Object Oriented Design using UML

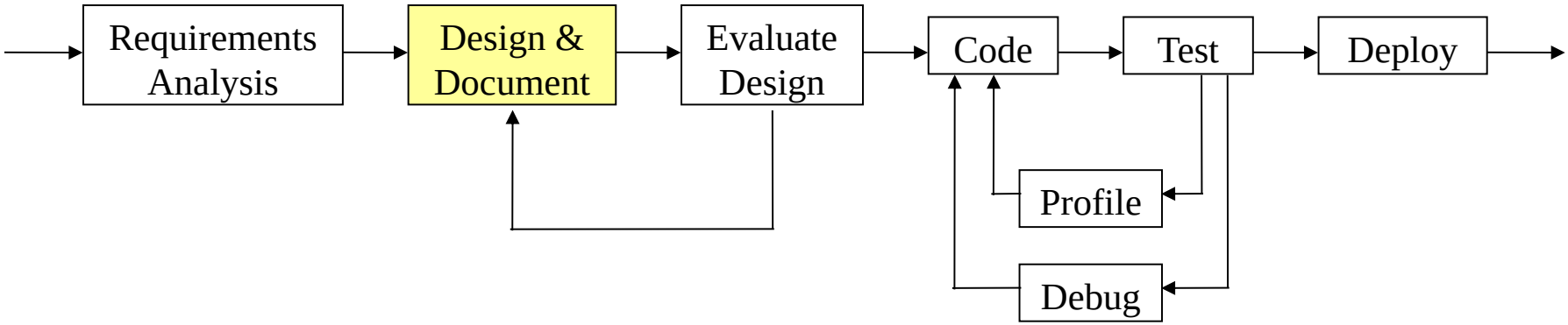
CSE219, Computer Science III

Stony Brook University

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

Software Development Life Cycle

- Using well proven, established processes
  - preferably while taking advantage of good tools



Design Approaches

- Have other "similar" problems been solved?
  - Do design patterns exist to help?
- What are the "easy" and "hard" parts?
  - Why is this important?
    - work measurement
- Employ:
  - data-driven design
    - Note: data-driven programming is a programming paradigm in which the program statements describe the data to be matched and the processing required rather than defining a sequence of steps to be taken.
  - top-down design
    - A top-down approach is the breaking down of a system to gain insight into its compositional sub-systems.

Data-driven Design

- From the problem specification, extract:
  - nouns (they are objects, attributes of objects)
  - verbs (they are methods)
- Divide data into separate logical, manageable groupings
  - these will form your objects
- Note needs for data structures or algorithms
  - design your data management classes early on

Data-driven Design gives the Class relationships

- Think data flow:
  - What HAS what?
  - What IS what?
  - What USES what?
  - Where should data go?
  - How will event handler X change data in class Y?
  - Static or non-static?
- Design patterns will help us make these decisions
- Bottom line: think modular
  - no 1000 line classes or 100 line methods

Modularity

- How reusable are your classes?
  - can they be used in a future project?
- Think of programmers, not just users
- Can individual classes be easily separated and re-used?
  - Separate Data from Mechanics
  - Separate Functionality from Presentation

Functionality vs. Presentation

The state manager:

- manages the state of one or more user interface controls such as text fields, OK buttons, radio buttons, etc. in a graphical user interface.
  - In this user interface programming technique, the state of one UI control depends on the state of other UI controls.
- classes that do the work of managing data & enforcing rules on that data

- Why separate the state management and the UI?
  - so we can design several different UIs for a state manager
  - so we can change the state management without changing the UI
  - so we can change the UI without changing the state manager
  - reuse code that is proven to work
  - This is a common principle throughout GUI design
    - even for Web sites (separate content)
    - different programmers for each task

Choosing Data Structures

- Internal data structures
  - What is the natural representation of the given data?
  - Trade-offs: Setup vs. access speeds
  - Keep data ordered?
    - Which access algorithms?
    - Ordered by what?

