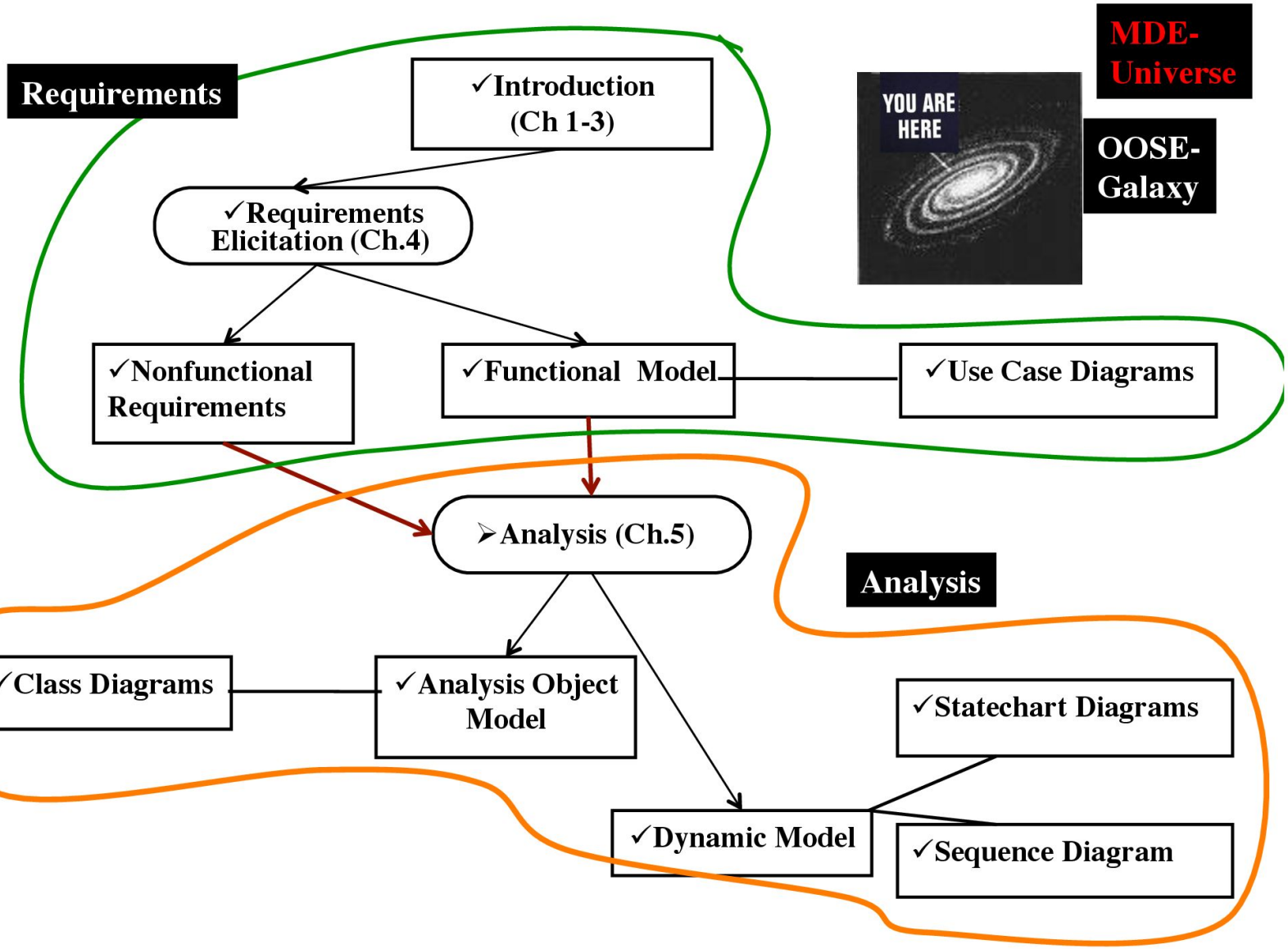
