COMP20220
Programming II (Conversion)

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Chapter 10 Thinking in Objects

Objectives

- To use the `String` class to process immutable strings.
- To use the `StringBuilder` classes to process mutable strings.
- To explore the differences between the procedural paradigm and object-oriented paradigm.
- To discover the relationships between classes.
- To understand guidelines for class design.
- To understand class abstraction when developing software.

The `String` and `StringBuilder` Classes

Strings are widely used in programming and Java supports a number of classes and methods to handle and manipulate strings.

We begin by considering the `String` class, and then the `StringBuilder` class which supports mutable strings.

Constructing Strings

General syntax:

```
String s = new String(stringLiteral);
```

Example:

```
String message = new String("Welcome to Java");
```

Since strings are often used, Java treats a string literal as a `String` object and provides the following shorthand for creating a string:

```
String message = "Welcome to Java";
```

You can also create a string from an array of characters. For example, the following statements create the string `"Hi All"`:

```
char[] charArray = {'H', 'i', ' ', 'A', 'l', 'l'};
String str = new String(charArray);
```

Strings Are Immutable

A `String` object is immutable – its content cannot be changed once the string is created.

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String s = "Java";
s = "HTML";
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Does the following code change the contents of the string?

```
String s = "Java";

s = "HTML";
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The answer is no.

animation

Trace Code

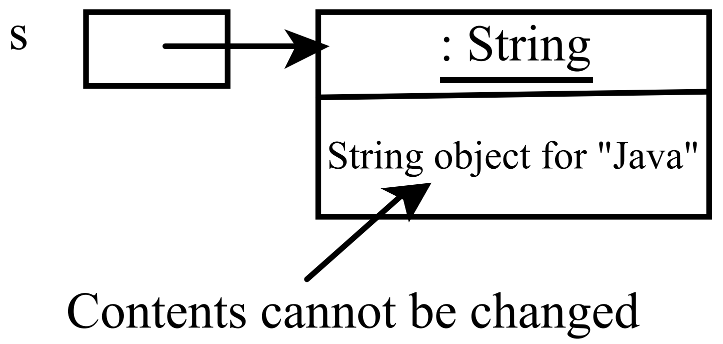
```
String s = "Java";
s = "HTML";
```

animation

Trace Code

```
String s = "Java";
s = "HTML";
```

After executing `String s = "Java";`

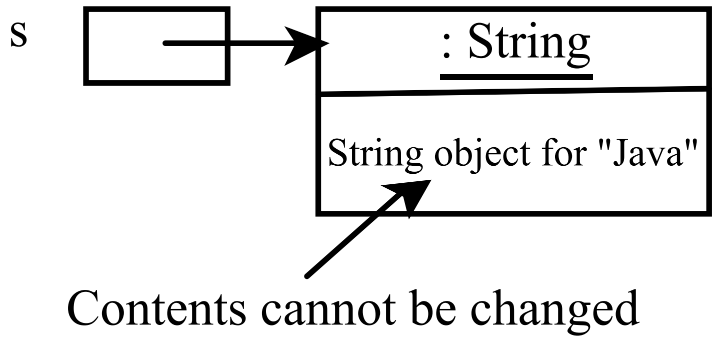


animation

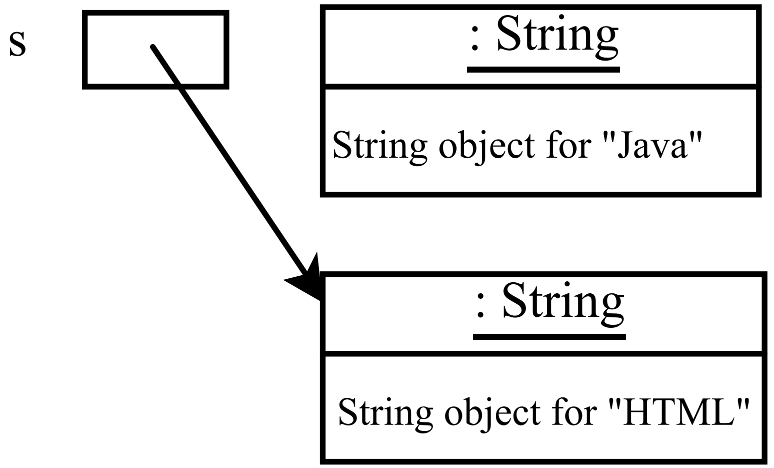
Trace Code