UML Diagrams

- UML - Unified Modeling Language
- UML diagrams are used to design object-oriented software systems
  - represent systems visually = Client-friendly!
  - provides a system architecture
  - makes coding more efficient and system more reliable
  - diagrams show relationships among classes and objects
- Can software engineering be automated?
  - Visual programming
  - Patterns & frameworks
  - Computer-Aided Software Engineering (CASE) tools

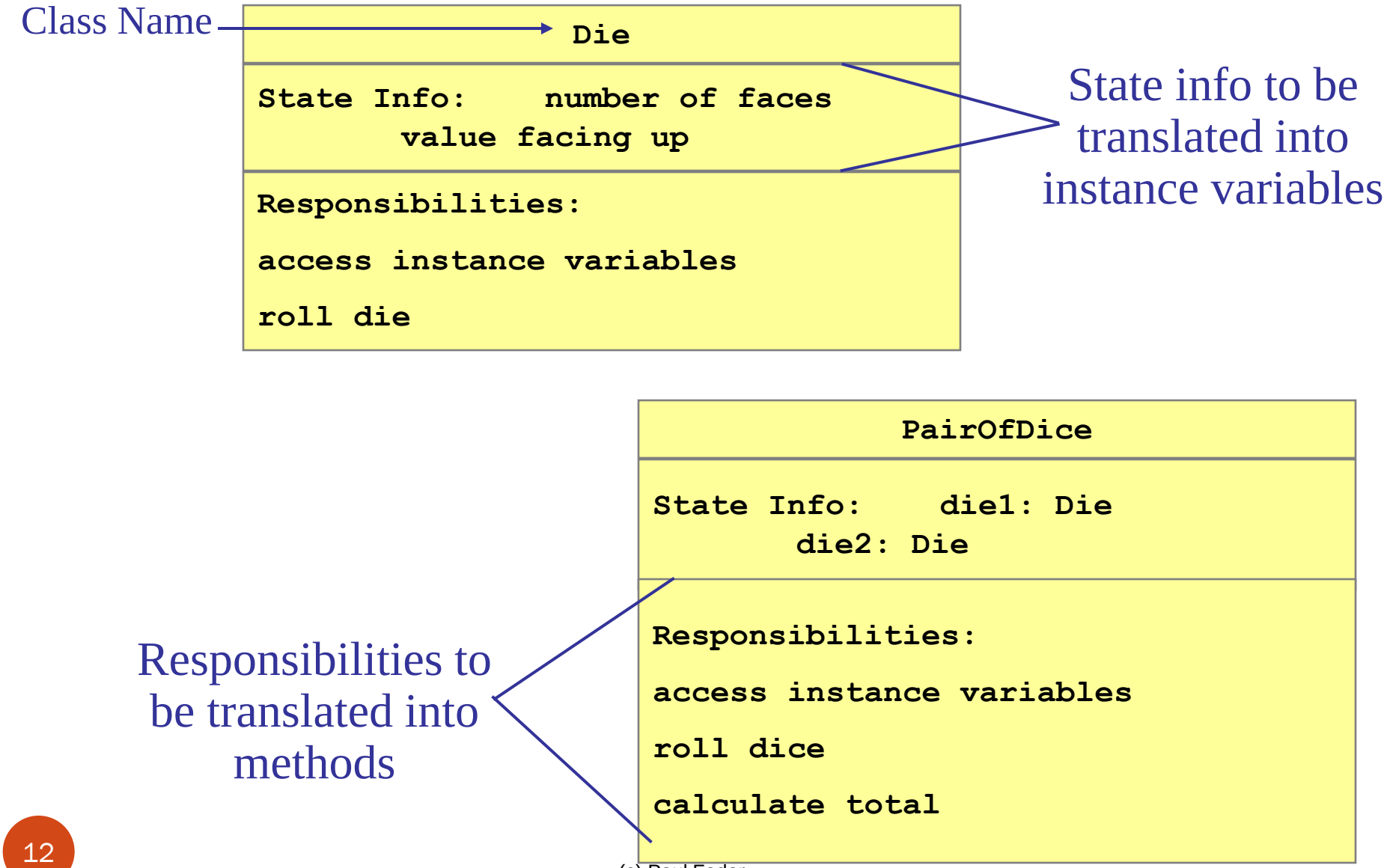
Types of UML Diagrams

- Types of UML diagrams that we will make in CSE219:
  - Use Case Diagram
  - Class Diagram
  - Sequence Diagram
- Other types of UML diagrams (you will make in our CSE308):
  - State, Activity, Collaboration, Communication, Component, & Deployment Diagrams