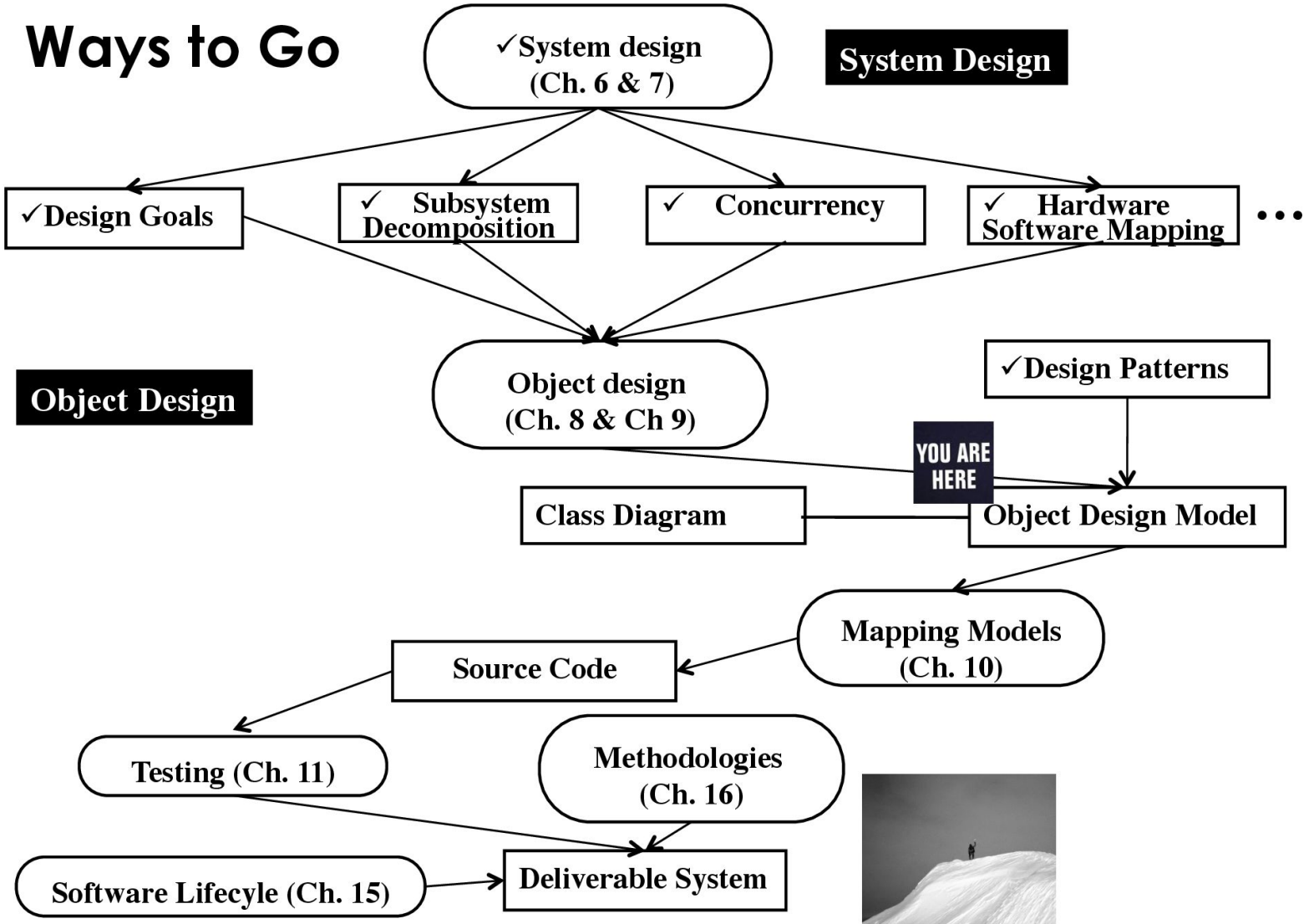

