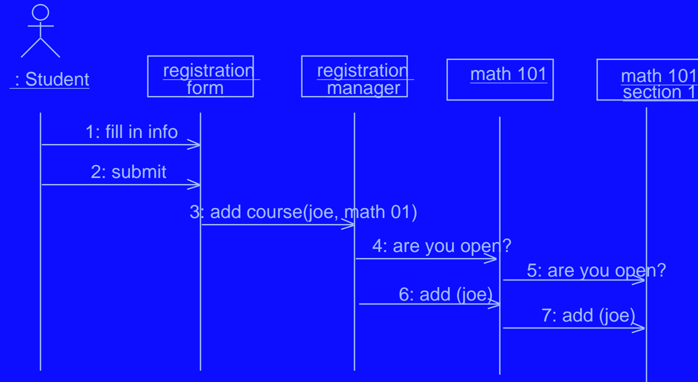
Sequence Diagram

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



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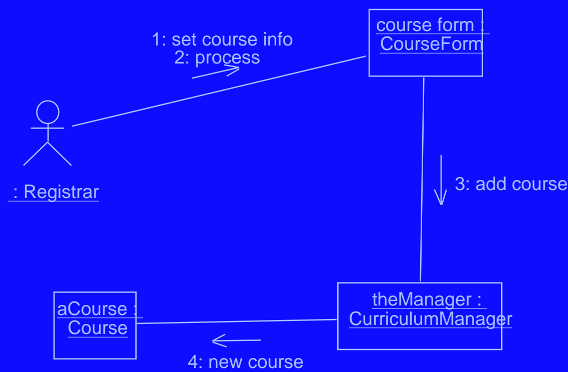
Collaboration Diagram

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



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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

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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

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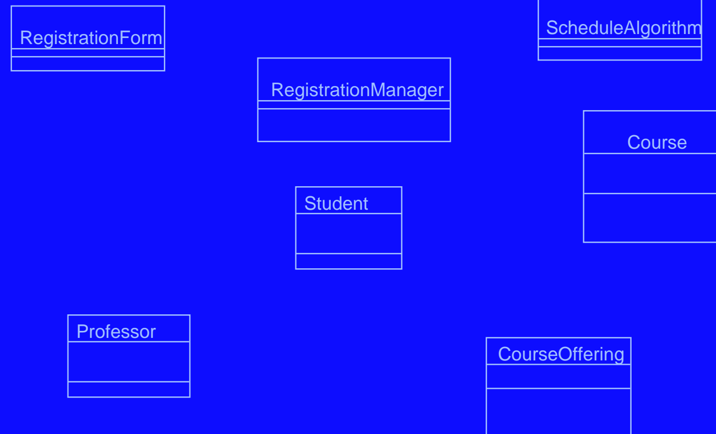
Classes



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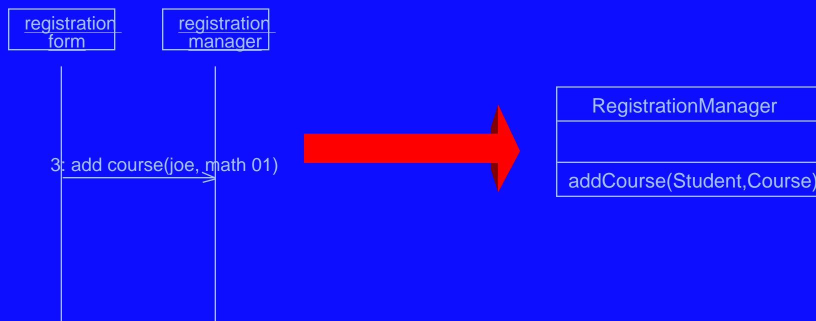
Operations

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



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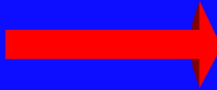
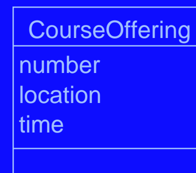
Attributes

