Introduction to OOP and UML

- Programming Paradigms
  - Procedural
  - Functional
  - Object Oriented
- Object-Oriented Design
- Unified Modeling Language
  - Use Cases
  - Class Diagrams
  - Sequence Diagrams
  - Example from Project 1

Programming Paradigms

- A paradigm is an ideal or a model to follow in doing something, e.g. programming
- In CS110, you were introduced to the three predominant programming paradigms:
  - Procedural
  - Functional
  - Object-Oriented
- In this course, we will further explore the Object-Oriented paradigm using Java

Object-Oriented Design

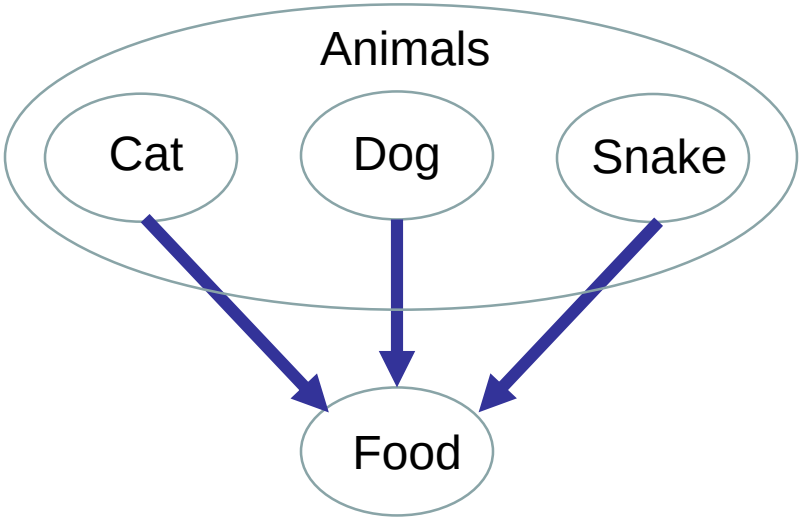
- The OOP paradigm was developed by SW engineers to solve most if not all of the problems described in L&C section 1.1.
- It has become a predominant programming style for use in many applications, e.g. graphical user interfaces (GUIs), etc.
- Java is considered to be an Object-Oriented Programming (OOP) language because it has specific features to fully support OOP

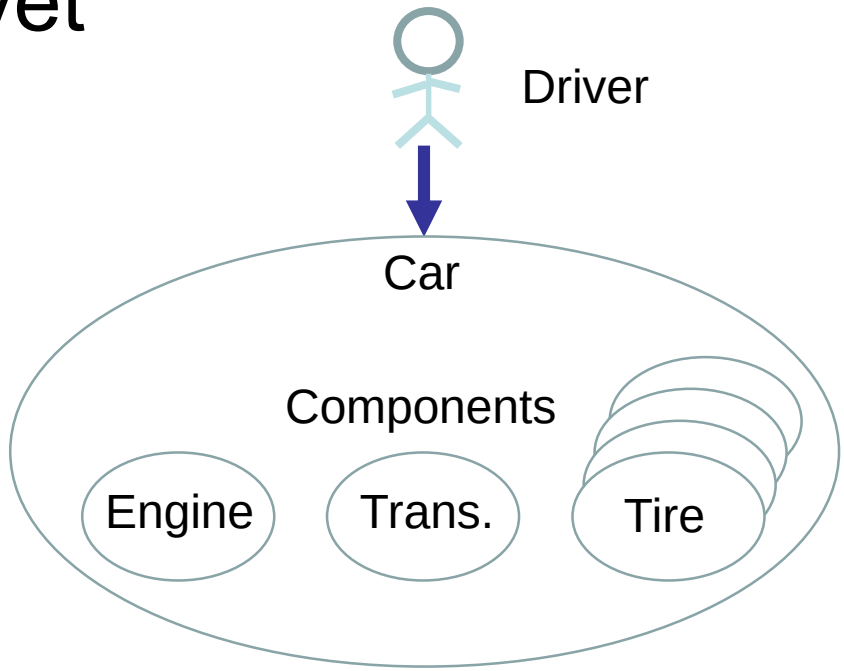
Object-Oriented Design

- In the OOP paradigm, the designer focuses on the data rather than the algorithm steps
- The data is associated with objects that are present in the problem, such as:
  - Monitor
  - Keyboard
  - File
  - Frame for a GUI
  - Icon in a frame for a GUI

