Unit 03: Interfaces and Abstract Data Types (ADTs)

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CSC 115: Fundamentals of Programming II

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Unit 03 Overview

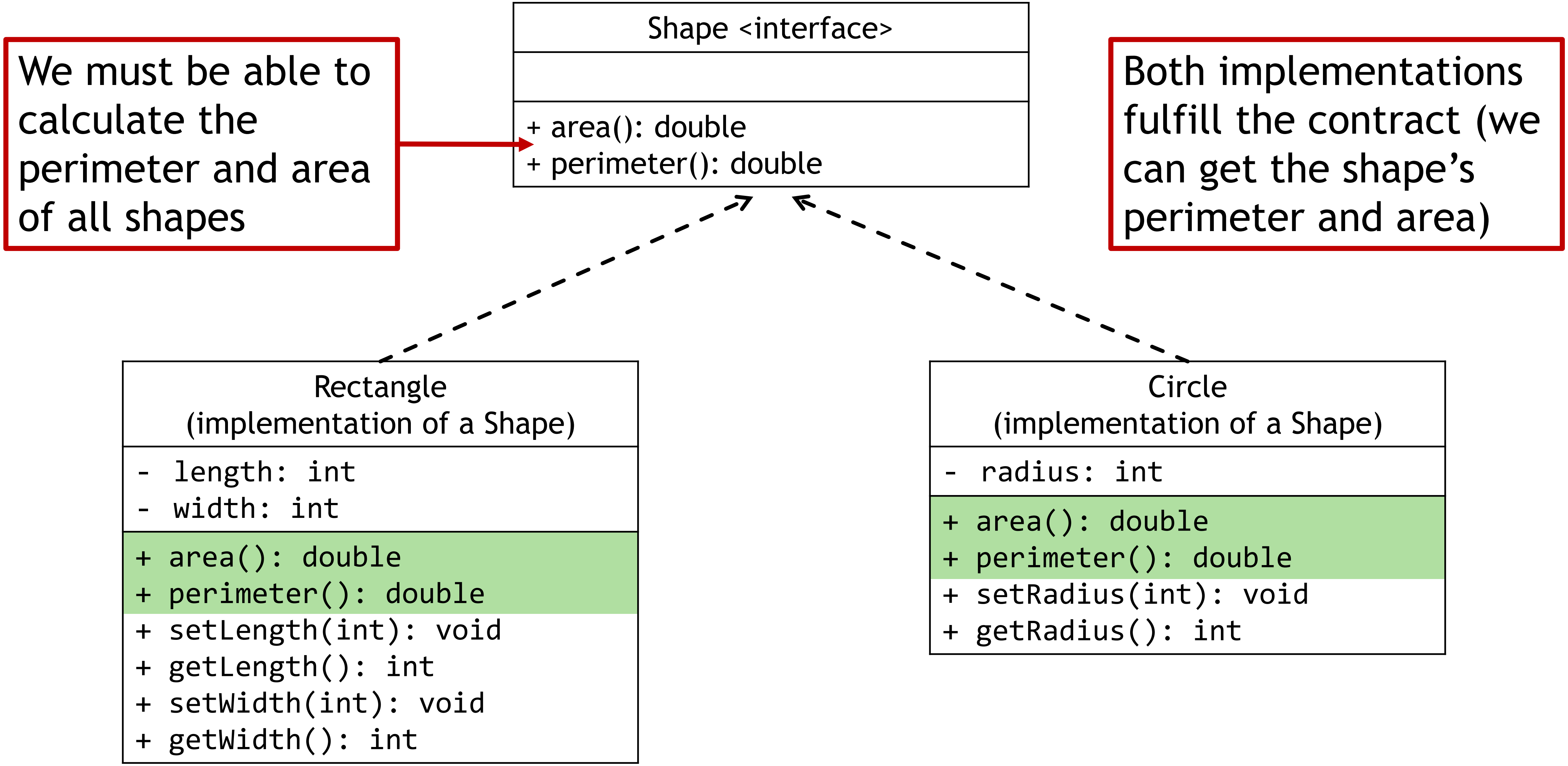
- Related Reading:
  - Textbook Chapter 4
- Learning Objectives: (You should be able to…)
  - Be able to write an interface and implement an interface
  - understand the concept of an abstract data type