UML Class Diagrams

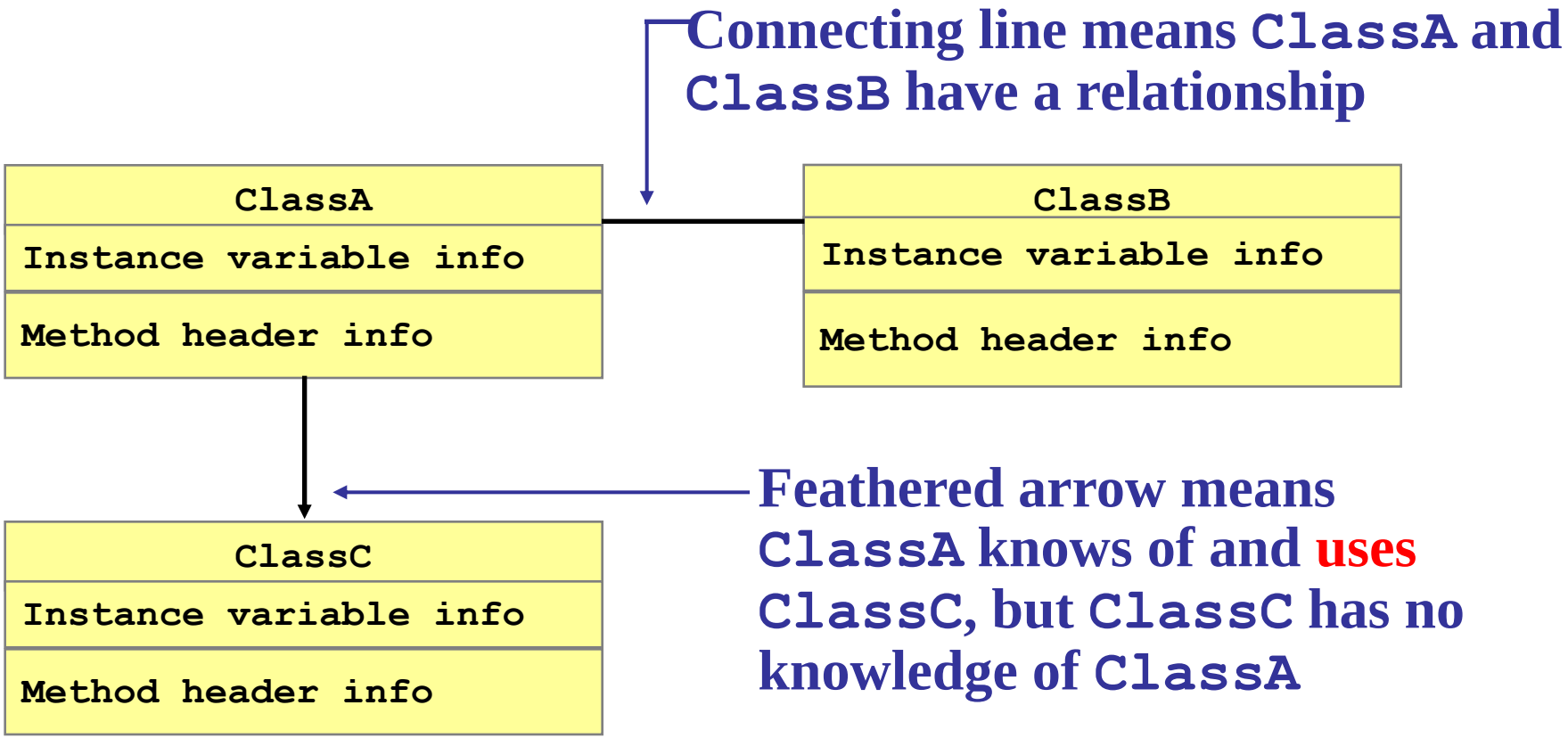
- A UML class diagram consists of one or more classes, each with sections for:
  - class name
  - instance variables
  - methods
- Lines between classes represent associations
  - Uses
  - Aggregation (HAS-A)
    - Containment
  - Inheritance (IS-A)

UML Class Responsibilities Diagrams



UML Class Diagrams

- Derived from class responsibilities diagrams
- Show relationships between classes
  - Class associations denoted by lines connecting classes
  - A feathered arrow denotes a one-directional association