Object-Oriented Design

- Use UML “use case diagrams” to sketch out aspects of the problem you are trying to solve
- Don’t get too detailed yet





- Do NOT use flow charts or pseudo-code yet

Object-Oriented Design

- “Classify” the objects based on similarities of their attributes and behaviors
  - Examples of objects that could be classified as Animals: Dogs, Cats, Snakes, Fish, etc.
- Identify objects that have other objects as components or parts of themselves
  - Example: A car is made up of an engine, a transmission, and tires
- Identify objects that use other objects
  - A Driver drives a Car and an Animal eats Food

Object-Oriented Design

- Define the names of classes for the objects
  - Usually nouns, e.g. Driver, Car, Animal, Cat, etc.
- Define the attributes of the classes
  - Attributes: “things that objects of the class are”
  - Usually adjectives, e.g. color, size, furry, etc.
- Define the behaviors of the classes
  - Behaviors: “things that object of the class can have done to them or services they can perform”
  - Usually verbs, e.g. drive, eat, etc.

Object-Oriented Design

- Define the relationships between classes
  - Inheritance – More specific classes from general ones, e.g. a Cat is an Animal, a Dog is an Animal
  - Interface – A standard way that these objects can connect to other objects, e.g. power cord, etc.
  - Aggregation/Composition – Classes that are built up from or composed of component classes, e.g. a Car has an Engine, a Transmission, and Tires
  - Dependencies – Need for objects of other classes, e.g. a Driver drives a Car, a Cat eats Food

Object-Oriented Design

- Define the methods of each class to support the interactions and behavior of its objects
- Identify any methods that are identical to methods other classes also provide to connect to a standard interface, e.g. implementing a network connector or a power cord on a PC
- Flow charts or pseudo code may be used for individual method designs (procedural code)

Unified Modeling Language (UML)

- The Unified Modeling Language (UML) was developed in the 1990's to support OOP software design
- The "three amigos" (Grady Booch, Ivar Jacobson, and Jim Rumbaugh) unified their separate methodologies when they formed Rational Corporation
- A good reference is *UML Distilled, 3rd Ed.,* Martin Fowler, Addison-Wesley/Pearson

Unified Modeling Language (UML)

- UML is a graphical tool to visualize and analyze the requirements and do design of an object-oriented solution to a problem
- Three basic types of diagrams:
  - Use Case Diagram (Shown previously)
  - Class Diagram (The most useful one for us)
  - Interaction Diagram
- I will use Class Diagrams in presenting the design for our Java programs / projects

Unified Modeling Language (UML)

- Advantage of UML – It is graphical
  - Allows you to visualize the problem / solution
  - Organizes your detailed information
- Disadvantage of UML – It is graphical
  - Can be done with pencil and paper – tedious!
  - Commercial UML S/W tools are expensive!
    - Example: Rational ROSE
    - IBM acquired Rational and the three amigos got rich
  - There are some free-ware UML Design Tools