Interfaces in Java

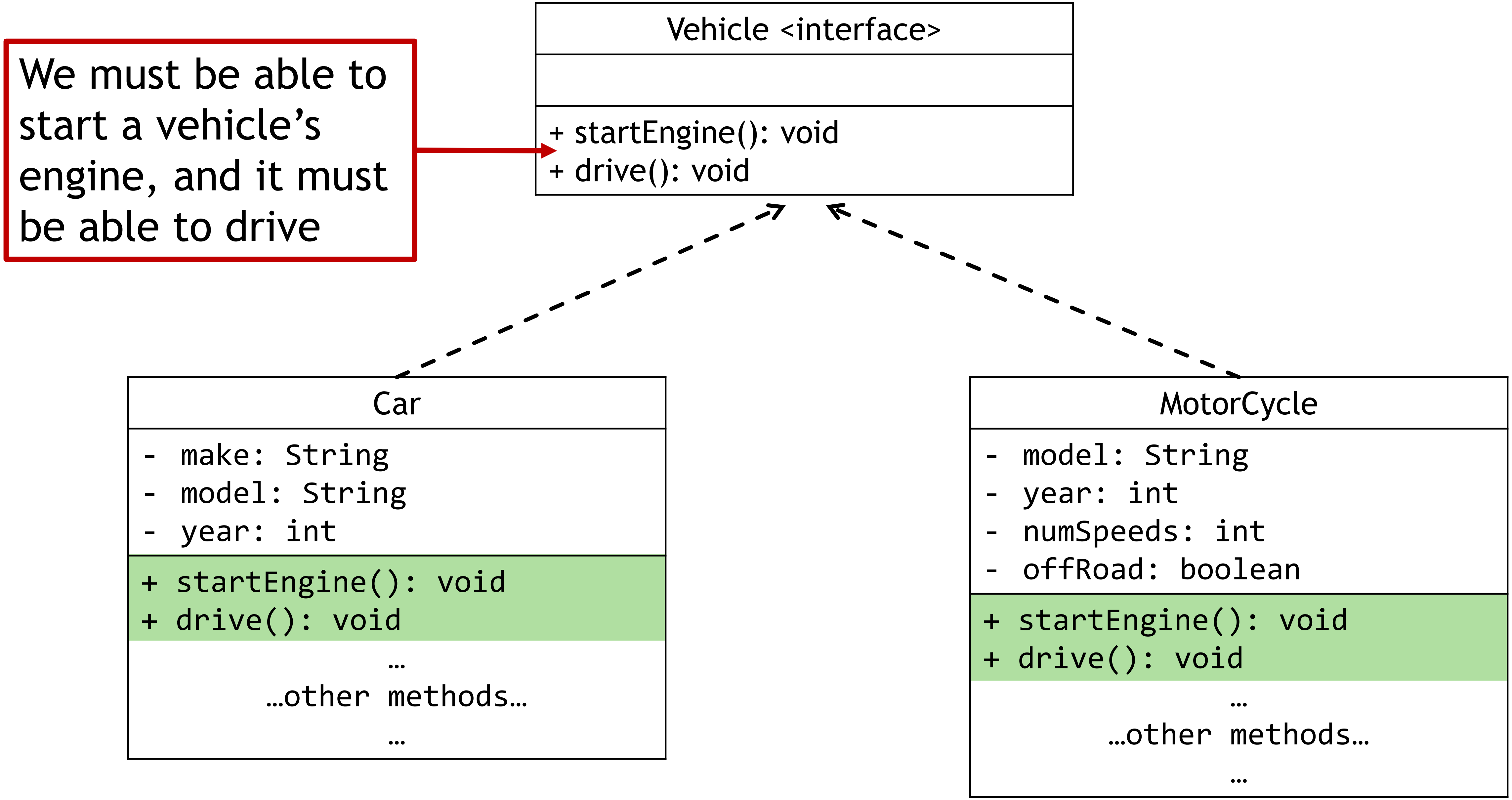
- A Java interface specifies methods and constants but supplies no implementation details
- Can be used to specify some common behavior that may be useful over many different types of objects