- 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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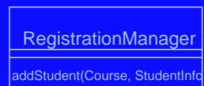
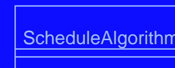
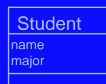
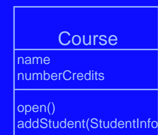
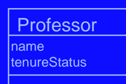
Classes

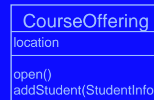












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Relationships

- 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

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Relationships

- 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

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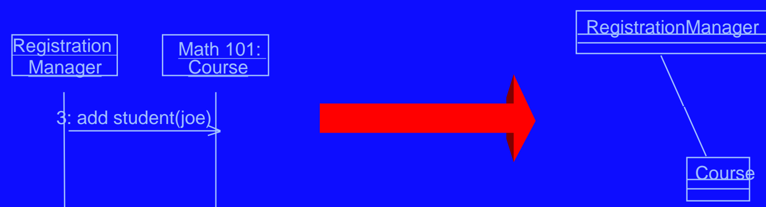
Finding Relationships

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



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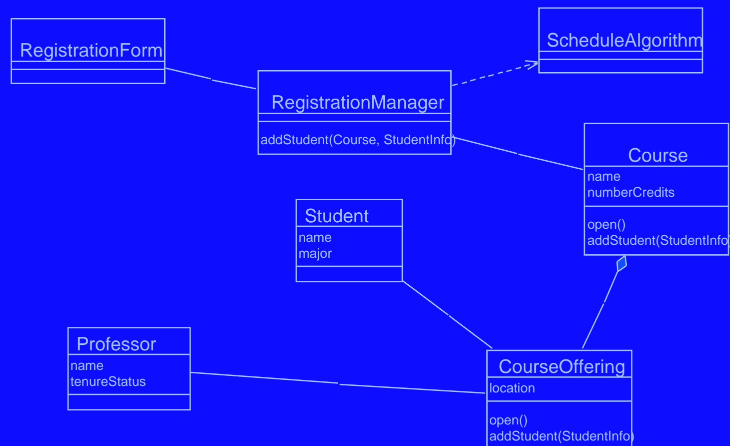
Relationships



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Multiplicity and Navigation

- Multiplicity defines how many objects participate in a relationships
  - 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

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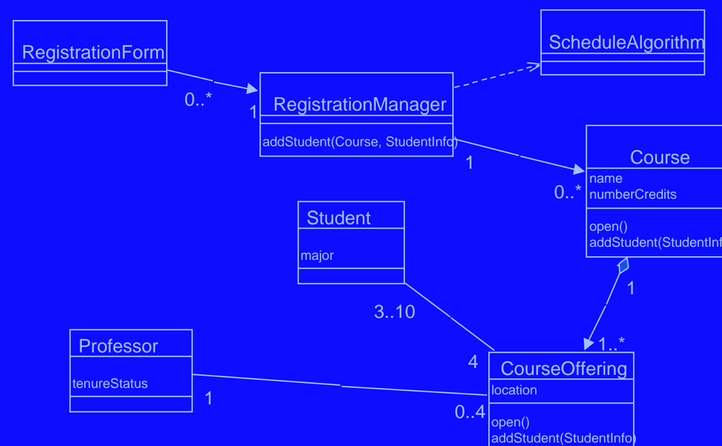
Multiplicity and Navigation



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Inheritance

- Inheritance is a relationships 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

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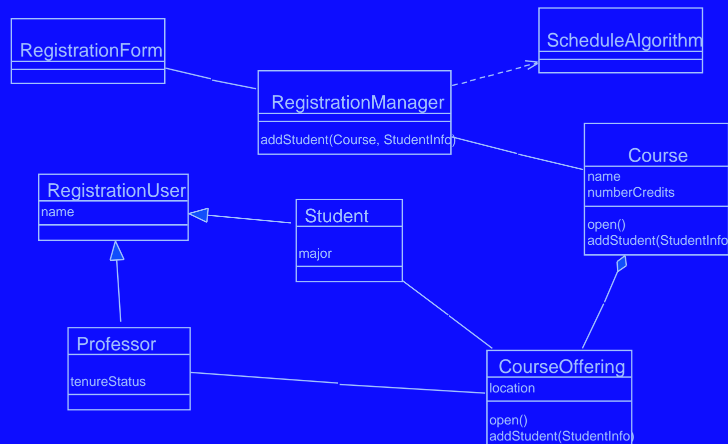
Inheritance