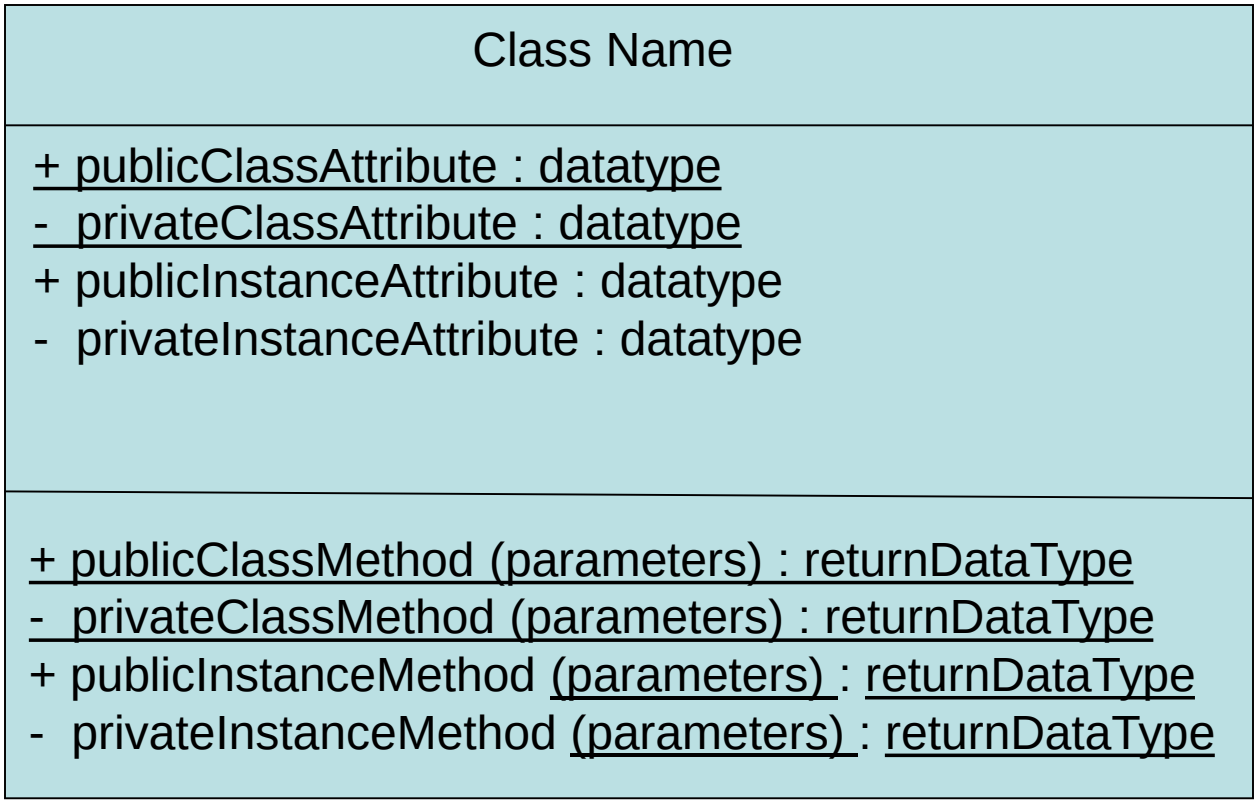
UML Class Diagrams

- UML class diagrams show:
  - The external and internal attributes and methods for each class
  - The relationships between the classes
- They’re a static view of the program structure
- They do not show:
  - The number of objects of each class instantiated
  - The timing of the interactions between objects