- We can think of an interface like a **contract**. The person writing the interface (presenting the contract) says, *“I want these features”*
- The developer implementing the interface (fulfills the contract), replies, *“Okay, I will build those features into the solution”*

Interface Shape Example



Interface Vehicle Example



Writing code that uses an Interface

- General structure:

```
public interface name {
    public returnType method1();
    public returnType method2();
}
```

- Specific example:

```
public interface Shape {
    public double area();
    public double perimeter();
}
```

Our classes begin with:

```
public class name
```

Interfaces instead have:

```
public interface name
```

The methods are only signatures (they don’t have a body)

An interface doesn’t do anything; it specifies desired behaviors

An interface typically does provide documentation for each method specified (comments)

Interface Code Example

- General structure:

```
public class name implements interfaceName {
    public returnType method1() {
        statements;
    }
}
```

Classes that implement an interface specify which interface they implement (which contract they fulfill)

- Specific example:

```
public class Circle implements Shape {
    …
    public double area() {
        return Math.PI * radius * radius;
    }
}
```

The methods do have bodies, as they provide an implementation of the required operations.

Documentation / Comments are okay!

```
public interface Shape{

    /*
     * Purpose: calculates the area of this Shape
     * Parameters: none
     * Returns: double - the area of the shape
     */
    double area();

    /*
     * Purpose: calculates the perimeter of this Shape
     * Parameters: none
     * Returns: double - the perimeter of the shape
     */
    double perimeter();

```

- My example didn't include documentation, but it should be used to clarify the desired behaviour

Interfaces – Why?

- What are the reasons we might want to use an Interface?

- Being able to guarantee a program (or suite of programs) all include certain features that work in a certain way is very useful

Interfaces – Why?

- Also think about it from a software development perspective:

- Interfaces only contain desired behaviours, no code
  - This is the perfect medium for which clients and developers can communicate
  - Clients can request behaviours and/or operations about their desired product; developers can discuss these requests, until an agreement is made
  - Clients are not programmers, they are not interested in implementation details. They only need to see the interface (contract).
  - Developers then provide an implementation based on the contract (the clients will *use* the end product, but don’t ever have to see the underlying code)

Data abstraction

- We have now seen that we can create interfaces in Java
- Interfaces provide required methods, but omit the details of **fields** and ***how*** the methods are implemented
  - So far, we have seen that interfaces can be used to create types for data that supports multiple variants (different shapes or different vehicles)

- The separation of what something does (specification) and how it does it (implementation) is a fundamental concept in engineering!

Data structures

- A storage structure for data
  - We will explore different types of data structures throughout this course (and explore even more in CSC 225)
- A way of *storing*, *accessing*, *organizing*, and *manipulating* data using a set of well-define operations
  - Wikipedia definition: a collection of data values, the relationships among them, and the functions or operations that can be applied to the data
- The only data structure we have used so far is an array
  - there are other data structures we can use to perform the same operations on our collection of data, which are implement in different ways
  - … and have different speeds and memory requirements

Two important pieces

- Interfaces and data structures are two very important pieces:
  - Interfaces allow us to specify operations
  - Data structures allow us to organize, access, and manipulate data

Abstract Data Types (ADTs)

- An ADT is composed of:
  - A description of what data is stored (but not how the data is stored)
  - A set of operations on that data (but not how the operations are implemented)