Method and Instance Variable Descriptions

- Instance Variables Format

  `variableName : variableType`

  - For example: **`upValue : int`**

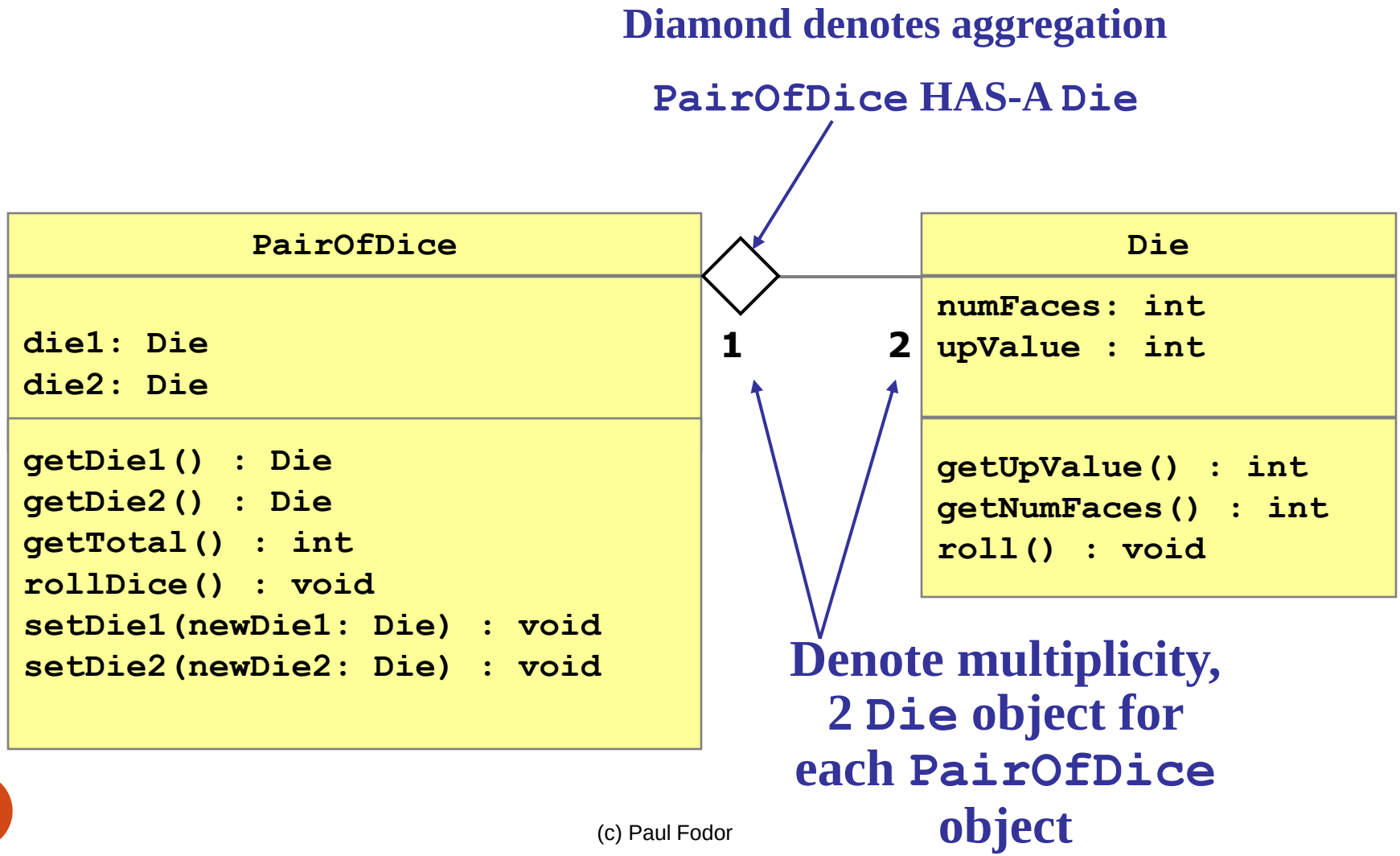
- Method Header Format

  `methodName(argumentName:argumentType)`
  `:returnType`

  - For example: **`setDie1(newDie1:Die):void`**
  - Underlined or $ denotes a static method or variable
    - For example: **`myStaticMethod(x:int):void`**