UML Class Diagrams

List of Attributes

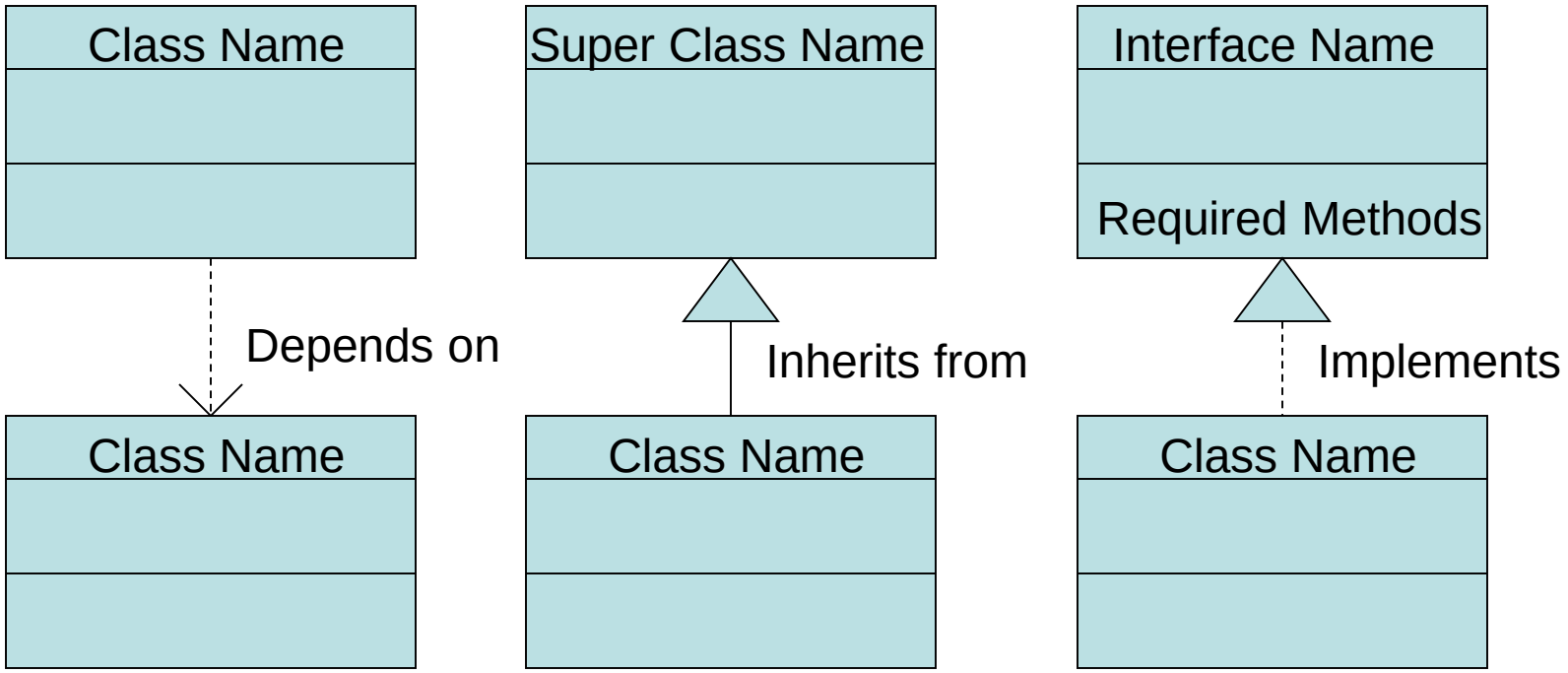
List of Methods



UML Class Diagrams

- UML Attribute Descriptions
  - Protection: + public, - private, # protected
  - Attribute name :
  - Attribute data type
- UML Method Descriptions
  - Protection: + public, - private, # protected
  - Method name
  - Method parameter list (name : datatype, etc.) :
  - Method return type
- Underlined means class attribute or method