- Specifications of an ADT indicate
  - What the ADT operations do *(interface)*
- Implementations of an ADT include choosing a particular data structure
  - *how* is the data stored, accessed, organized, etc. *(data structure)*

Example

- ADT Dictionary:
- *What* does it do?
  - Stores a pair of strings, representing the word and definition (data)
  - Operations:
    - insert(word, definition)
    - delete(word)
    - find(word)

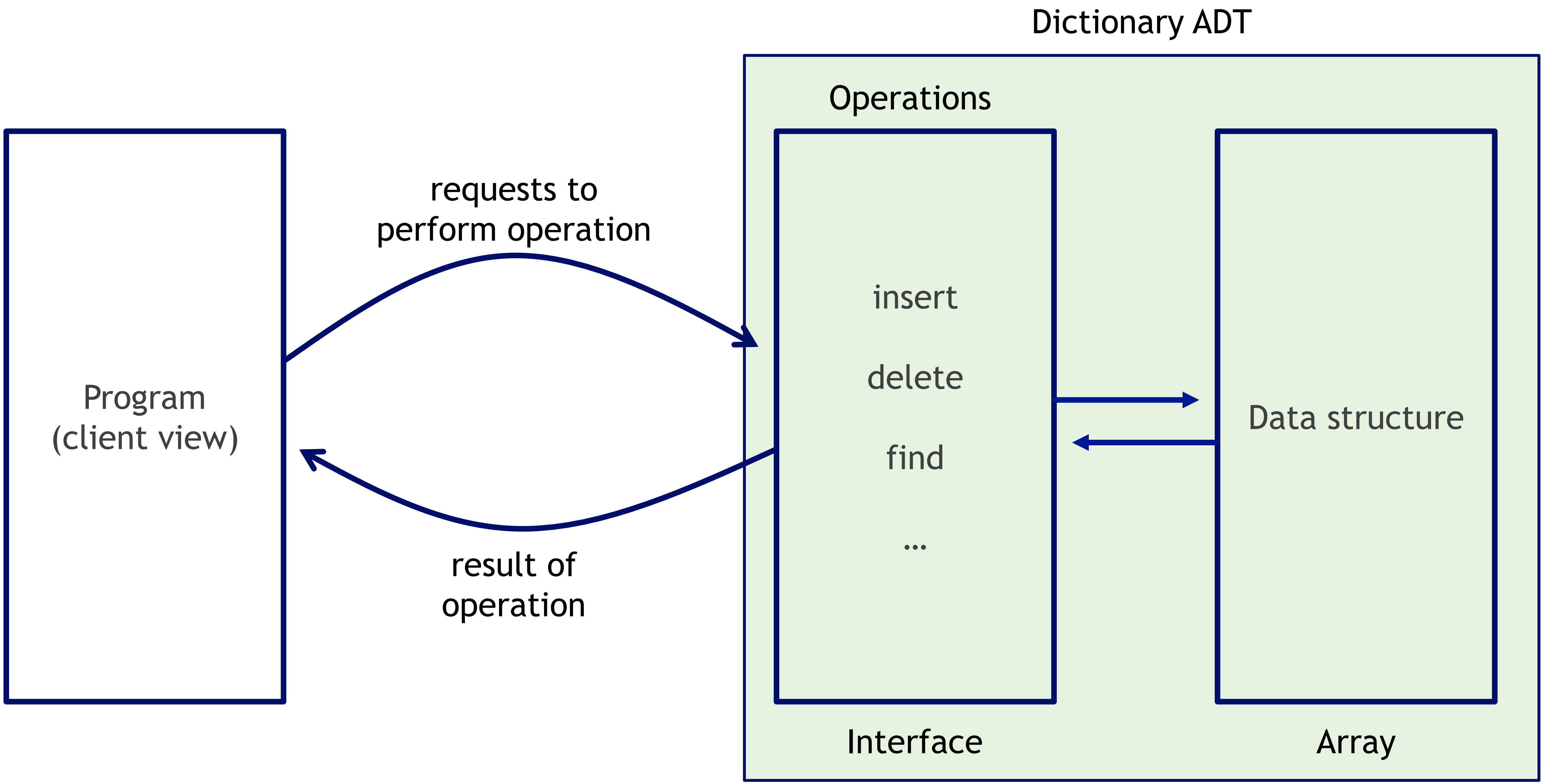
We also know the effect operations have on the data.
If we ***delete*** a word from the dictionary, a subsequent ***find*** operation should fail.