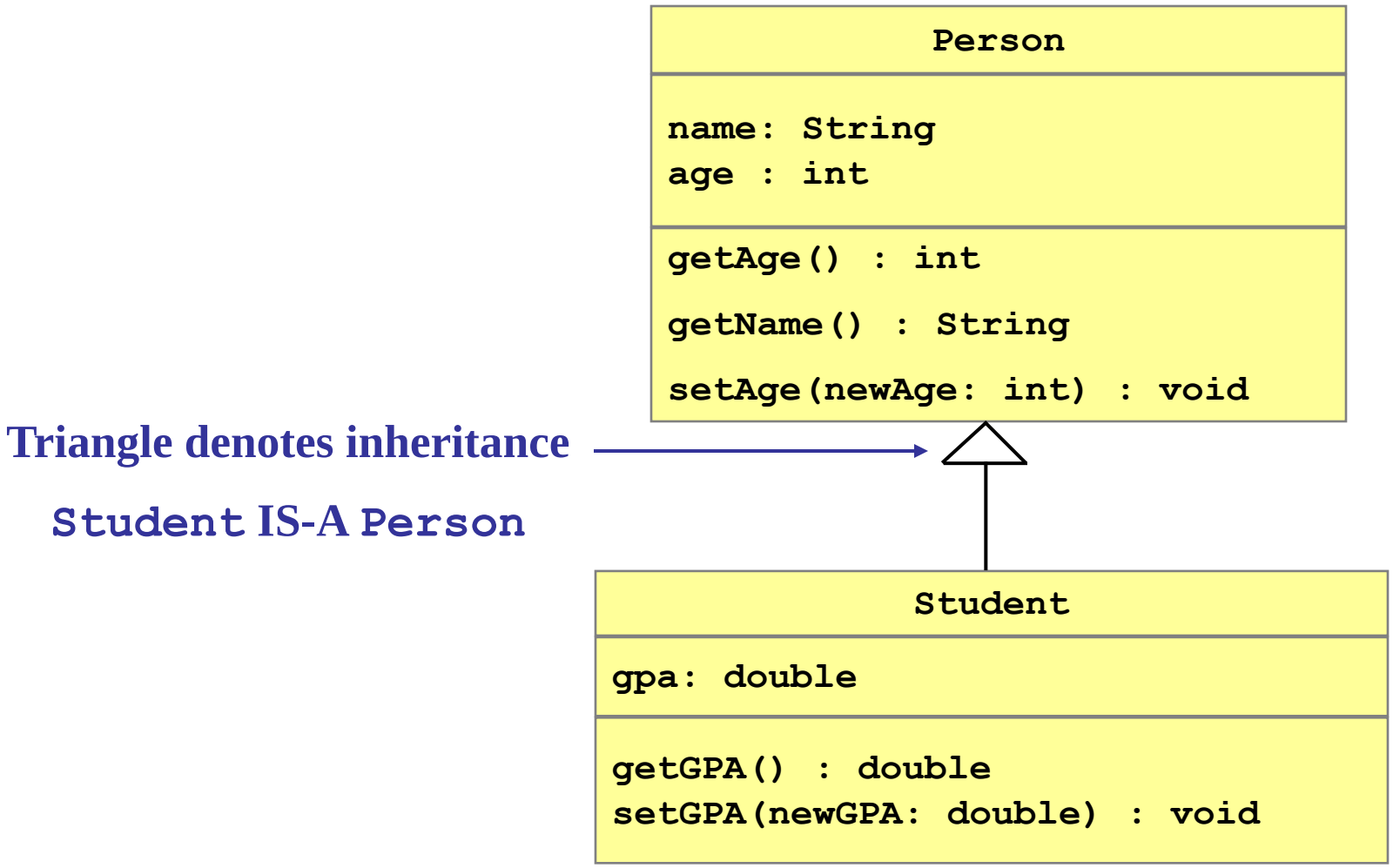
UML Class Diagrams & Aggregation

- UML class diagram for **`PairOfDice & Die:`**



UML Class Diagrams & Inheritance

`public class Student extends Person`

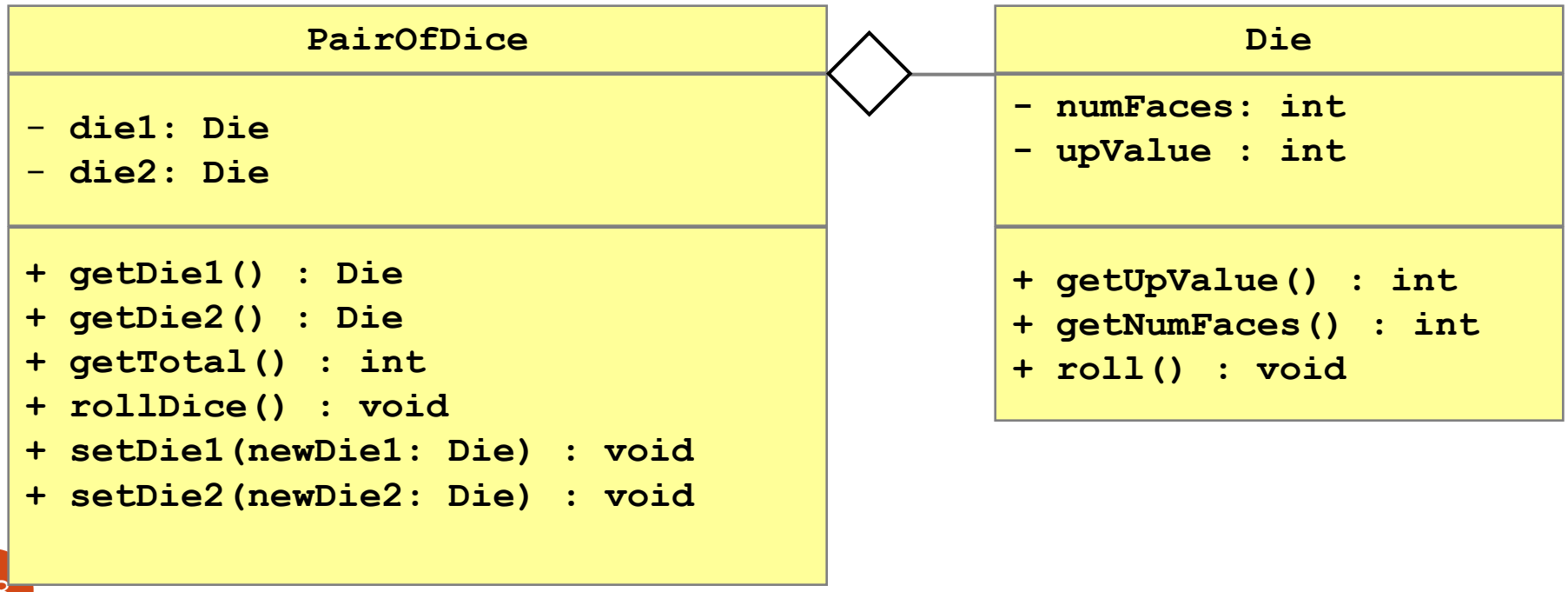


Encapsulation

- We can take one of two views of an object:
  - internal - the variables the object holds and the methods that make the object useful
  - external - the services that an object provides and how the object interacts
