Lecture 5

Introduction to UML

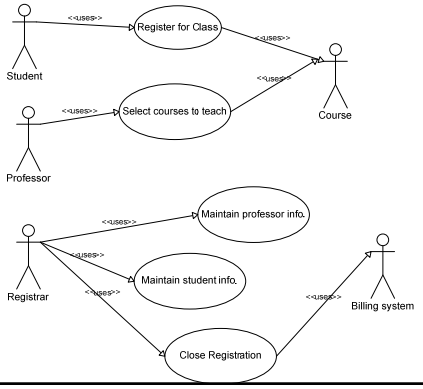
Today's Topic

- What is UML
- Why use UML?
- UML Diagrams
  - Static
    - Use case, Class, Object
    - Deployment, Component (Physical Diagrams)
  - Dynamic
    - Sequence, Collaboration (Interaction Diagrams)
    - Activity, State

What is UML ?

- UML: Universal Modeling Language
- A standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems.
- UML uses mostly graphical notations.
- Current version: 2.3 (2.4 beta2)
- Complete spec can be freely downloaded at www.uml.org

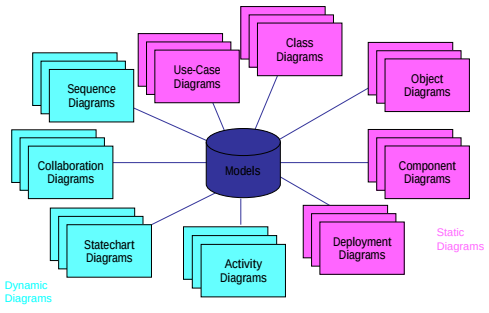
Example: University Course Registration System



Why Use UML

- UML is a technique to manage the complexity of object-oriented systems as they increase in scope and scale.
- Programming language independent
- Communication: clearer than natural language, provides a level of precision, but avoids details
- Supports iterative development (i.e., spiral model)
  - Supports both high level requirements/design in early spirals and detailed requirements/design later
- Provides a blueprint for programmers to implement

UML Diagrams



Source: Rational Software

Using multiple views for a single model.

Reference: UML Distilled: A Brief Guide to the Standard Object Modeling Language, Third Edition, by Martin Fowler (2003)

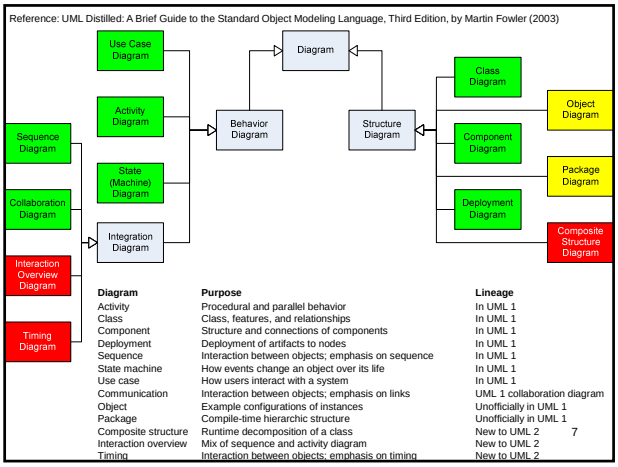


Diagram	Purpose	Lineage
Activity	Procedural and parallel behavior	In UML 1
Class	Class, features, and relationships	In UML 1
Component	Structure and connections of components	In UML 1
Deployment	Deployment of artifacts to nodes	In UML 1
Sequence	Interaction between objects; emphasis on sequence	In UML 1
State machine	How events change an object over its life	In UML 1
Use case	How users interact with a system	In UML 1
Communication	Interaction between objects; emphasis on links	UML 1 collaboration diagram
Object	Example configurations of instances	Unofficially in UML 1
Package	Compile-time hierarchic structure	Unofficially in UML 1
Composite structure	Runtime decomposition of a class	New to UML 2
Interaction overview	Mix of sequence and activity diagram	New to UML 2
Timing	Interaction between objects; emphasis on timing	New to UML 2