Requirements
✓Introduction (Ch 1-3)
✓Requirements Elicitation (Ch.4)
✓Nonfunctional Requirements
✓Functional Model
✓Use Case Diagrams
➢Analysis (Ch.5)
Analysis
✓Class Diagrams
✓Analysis Object Model
✓Statechart Diagrams
✓Dynamic Model
✓Sequence Diagram
YOU ARE HERE
MDE-Universe
OOSE-Galaxy

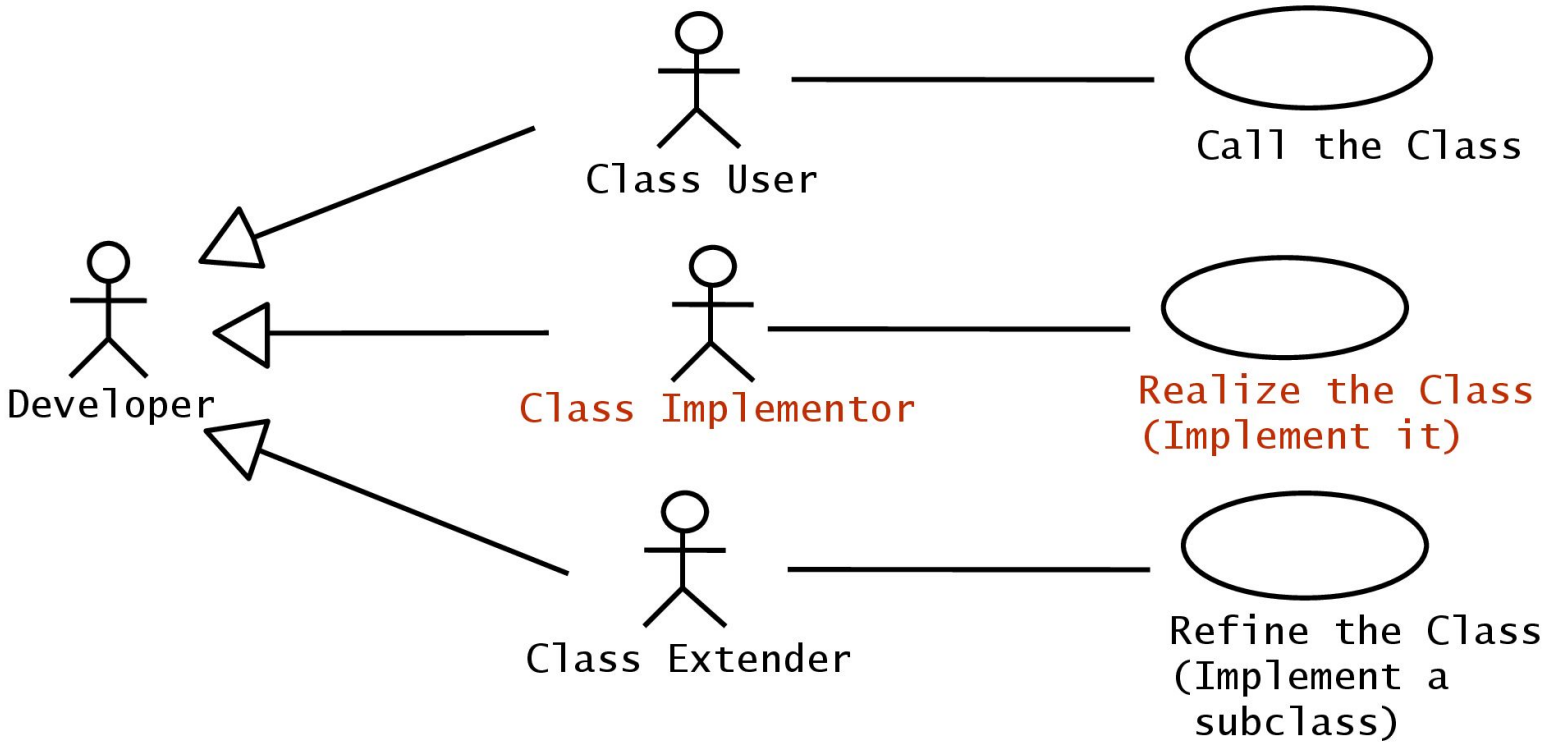
Ways to Go


✓System design
(Ch. 6 & 7)
System Design
✓Design Goals
✓ Subsystem Decomposition
✓ Concurrency
✓ Hardware Software Mapping
...
Object Design
Object design
(Ch. 8 & Ch 9)
✓Design Patterns
YOU ARE HERE
Class Diagram
Object Design Model
Mapping Models
(Ch. 10)
Source Code
Testing (Ch. 11)
Methodologies
(Ch. 16)
Software Lifecyle (Ch. 15)
Deliverable System