- From the external view, an object is an *encapsulated* entity, providing a set of specific services
- These services define the *interface* to the object
  - *abstraction* hides details from the rest of the system

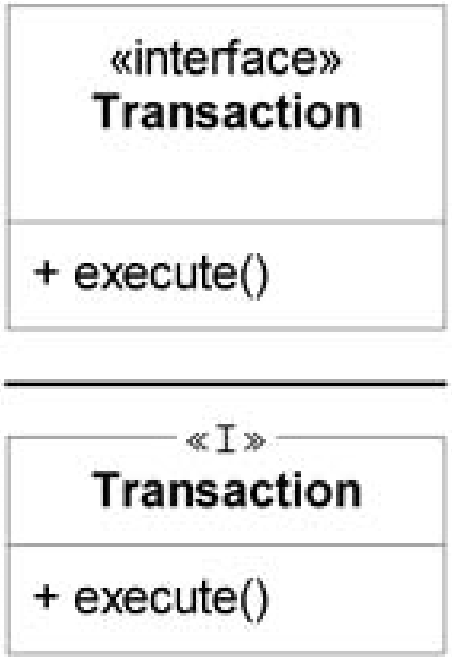
Class Diagrams and Encapsulation

- In a UML class diagram:
  - public members can be preceded by +
  - private members are preceded by -
  - protected members are preceded by #