```
String s = "Java";
s = "HTML";
```

After executing `String s = "Java";`



After executing `s = "HTML";`



Interned Strings

Since strings are immutable and are frequently used, Java uses a *unique instance* for *string literals* with the *same character sequence*.

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Interned Strings

Since strings are immutable and are frequently used, Java uses a *unique instance* for *string literals* with the *same character sequence*.

string literal

```
String message = "Welcome to Java";
```

Such an instance is called an *interned string*.

The rationale for interned strings is to improve efficiency/ save memory.

Trace Code

```java
String s1 = "Welcome to Java";

String s2 = new String("Welcome to Java");

String s3 = "Welcome to Java";
```

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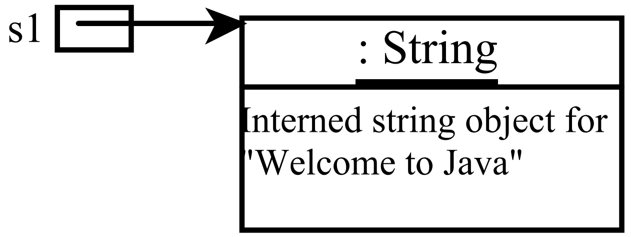

Trace Code

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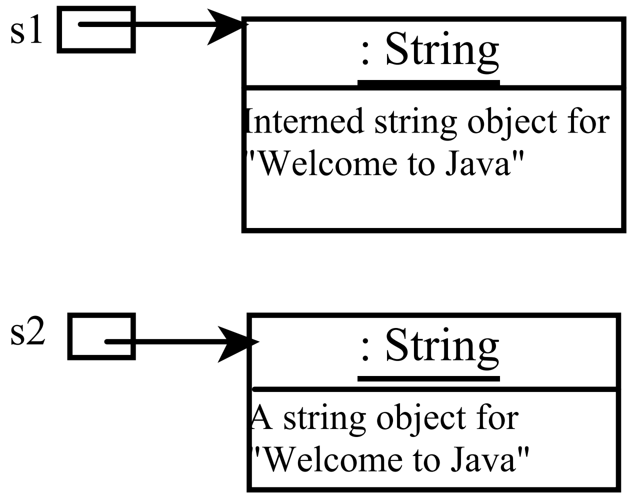
s1
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Interned string object for "Welcome to Java"
s2
: String
A string object for "Welcome to Java"

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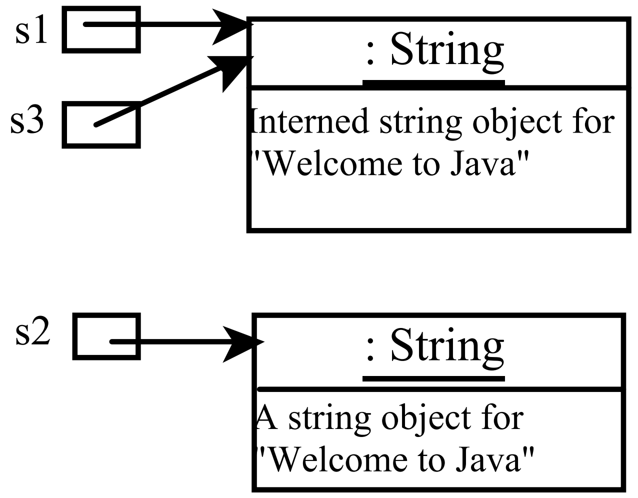
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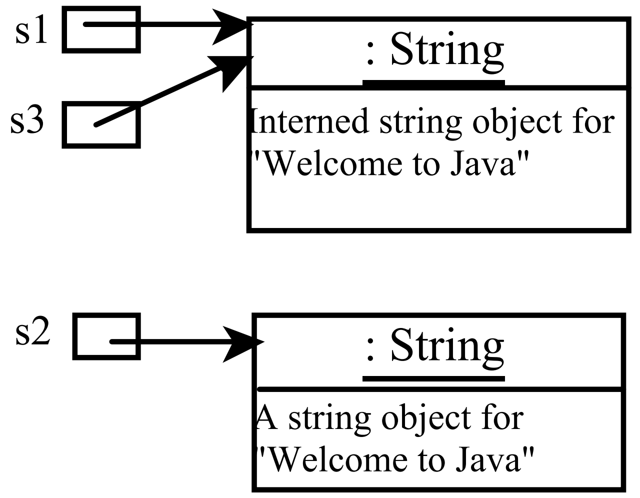

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In the above example:

- `s1 == s3` is true
- `s1 == s2` and `s2 == s3 are both false`

Trace Code

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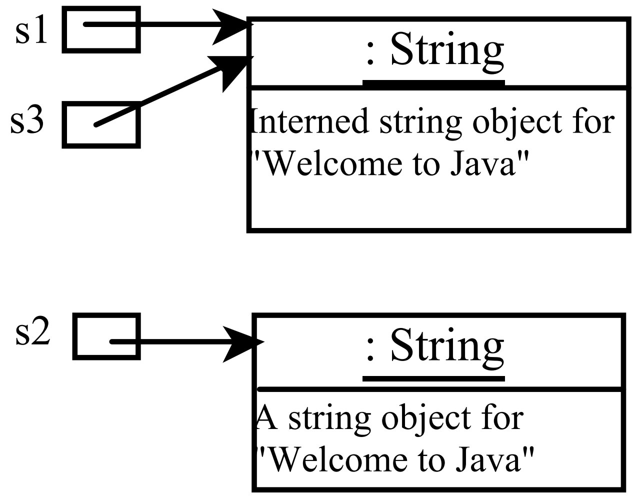
String s1 = "Welcome to Java";

String s2 = new String("Welcome to Java");

String s3 = "Welcome to Java";
```