- We use a data structure to implement an ADT
  - this is where the *how* comes in

Client vs Programmer

- Clients know how to use something
  - ***What*** operations are available and ***what*** they do
- Programmers must decide ***how*** to implement the operations
- Their choices may be influenced by a number of things:
  - execution speed
  - memory requirements
  - maintenance (debugging, scalability, etc.)
- Dictionary example:
  - Clients/users: add new words to dictionary, look up words to see definitions
  - Programmer: determine ***how*** data is stored; ***how*** operations are implemented

Implementing the Dictionary ADT



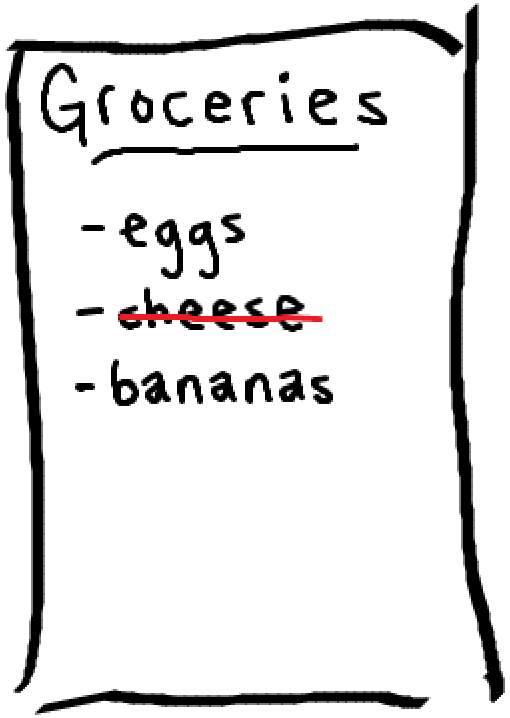
ADT Example

- Assume you wanted to create something that allowed someone to:
  - Keep track of what groceries they needed to buy
  - Maintain information about all of their contacts
  - Record all of the courses they have completed as they progress through their undergraduate degree program

- Can these be generalized into a common set of required features?

The Notion of a List

- A **list** allows us one to manage a collection of items
  - Elements can be inserted and removed in ***any*** order
  - Any element can be accessed at any given time by their position in the list



Another ADT Example: List

- ADT List Operations:
  - Create an empty list
  - Determine whether a list is empty
  - Determine the number of items in a list
  - Add an item at a given position in a list
  - Remove the item at a given position in a list
  - Get the item at a given position in a list
  - Remove all items from a list
- Items are referenced by their position in a list:
  - (1st, 2nd, 3rd, etc)

The ADT List

- Specifications of the operations (interface)
  - Define the *'contract'* for the ADT list
  - Include the operations a list must be able to perform
  - Do not specify how to store the list or how to perform the operations

- Remember the important takeaway:
  - The operations can be used in an application without knowledge of how the operations are implemented

The ADT List

- Programmer implements a list using a data structure
- So far the only data structure we have seen is an array:
  - Each item in the list is stored in an array
  - Items positions are identified by their index within the array (so the kth item will be stored at index k-1 (since arrays are 0-indexed)
- We will work on this implementation next lectre!
- But next week we will see there are other data structures we can use to implement the list ADT (and other ADTs as well)