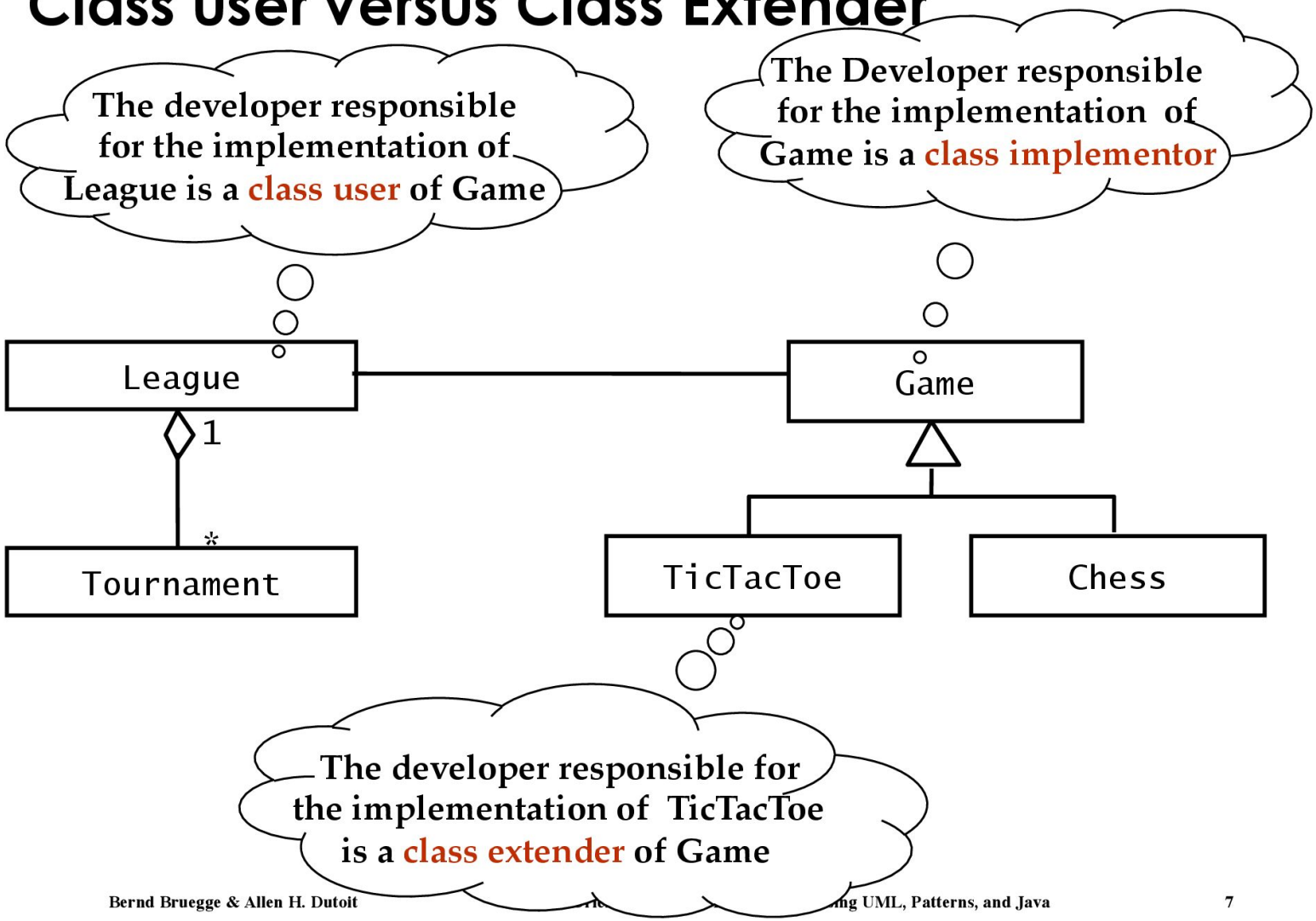
Outline of today's Lecture

- Object Design Activities
- Visibilities
- Information Hiding
- Contracts
- OCL.