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- A new object is created if the `new` operator is used.

Trace Code

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String s1 = "Welcome to Java";

String s2 = new String("Welcome to Java");

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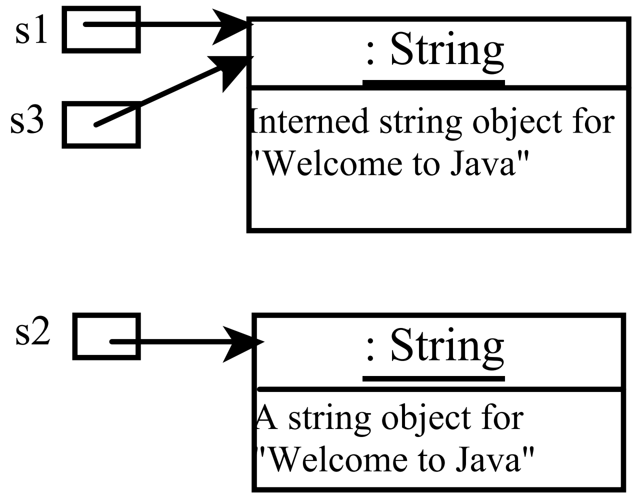
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: String
A string object for "Welcome to Java"

In the above example:

- `s1 == s3` is true
- `s1 == s2` and `s2 == s3 are both false`
- A new object is created if the `new` operator is used.
- A *unique instance* is used for *string literals* with the *same character sequence* – a new object is not created if the interned string has already been created.

`StringBuilder` Class

The `StringBuilder` class is an alternative to the `String` class.

`StringBuilder` is more flexible than `String`, and allows you to add, insert, or append new contents, whereas the value of a `String` object is fixed once the string is created.

In general, a `StringBuilder` can be used wherever a string is used:

- Note: If a string does not require any changes, use `String` rather than `StringBuilder`. Java can perform some optimisations for `String`, such as sharing interned strings.

StringBuilder Class

The StringBuilder class provides several overloaded methods to append boolean, char, char[], double, float, int, long, and String into a string builder.