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Static Model Diagrams

- Use case diagram
  - Drawings and structured descriptions of steps in workflows
- Class diagram
  - Internal structure of system, extension of entity-relationship diagram (ER diagram for database, to be covered).
  - Three elements in each entity: name, attributes, methods
- Deployment diagram
  - Physical components: processors, workstations, network
- Component diagram
  - High level model of physical software architecture
  - Consists of modules, which are grouped in packages
  - Packages contains definition of group of classes (entities, methods)

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Source: MIT 1.264 lecture notes

Dynamic Model Diagrams

While static models are done for the system as a whole, dynamic models are done only for key components

- Activity Diagram
- State diagram
  - Specifies behavior of an object (entity)
- Sequence diagram (or ladder diagram)
  - Shows details of scenario and messages that flow between objects over time
  - Heavily used in standards
- Collaboration diagram
  - Shows flow of messages as a graph.

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Source: MIT 1.264 lecture notes

UML Modeling Tools

- There are several free and commercial software for creating UML diagrams
  - Microsoft Visio
    - http://office.microsoft.com/en-us/FX010857981033.aspx
  - Rational Rose (now with IBM)
    - http://www-306.ibm.com/software/rational/
  - Poseidon for UML
    - http://www.gentleware.com/
    - The user guide is a good reference !

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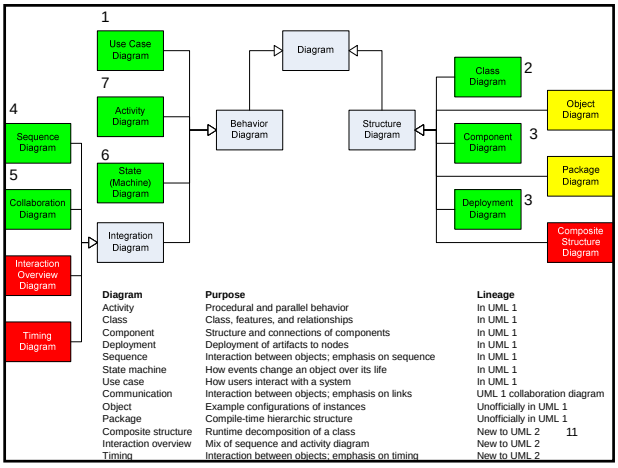

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Use Case Diagram

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Use Case Diagram

- Describes the requirements of the system, especially functional requirements
- Use case diagram contains
  - Actors and their descriptions
  - Relationships between different entities

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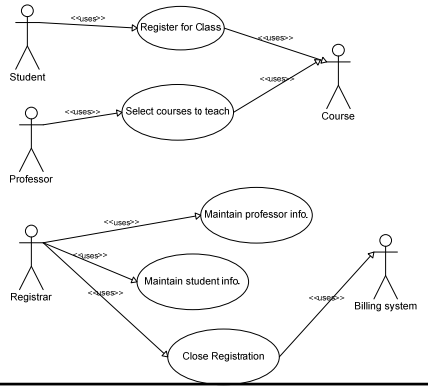
Example: University Course Registration System



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Elements of Use Case Diagram

An actor represents anything that interacts with the system.
- Actors are not part of the system, they represent roles a user of the system can play.
- An actor can actively interchange information with the system.
- An actor can be a passive recipient of information.
- An actor can be a giver of information.
- An actor can represent a human, a machine or another system.

A use case (instance) defines a sequence of actions a system performs that yields a result of observable value to an actor.
- A use case models a dialogue between an actor and the system.
- A use case is initiated by an actor to invoke a certain functionality in the system.
- A use case is a complete and meaningful flow of events.
- Taken together, all use cases constitute all possible ways of using the system.

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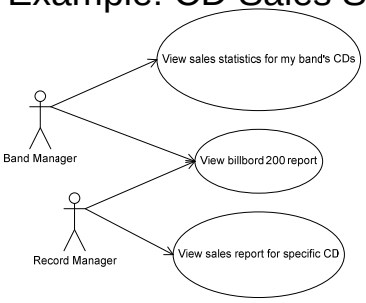
Example: CD Sales System



DEMO

http://bronze.rational.com:8169/content/jun_03/f_UMLintro_db.jsp

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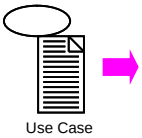
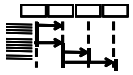
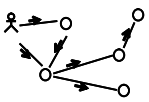
- Once the use case diagram is completed (in other words, the requirement specification is done), analysis and design take places.