Developers play 3 different Roles during Object Design of a Class



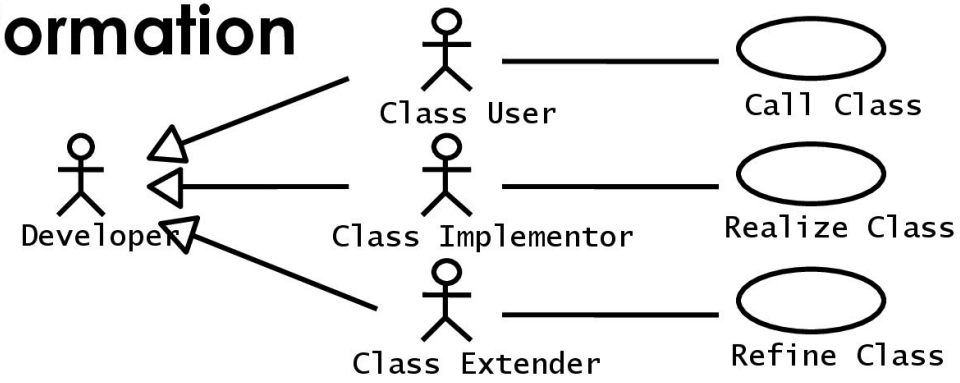
Class user versus Class Extender



Specifying Interfaces

- Requirements analysis activities
  - Identify attributes and operations without specifying their types or their parameters
- Object design activities
  - Add visibility information
  - Add type signature information
  - Add contracts.

Add Visibility Information



Class user ("Public"): +

- Public attributes/operation can be accessed by any class

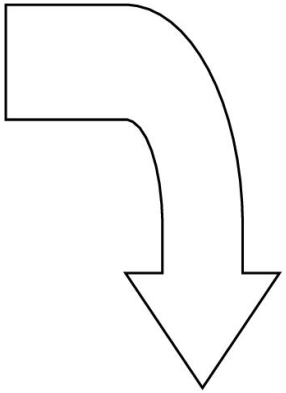
Class implementor ("Private"): -

- Private attributes and operations can be accessed only by the class in which they are defined
- They cannot be accessed by subclasses or other classes

Class extender ("Protected"): #

- Protected attributes/operations can be accessed by the class in which they are defined and by any descendent of the class.

Implementation of UML Visibility in Java



```
public class Tournament {
      private int maxNumPlayers;

public Tournament(League l, int maxNumPlayers)
public int getMaxNumPlayers() {…};
public List getPlayers() {…};
public void acceptPlayer(Player p) {…};
public void removePlayer(Player p) {…};
public boolean isPlayerAccepted(Player p) {…};
```

Information Hiding Heuristics

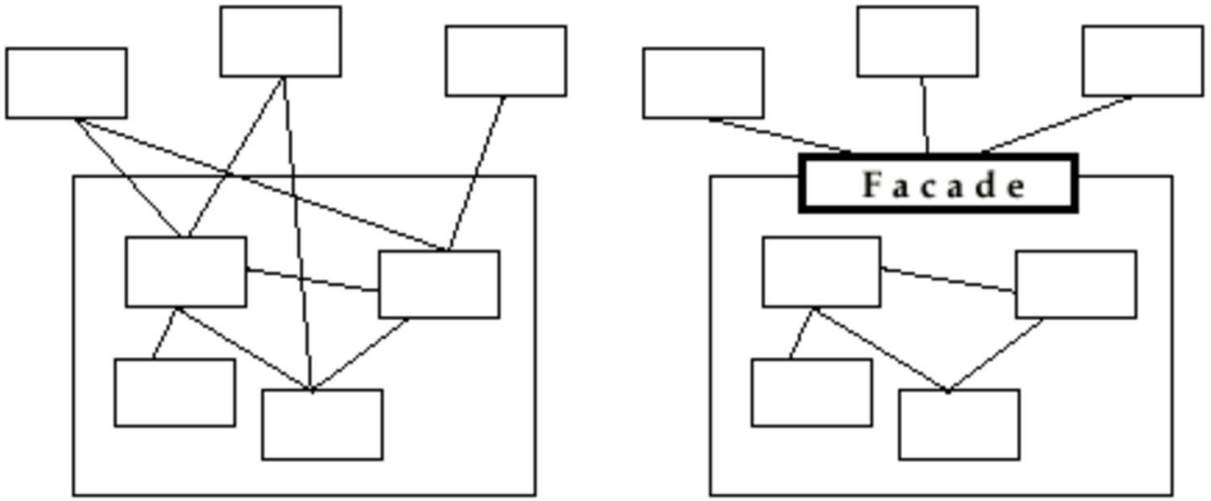
- Carefully **define the public interface** for classes as well as subsystems
  - For subsystems use a **façade** design pattern if possible (see next slides)
- Always apply the "**Need to know" principle**:
  - Only if somebody needs to access the information, make it publicly possible
- The fewer details a class user has to know
  - the easier the class can be changed
  - the less likely they will be affected by any changes in the class implementation
- Trade-off: Information hiding vs. efficiency
  - Accessing a private attribute might be too slow.