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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

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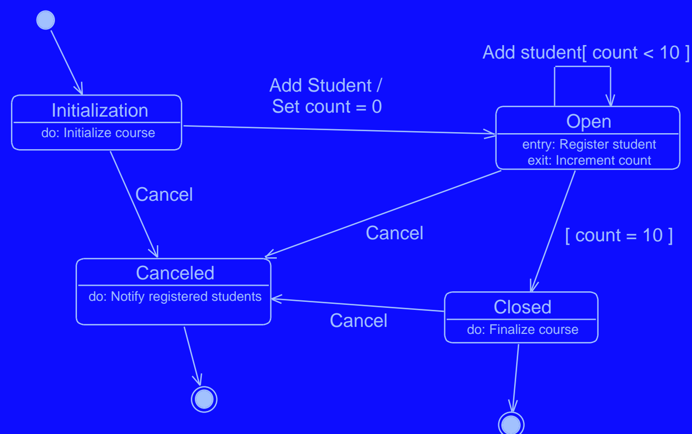
State Transition Diagram



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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

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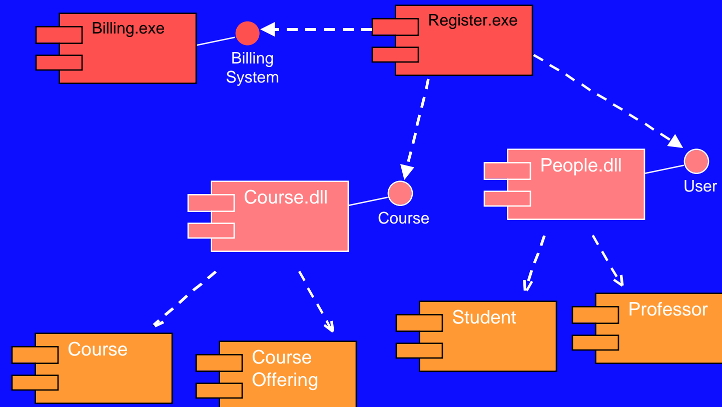
Component Diagram



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Deploying the System

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

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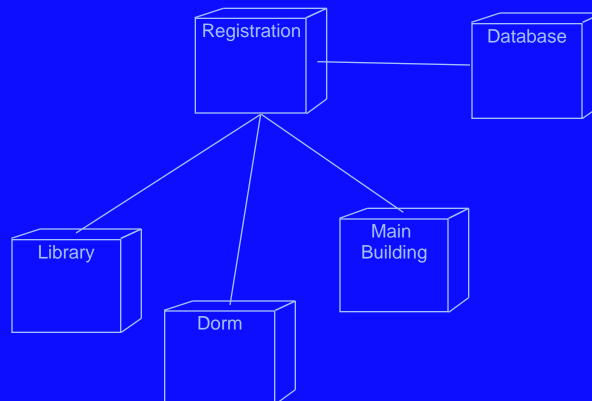
Deployment Diagram



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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

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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

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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

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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

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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

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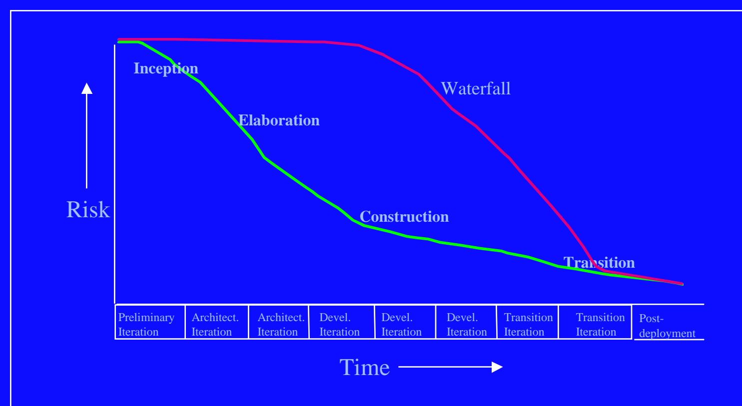
Risk Profile of an Iterative Development