Use Case


Sequence Diagrams


Collaboration Diagrams


Class Diagrams

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Class Diagram

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Class Diagram

- Used in requirements, design and implementation:
  - Conceptual, to represent general entities in system
  - Specification, where we specify what each entity (class) will do (but not how)
    - List the methods/actions
  - Implementation
    - Detailed class diagram of actual software (Java or C++)
- List attributes, same as data model
- List methods/operations/functions
  - Activities naturally associated with the data in the entity
- We often don't model everything—too hard to read
  - Focus on key parts of system

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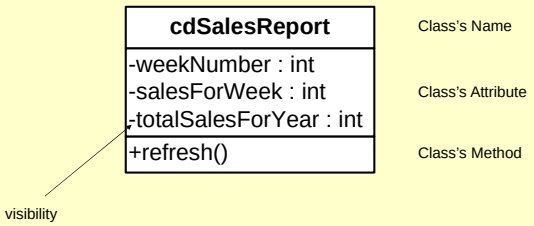
A class element



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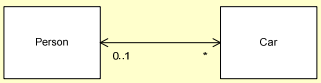
Association

- Associations describe relationships between classes
  - Solid lines are used to describe associations
    - Multiplicity
    - Unidirectional vs. bidirectional



•A person may own 0 to many cars
•A car may have 0 or 1 owner

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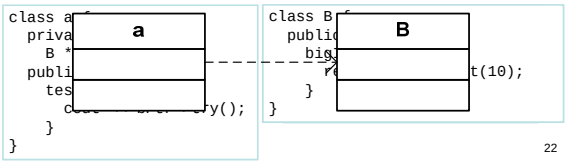
Dependency

- A dependency exists between two elements if changes to the definition of one element (the supplier) may cause changes to the other (the client).
  - one class sends a message to another;
  - one class has another as part of its data;
  - one class mentions another as a parameter to an operation.



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Relationships

Construct	Description	Syntax
Association	A relationship between two or more classifiers that involves connections among their instances.	———
Aggregation	A special form of association that specifies a whole-part relationship between the aggregate (whole) and the component part.	——◇
Generalization	A taxonomic relationship between a more general and a more specific element	——▷
Dependency	A relationship between two modeling elements, in which a change to one modeling element (the independent element) will affect the other modeling element (the dependent element)	- - - - - ▷
Realization	A relationship between a specification and its implementation	- - - - - ▷
Composition	If a class cannot exist by itself, and instead must be a member of another class, then that class has a Composition relationship with the containing class. A Composition relationship is indicated by a line with a filled diamond.	——◆

Constraint

- Constraints can be described by anything, as long as they are inside braces {}.
  - E.g. {debt free: cash in bank should be > 0}
- Conditions
  - Pre-condition: apply to operations. A pre-condition is a statement of how we expect the world to be before we execute an operation.
    - E.g. "square root" operation of input > = 0.
  - Post-condition: applies to operations. A post-condition is a statement of what the world should look like after execution of an operation.
    - E.g. After "square root" operation, input = result * result
  - The conditions suggest the responsibility of checking arguments and results falls on the shoulder of callers
  - Invariant: is an assertion about a class. The invariant is "always" true for all instances of the class.

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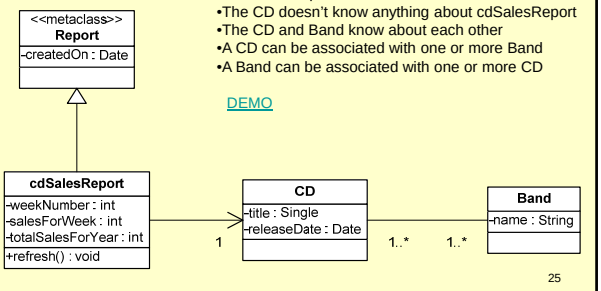
Example