Interfaces in UML

- 2 ways to denote an interface
  - <<interface>> (standard), OR
  - <<I>>

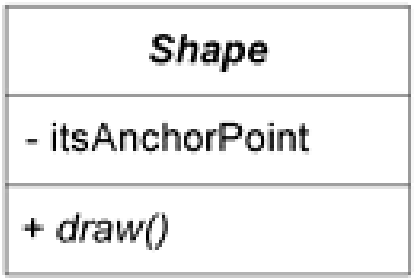


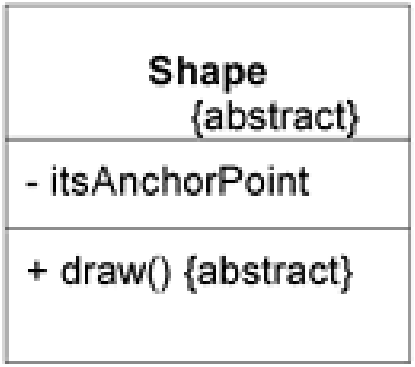

```
interface Transaction
{
   public void execute();
}
```

http://www.informit.com/articles/article.asp?p=336264&seqNum=3

Abstract Classes in UML

- 2 ways to denote a class or method is abstract:
  - class or method name in italics, OR
  - {abstract} notation

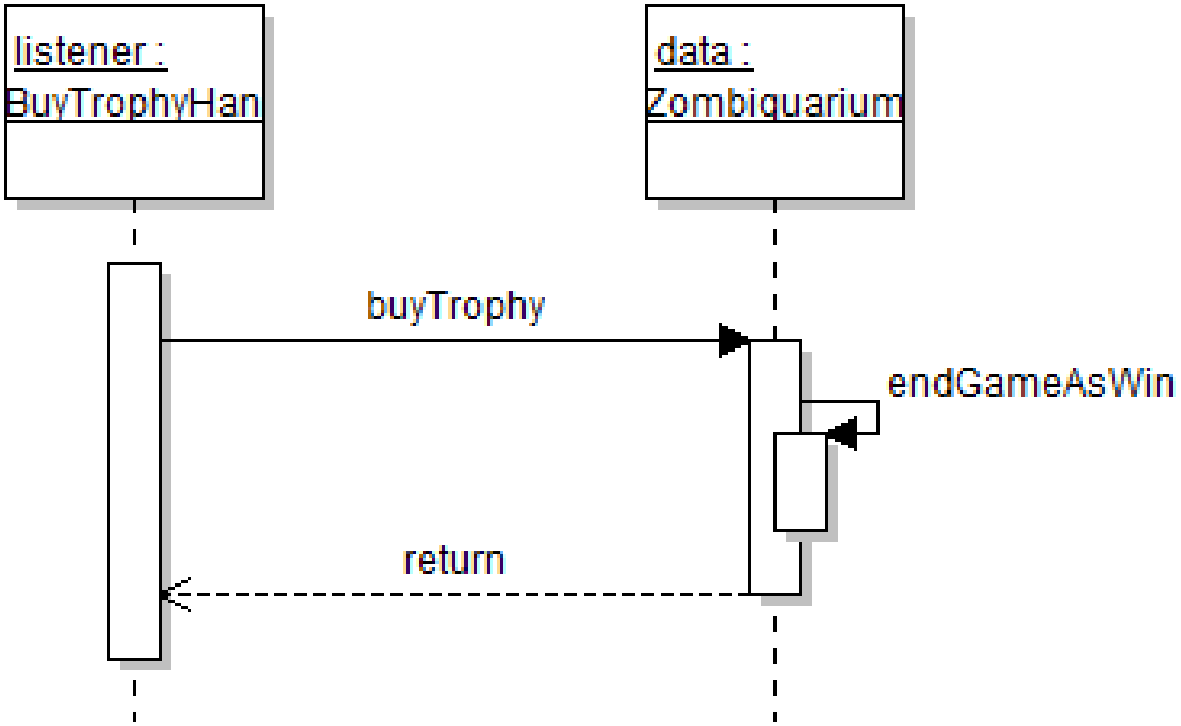





```
public abstract class Shape
{
   private Point itsAnchorPoint;
   public abstract void draw();
}
```

UML Sequence Diagrams

- Demonstrate the behavior of objects in program
  - describe the objects and the messages they pass
  - diagrams are read left to right and descending



What will we use UML Diagrams for?