For example, the following code appends strings and characters into a StringBuilder object sb to form a new string, "Welcome to Java".

```
StringBuilder sb = new StringBuilder();
sb.append("Welcome");
sb.append(' ');
sb.append("to");
sb.append(' ');
sb.append("Java");
```

`StringBuilder` Class

The `StringBuilder` class also contains overloaded methods to insert `boolean`, `char`, `char[]`, `double`, `float`, `int`, `long`, and `String` into a string builder.

Suppose `sb` contains `"Welcome to Java"`. Consider the following code:

```
sb.insert(11, "HTML and ");
```

This code inserts `"HTML and "` at position 11 in `sb` (just before the `'J'`) – `sb` is now set to `"Welcome to HTML and Java"`.

`StringBuilder` Class

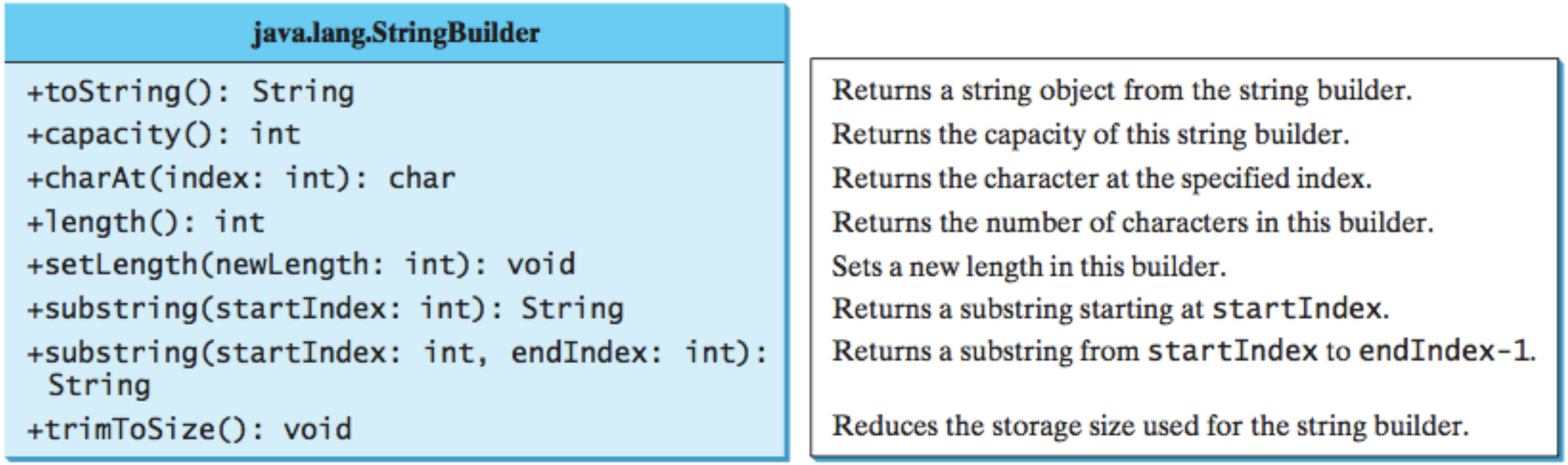
You can also delete characters from a string in the builder using the `delete` methods, reverse the string using the `reverse` method, replace characters using the `replace` method, or set a new character in a string using the `setCharAt` method.

For example, suppose `sb` contains `"Welcome to Java"` before each of the following methods is applied:

- `sb.deleteCharAt(8)` changes the builder to `"Welcome o Java"`.
- `sb.reverse()` changes the builder to `"avaJ ot emocleW"`.
- `sb.replace(11, 15, "HTML")` changes the builder to `"Welcome to HTML"`.
- `sb.setCharAt(0, 'w')` sets the builder to `"welcome to Java"`.

`StringBuilder` Class

The `StringBuilder` class provides additional methods for manipulating a string builder and obtaining its properties:



java.lang.StringBuilder	
`+toString(): String`	Returns a string object from the string builder.
`+capacity(): int`	Returns the capacity of this string builder.
`+charAt(index: int): char`	Returns the character at the specified index.
`+length(): int`	Returns the number of characters in this builder.
`+setLength(newLength: int): void`	Sets a new length in this builder.
`+substring(startIndex: int): String`	Returns a substring starting at `startIndex`.
`+substring(startIndex: int, endIndex: int): String`	Returns a substring from `startIndex` to `endIndex-1`.
`+trimToSize(): void`	Reduces the storage size used for the string builder.