Information Hiding Design Principles/2

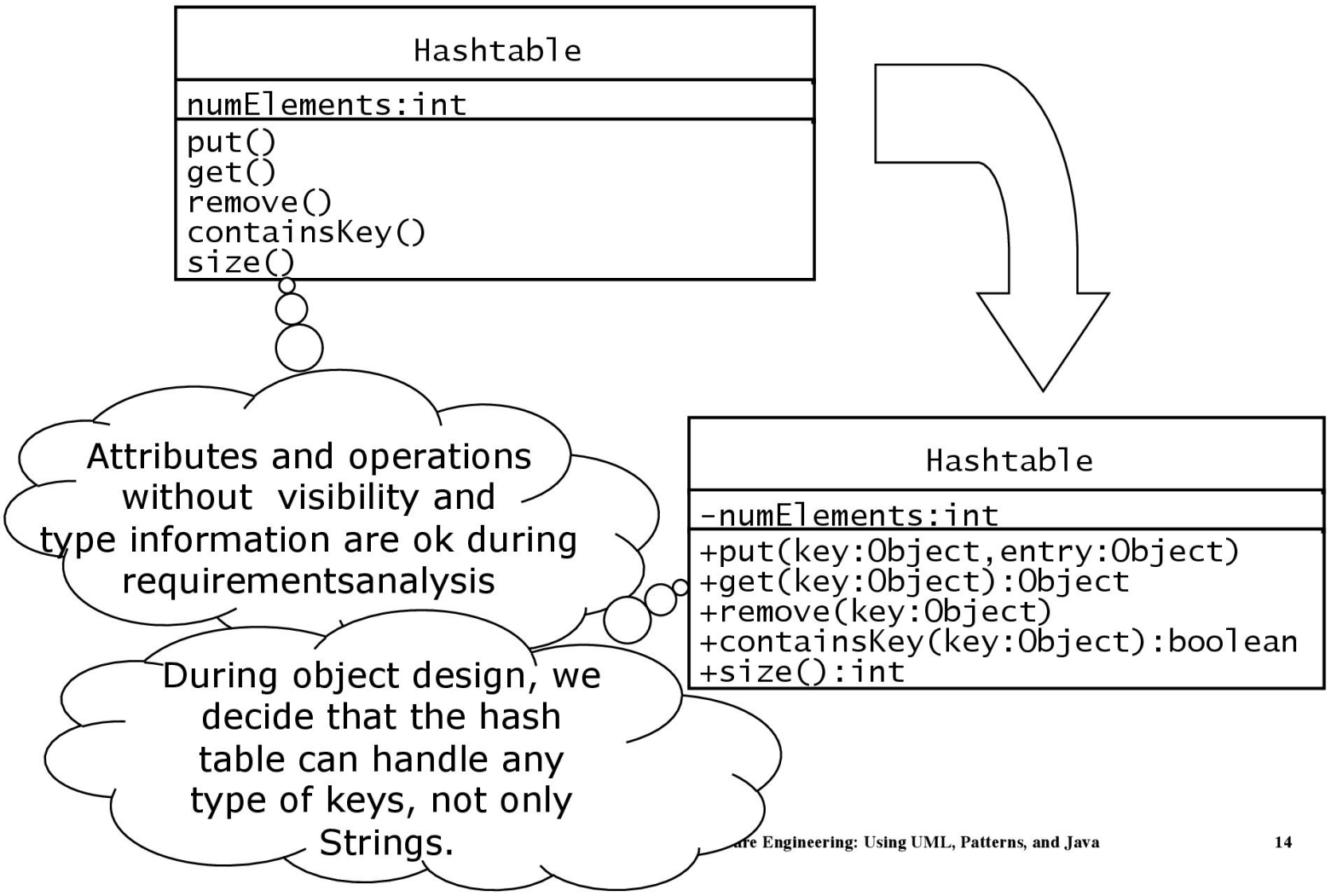
- Only the operations of a class are allowed to manipulate its attributes
  - Access attributes only via operations
- Hide external objects at subsystem boundary
  - Define abstract class interfaces which mediate between the external world and the system as well as between subsystems
  - Use the **façade pattern**
- Do not apply an operation to the result of another operation
  - Write a new operation that combines the two operations.