UML Class Diagrams

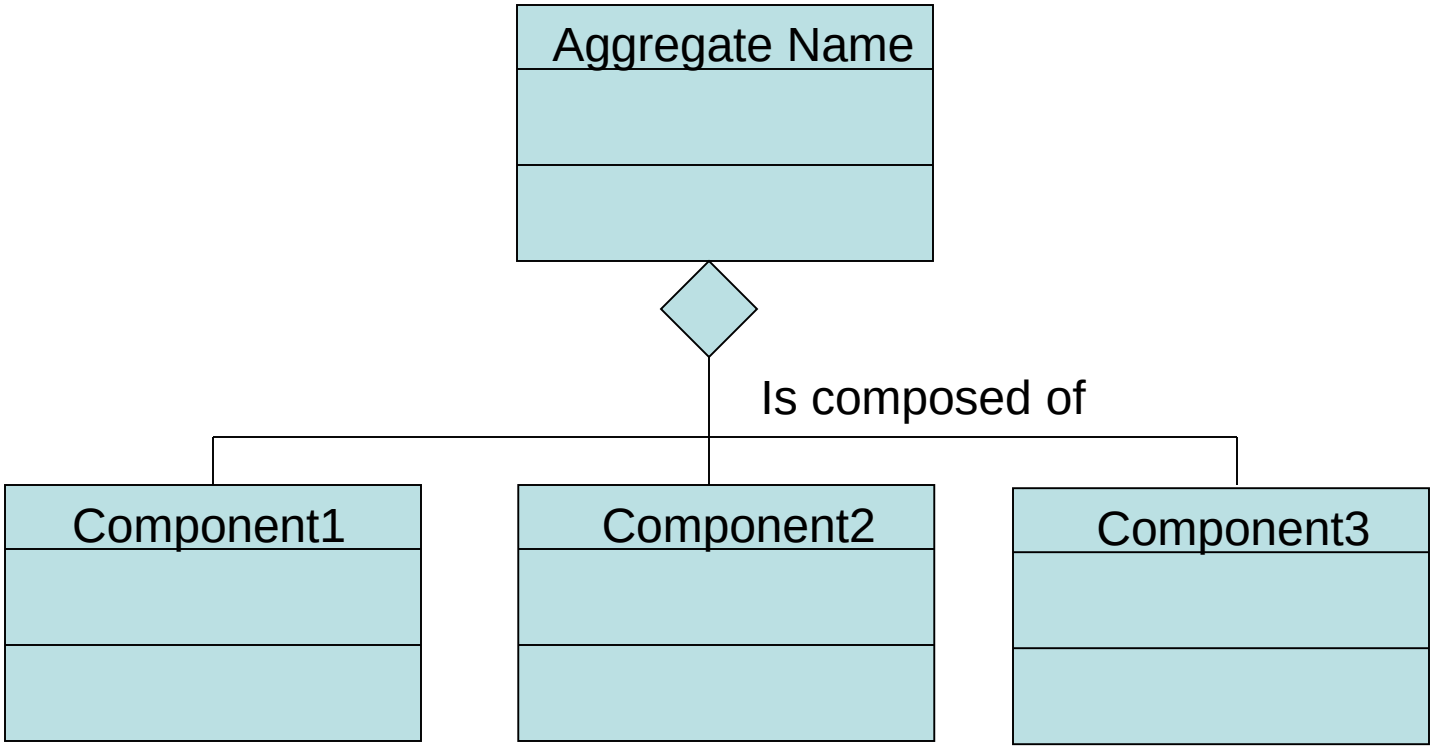


Driver Class depends on Car Class

Cat Class inherits from Animal Class

Computer Class implements WiFi Interface

UML Class Diagrams

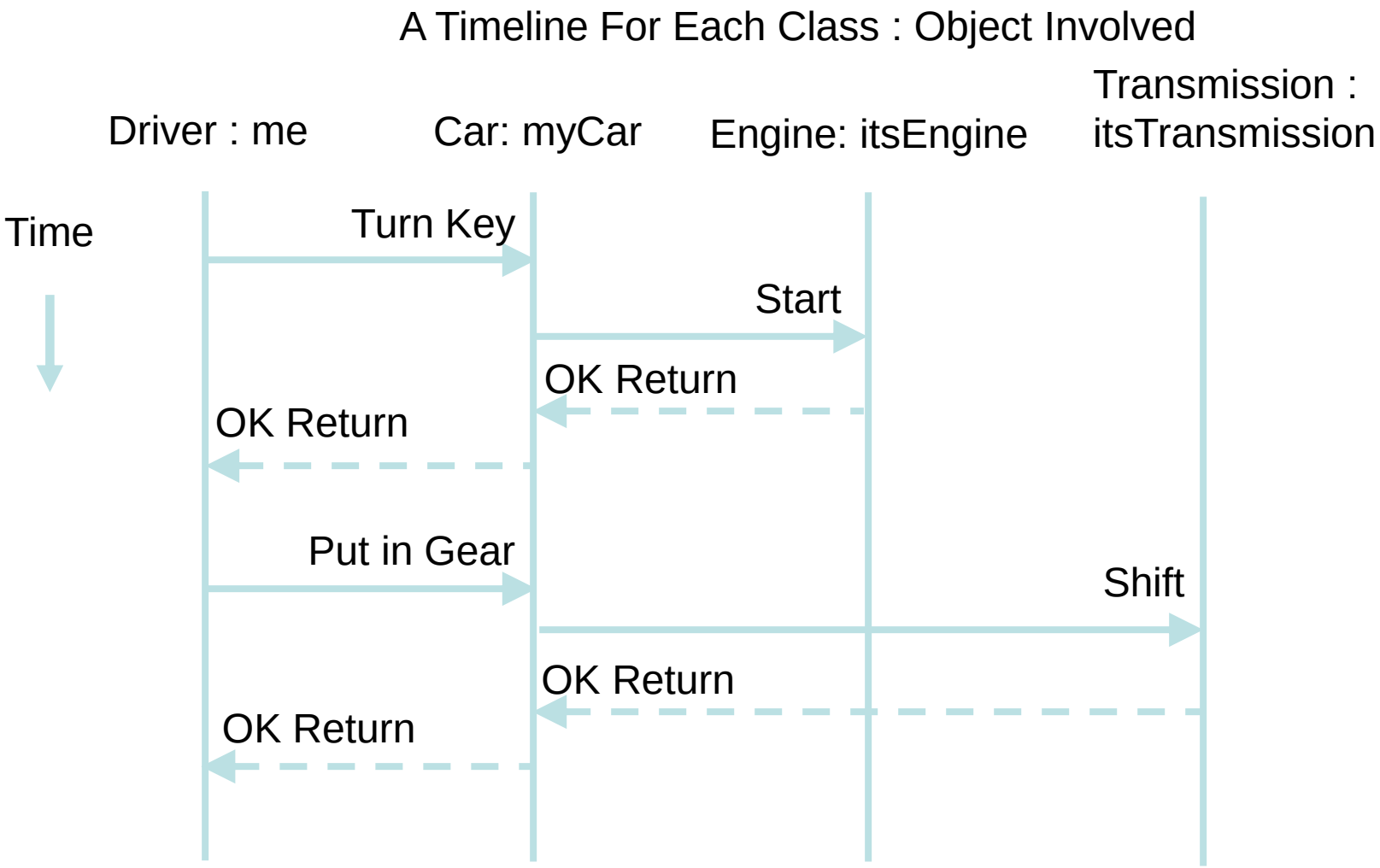


Car Class
is composed of
Engine Class, Transmission Class, and Tire Class

UML Interaction Diagrams

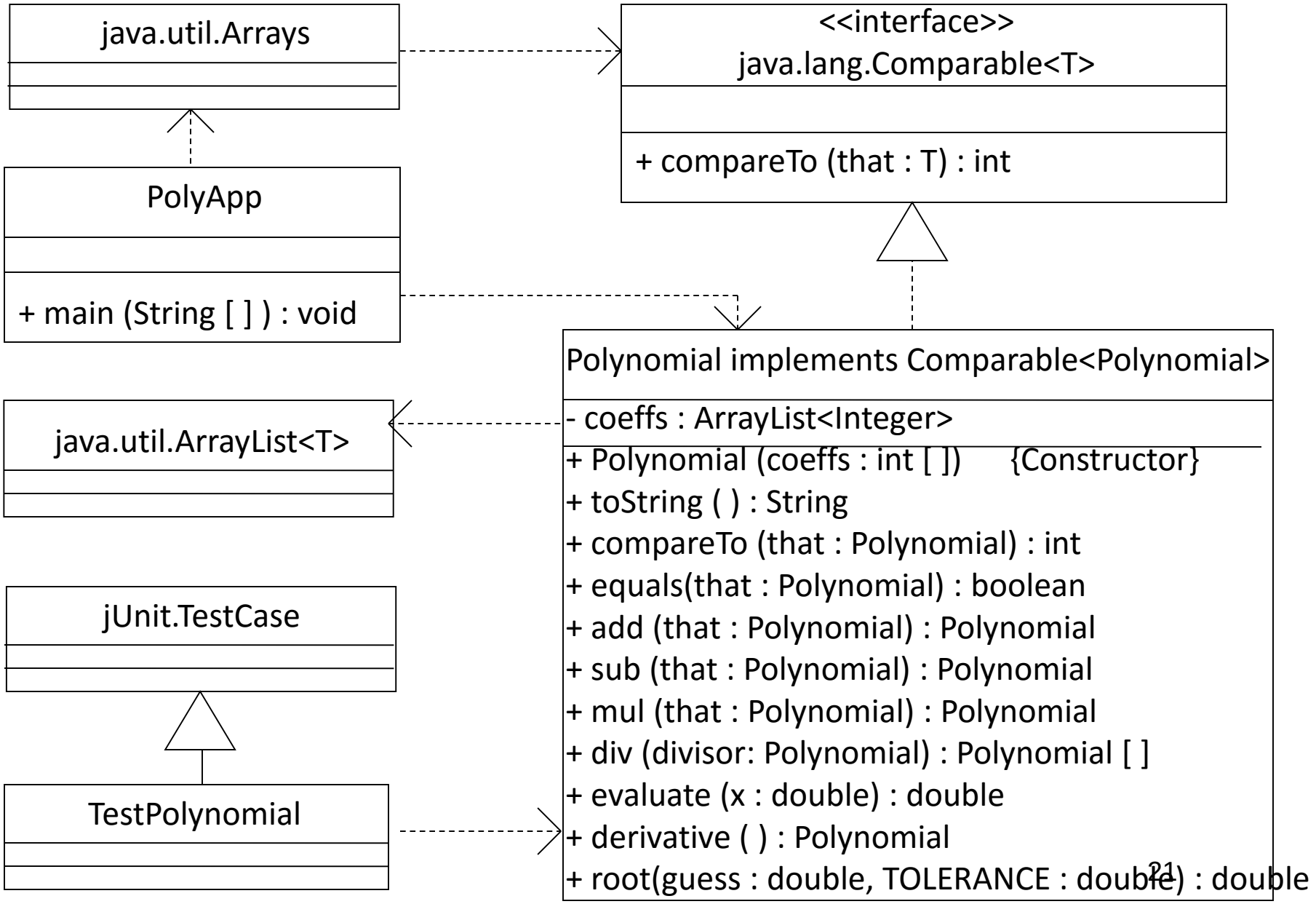
- UML interaction diagrams show
  - The objects of each class involved in a scenario
  - The order of interactions between the objects
- They are a dynamic view of the behavior