Problem: Checking for Palindromes – Ignoring Non-alphanumeric Characters

Write a program that ignores non-alphanumeric characters in checking whether a string is a palindrome.

Here are the steps to solve the problem:

1. Filter the string by removing the non-alphanumeric characters:
   - Create an empty string builder, adding each alphanumeric character in the string to the string builder, and returning the string from the string builder.

     Use the `isLetterOrDigit` method in the `Character` class to check whether a character is a letter or digit.
2. Obtain a new string that is the reverse of the filtered string.
3. Compare the reversed string with the filtered string using the `equals` method.

PalindromeIgnoreNonAlphanumeric

Procedural Programming Paradigm

Procedural programming is based upon the concept of procedure calls.

A procedure simply contains a series of computational steps to be carried out.

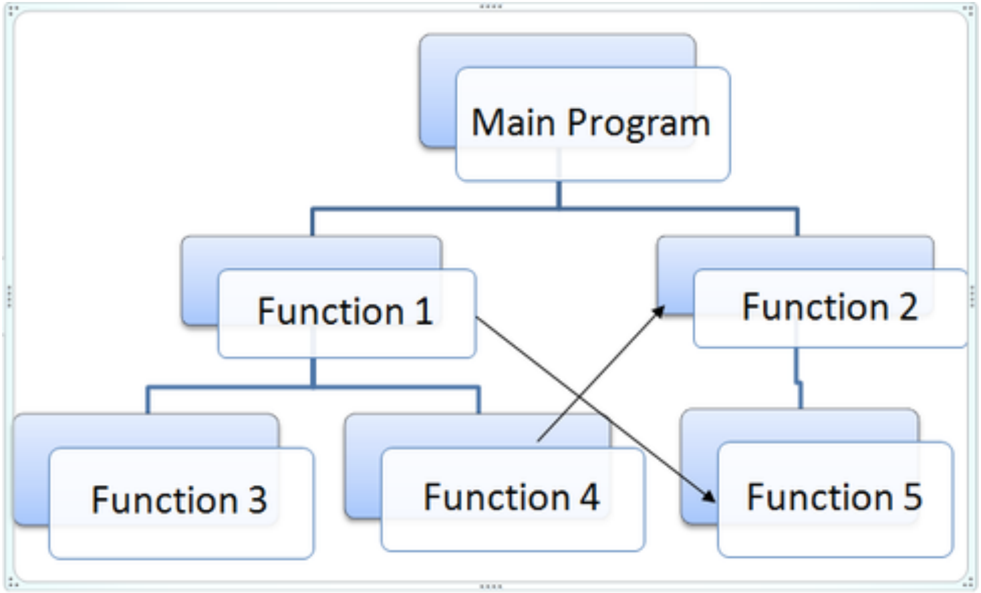
Any given procedure might be called at any point during a program’s execution, including by other procedures (or by itself).

In small programs, this approach works fine.

Procedural Programming Paradigm

But as specifications become more complicated and the size of programs grows, small changes to one part of the program can greatly effect (many) other parts.

For example, many dependencies can exist between procedures. A minor change to one procedure can result in a cascade of errors in other procedures that depended on the original code.