- Use Case Diagrams
  - describe all the ways users will interact with the program
- Class Diagrams
  - describe all of our classes for our app
- Sequence Diagrams
  - describe all event handling

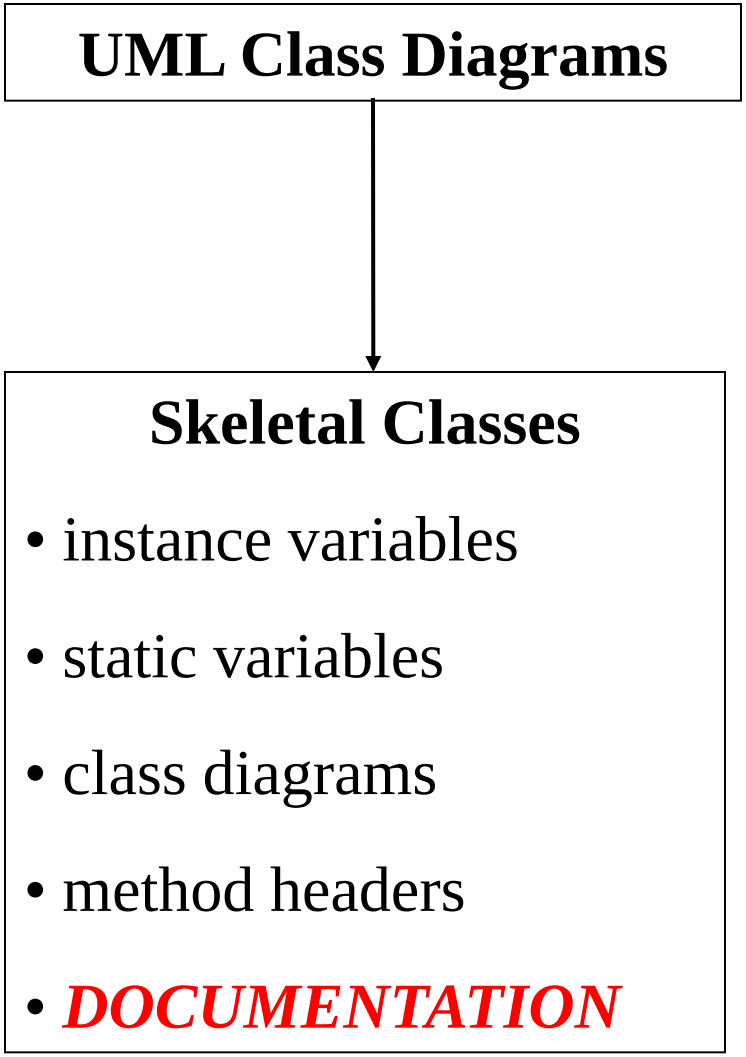
Top-down class design

- Top-down class design strategy:
  - Decompose the problem into sub-problems (large chunks).
  - Write skeletal classes for sub-problems.
  - Write skeletal methods for sub-problems.
  - Repeat for each sub-problem.
- If necessary, go back and redesign higher-level classes to improve:
  - modularity,
  - information hiding, and
  - information flow

Designing Methods

- Decide method signatures
  - numbers and types of parameters and return values
- Write down what a method should do
  - use top-down design
    - decompose methods into helper methods
- Use javadoc comments to describe methods
- Use method specs for implementation

Results of Top-down class design



Software Longevity

- The FORTRAN & COBOL programming languages are ~50 years old
  - many mainframes still use code written in the 1960s
  - software maintenance is more than ½ a project
- Moral of the story:
  - the code you write may outlive you, so make it:
    - Easy to understand
    - Easy to modify & maintain
  - software must be ready to accommodate change

Software Maintenance

- What is software maintenance?
- Improving or extending existing software
  - incorporate new functionality
  - incorporate new data to be managed
  - incorporate new technologies
  - incorporate new algorithms
  - incorporate use with new tools
  - incorporate things we cannot think of now ☺

Summary

- Always use data driven & top-down design:
  - identify and group system data
  - identify classes, their methods and method signatures
  - determine what methods should do
  - identify helper methods
    - Write down step by step algorithms inside methods to help you!
  - document each class, method and field
  - specify all conditions that need to be enforced or checked
    - decide where to generate exceptions
    - add to documentation
  - evaluate design, and repeat above process
    - until implementation instructions are well-defined