- The cdSalesReport inherits from the Report class
- A cdSalesReport is associated with one CD
- The CD doesn't know anything about cdSalesReport
- The CD and Band know about each other
- A CD can be associated with one or more Band
- A Band can be associated with one or more CD

DEMO



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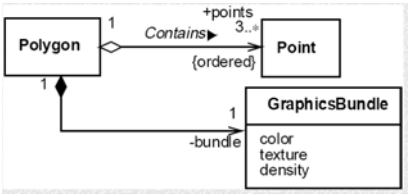
Example



- A polygon contains 3 or more points
- 3 or more points are aggregated in a polygon
- One polygon has one GraphicsBundle, and one GraphicsBundle belongs to exactly one polygon

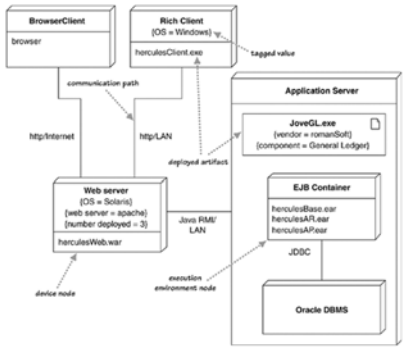
C. Kobryn (1999), "Object Modeling with UML: Introduction to UML"

Deployment Diagram

Deployment Diagrams

- Deployment diagrams show the physical relationship between hardware and software in a system.
- The solid lines represent communication links or dependencies.

Example



Reference: UML Distilled: A Brief Guide to the Standard Object Modeling Language, Third Edition, by Martin Fowler (2003)

Interaction Diagrams

Sequence Diagram

Sequence Diagram

- Shows a detailed or partial flow for a specific use case
- Shows the calls between different objects in their sequence
- 2-D:
  - Vertical: time/order
  - Horizontal: object instances

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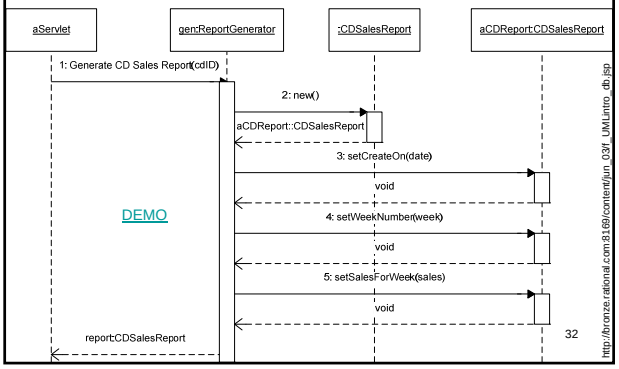
Example



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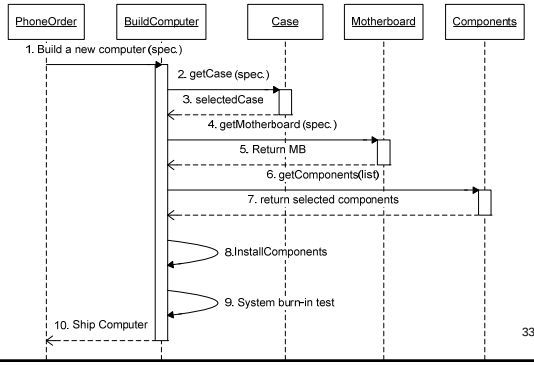
Example



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Summary

- Brief Introduction to UML Diagrams
  - Use case diagram
  - Class diagram
  - Deployment diagram
  - Sequence diagram

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References for UML

http://www-306.ibm.com/software/rational/uml/

http://atlas.kennesaw.edu/~dbraun/csis4650/A&D/UML_tutorial/index.htm

http://www.sparxsystems.com.au/uml-tutorial.html

UML Distilled: A Brief Guide to the Standard Object Modeling Language, Third Edition, by Martin Fowler (2003), ISBN 0-321-19368-7

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Online UML Examples

- Google: uml examples
- http://www.geocities.com/SiliconValley/Network/1582/uml-example.htm
- http://www.smartdraw.com/examples/software-uml/
- http://portal.etsi.org/mbs/Languages/UML/uml_example.asp

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