- Often called ladder diagrams due to their resemblance to a ladder or group of ladders

UML Interaction Diagrams



UML Example (Project 1)

- Polynomial Class implements Comparable<T> so that an array of its objects can be sorted
- It uses the library ArrayList<T> class to store its polynomial coefficients (private)
- TestPolynomial Class contains test cases that can be run automatically to test your class
- Arrays.sort() can sort Comparable<T> arrays
- PolyApp is your class using Polynomial objects


java.util.Arrays
<<interface>>
java.lang.Comparable<T>
+ compareTo (that : T) : int
PolyApp
+ main (String [ ]) : void
Polynomial implements Comparable<Polynomial>
- coeffs : ArrayList<Integer>
+ Polynomial (coeffs : int [ ]) {Constructor}
+ toString ( ) : String
+ compareTo (that : Polynomial) : int
+ equals(that : Polynomial) : boolean
+ add (that : Polynomial) : Polynomial
+ sub (that : Polynomial) : Polynomial
+ mul (that : Polynomial) : Polynomial
+ div (divisor: Polynomial) : Polynomial [ ]
+ evaluate (x : double) : double
+ derivative ( ) : Polynomial
+ root(guess : double, TOLERANCE : double) : double
java.util.ArrayList<T>
jUnit.TestCase
TestPolynomial