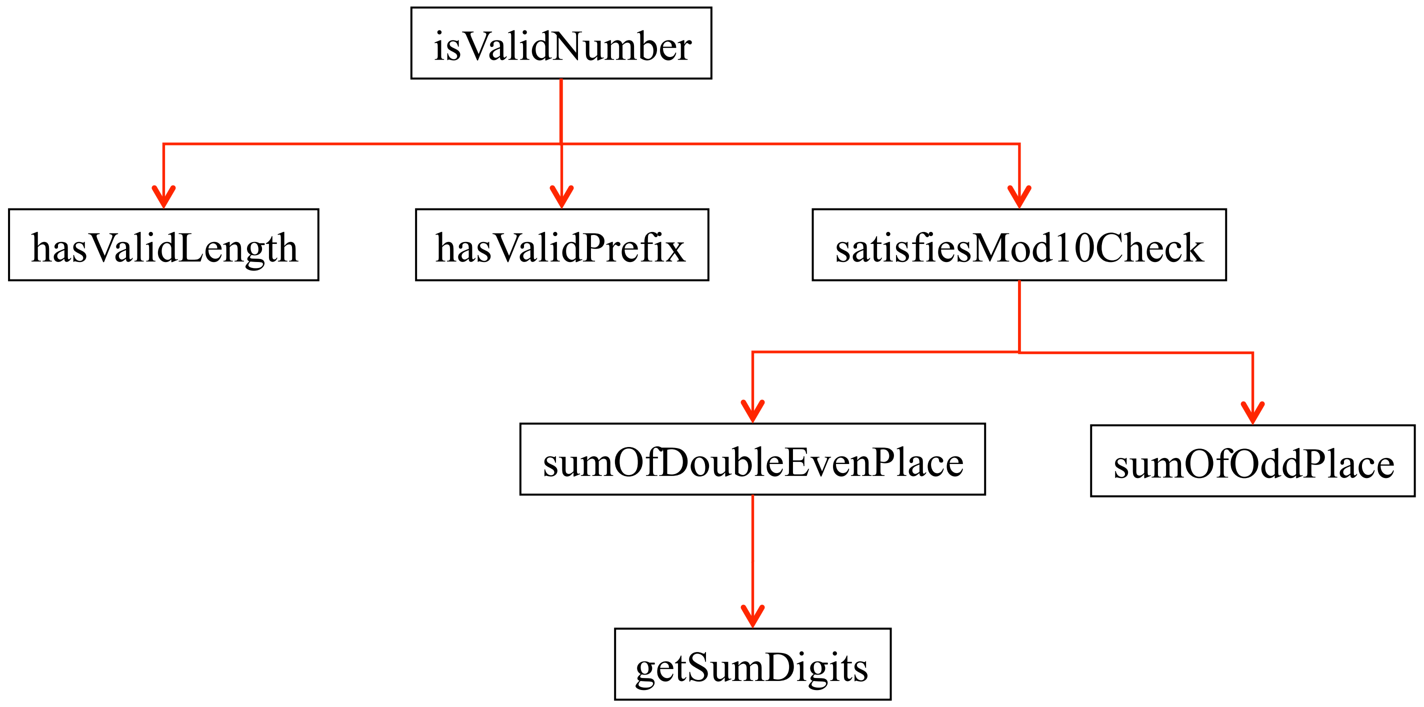


Procedural Programming Paradigm

From Chapter 6 – check if a credit card number is valid.

Using stepwise refinement, a number of methods are defined. Methods invokes other methods… dependencies exist between methods (by design):

- However none of these methods are tied to this particular problem – individual methods could be updated to solve a different problem, leading to errors in other methods…



Procedural vs. Object-Orientated Programming Paradigms

The traditional procedural programming paradigm is action-driven, and data are separated from actions:

- Suppose you wish to associate the balance, interest rate, repayment dates with a loan – there is no good way to tie these properties to a loan without using objects.

The object-oriented paradigm integrates data and methods together into objects:

- To tie a balance to a loan, you can define a loan class with a balance along with the loan's other properties as data fields (interest rate, repayment dates etc.).
- Actions are defined along with the data in objects – actions that are particular to the object's data (e.g. deposit, compute interest due, etc.).

Using objects improves software reusability and makes programs easier to develop, easier to maintain, and reduces bugs in the code.

Class Design Guidelines

We have seen how to design classes from the preceding lectures.

This section summarises some key guidelines that are helpful for designing robust, reusable, and easy to maintain classes:

- Coherence
- Consistency
- Encapsulation
- Clarity
- Completeness
- Instance vs. Static Members

Coherence

A class should describe a *single entity*, and all the class operations should logically fit together to support a coherent purpose.

You can use a class for students, for example, but you should not combine students and staff in the same class, because students and staff are different entities with different properties.