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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

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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

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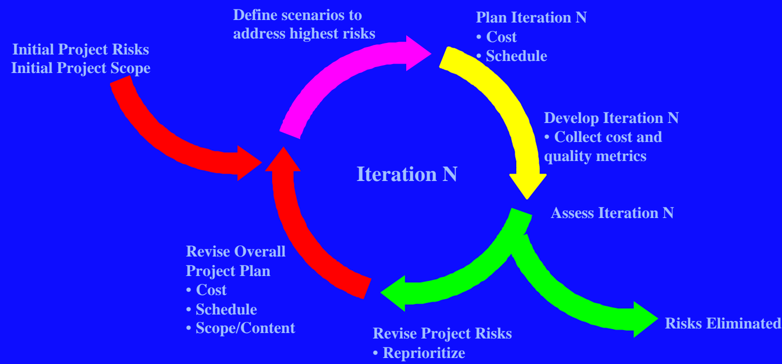
Risk Reduction Drives Iterations



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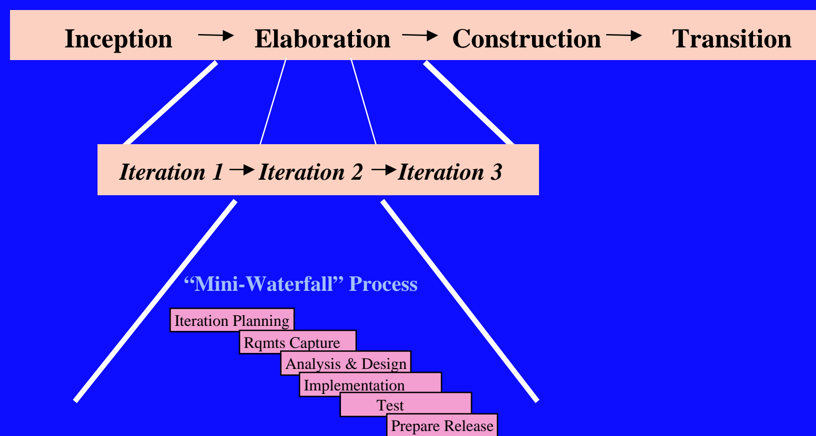
Use Cases Drive the Iteration Process



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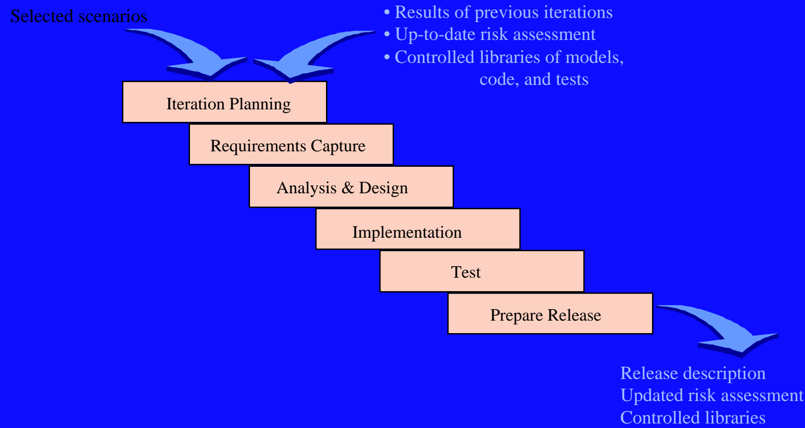
The Iteration Life Cycle: A Mini-Waterfall



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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

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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

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Detailed Iteration Life Cycle Activities (cont.)

- 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

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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

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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

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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

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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

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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

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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

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