Facade Pattern

- Provides a unified interface to a set of classes in a subsystem
  - A façade consists of a set of public operations
  - Each public operation is delegated to one or more operations in the classes behind the facade
- A facade defines a higher-level interface that makes the subsystem easier to use (i.e. it abstracts out the gory details).



Add Type Signature Information



Outline of Today's Lecture

- Object Design Activities
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- Information Hiding
- Contracts

Modeling Constraints with Contracts

- Example of constraints in Arena:
  - An already registered player cannot be registered again
  - The number of players in a tournament should not be more than maxNumPlayers
  - One can only remove players that have been registered
- These constraints cannot be modeled in UML
- We model them with contracts
- Contracts can be written in OCL.

Contract

- Contract: A lawful agreement between two parties in which both parties accept obligations and on which both parties can found their rights
  - The remedy for breach of a contract is usually an award of money to the injured party
- Object-oriented contract: Describes the services that are provided by an object if certain conditions are fulfilled
  - services = “obligations”, conditions = “rights”
  - The remedy for breach of an OO-contract is the generation of an exception.

Object-Oriented Contract

- An object-oriented contract describes the services that are provided by an object. For each service, it specifically describes two things:
  - The conditions under which the service will be provided
  - A specification of the result of the service
- Examples:
  - A letter posted before 18:00 will be delivered on the next working day to any address in Germany
  - For the price of 4 Euros a letter with a maximum weight of 80 grams will be delivered anywhere in the USA within 4 hours of pickup.

Object-Oriented Contract

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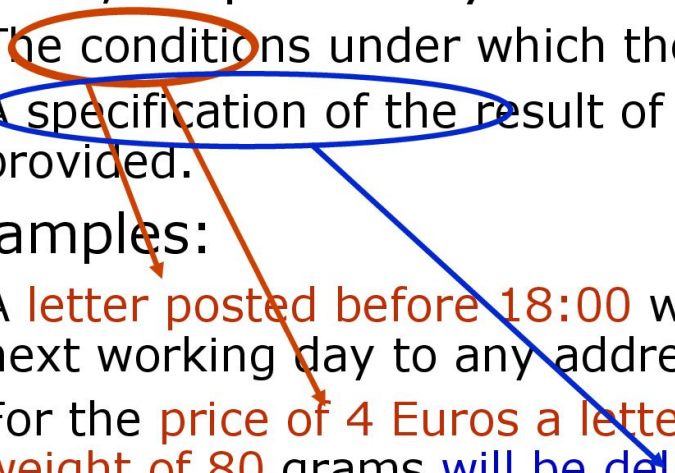


Modeling OO-Contracts

- Natural Language
- Mathematical Notation
- Models and contracts:
  - A language for the formulation of constraints with the formal strength of the mathematical notation and the easiness of natural language:

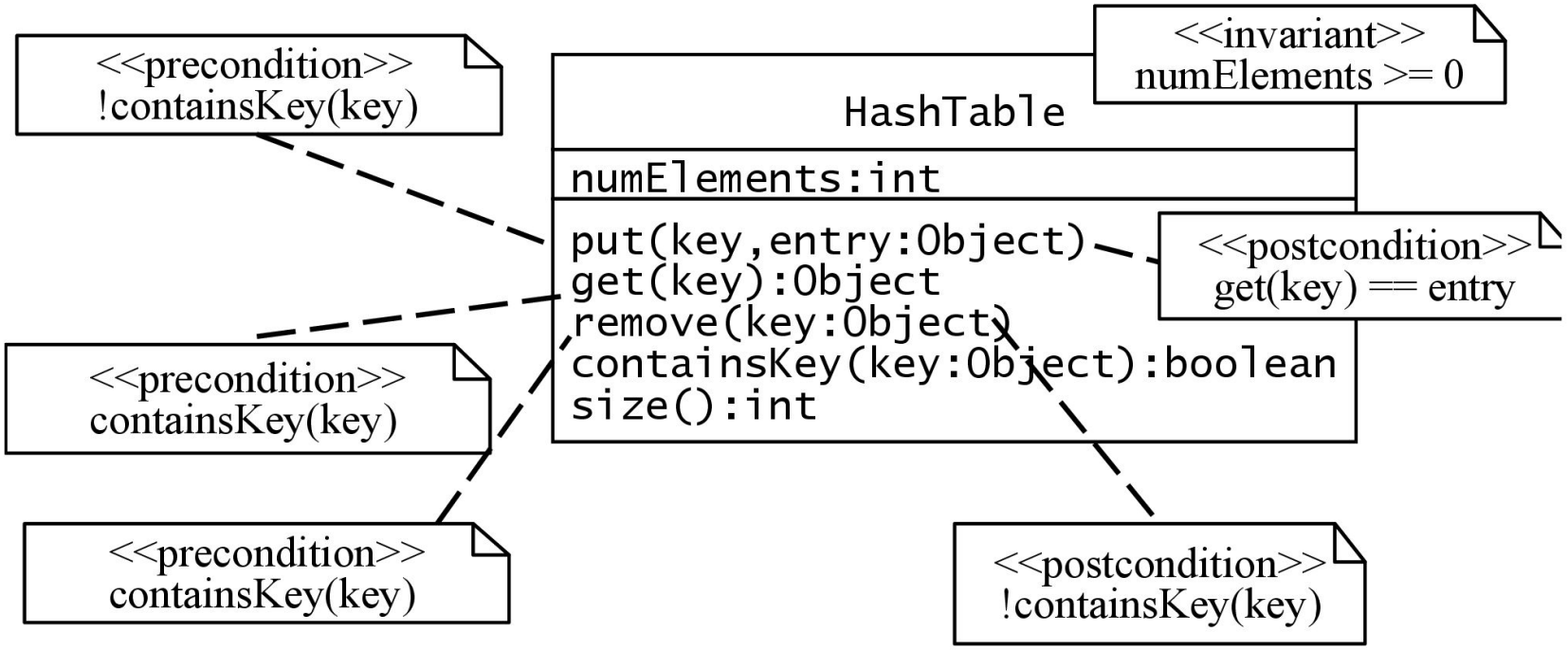
    $\Rightarrow$ UML + OCL (Object Constraint Language)
  - Uses the abstractions of the UML model
  - OCL is based on predicate calculus

Contracts and Formal Specification

- Contracts enable the caller and the provider to share the same assumptions about the class
- A contract is an exact specification of the interface of an object
- A contract include three types of constraints:
  - Invariant:
    - A predicate that is always true for all instances of a class
  - Precondition ("rights"):
    - Must be true before an operation is invoked
  - Postcondition ("obligation"):
    - Must be true after an operation is invoked.

Expressing Constraints in UML Models

- A constraint can also be depicted as a note attached to the constrained UML element by a dependency relationship.



Why not use Contracts already in Requirements Analysis?

- Many constraints represent domain level information
- Why not use them in requirements analysis?
  - Constraints increase the precision of requirements
  - Constraints can yield more questions for the end user
  - Constraints can clarify the relationships among several objects
- Constraints are sometimes used during requirements analysis, however there are trade offs

Requirements vs. Object Design Trade-offs

- Communication among stakeholders
  - Can the client understand formal constraints?
- Level of detail vs. rate of requirements change
  - Is it worth precisely specifying a concept that will change?
- Level of detail vs. elicitation effort
  - Is it worth the time interviewing the end user?
  - Will these constraints be discovered during object design anyway?
- Testing constraints
  - If tests are generated early, do they require this level of precision?

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