Coherence

A single entity with a number of responsibilities can be broken into several classes to separate responsibilities.

For example, the classes `String` and `StringBuilder` both deal with strings, but have different responsibilities:

- The `String` class deals with immutable strings.
- The `StringBuilder` class is for creating mutable strings.

Consistency

Follow standard Java programming style and naming conventions.

Choose informative names for classes, data fields, and methods.

A popular style is to place the data declaration before the constructors, and place the constructors before the methods.

Provide constructor(s) and explicitly initialize variables to avoid programming errors.

Encapsulation

Classes should use the `private` visibility modifier to hide its data from direct access by clients. This makes classes easy to maintain.

Provide a getter method only if you want a data field to be readable, and provide a setter method only if you want a data field to be updateable.

A class should also hide methods not intended for client use (e.g. a method that initialises data fields by reading from a database).

Clarity

Cohesion, consistency, and encapsulation are good guidelines for achieving design clarity.

Additionally, a class should have a clear contract that is easy to explain and easy to understand.

Classes are designed for reuse. Users can incorporate classes in many different combinations and orders, for example.

Therefore, you should design a class that imposes no restrictions on what or when the user can do with it, design the properties to ensure that the user can set properties in any order, with any combination of values, and design methods to function independently.

Completeness

Classes are designed for use by many different clients.

In order to be useful in a wide range of applications, the class should provide a comprehensive set of constructors, methods and (where appropriate) constants.

For example, the `String` class contains more than 40 methods that are useful for a variety of applications.

Instance vs. Static

Instance and static are integral parts of object-oriented programming. A data field or method is either instance or static.

A variable or method that is dependent on a specific instance of the class must be an instance variable or method.

A variable that is shared by all the instances of a class should be declared static:

- For example, the variable `numberOfObjects` in class `Circle` is shared by all the objects of the `Circle` class and therefore is declared static.

A method that is not dependent on a specific instance should be defined as a static method:

- For example, the method `getNumberOfObjects()` in class `Circle` is not tied to any specific instance and therefore is defined as a static method.
- Note: a static method cannot access instance members of the class.

Instance vs. Static

Always reference static variables and methods from a class name (rather than from a reference variable) to improve readability.

Do not pass a parameter to a constructor to initialise a static data field. Initialise static variables where they are declared. Use a setter method to change the static data field.

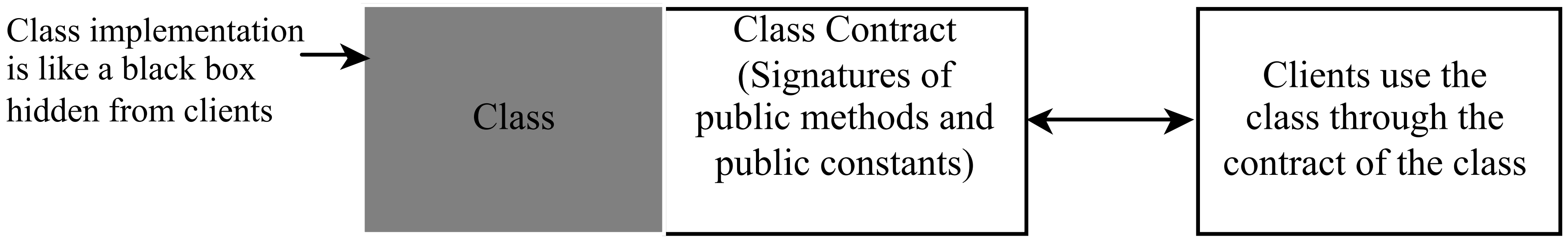
A constructor is always instance, because it is used to create a specific instance of a class.

Class Abstraction and Encapsulation

Class abstraction means to separate class implementation from the use of the class.

The creator of the class provides a description of the class and lets the user know how the class can be used.

The user of the class does not need to know how the class is implemented – the detail of implementation is *encapsulated* and hidden from the user.


Class implementation is like a black box hidden from clients
Class
Class Contract (Signatures of public methods and public constants)
Clients use the class through the contract of the class

Class Relationships

To design classes, you need to explore the *relationships* among classes.

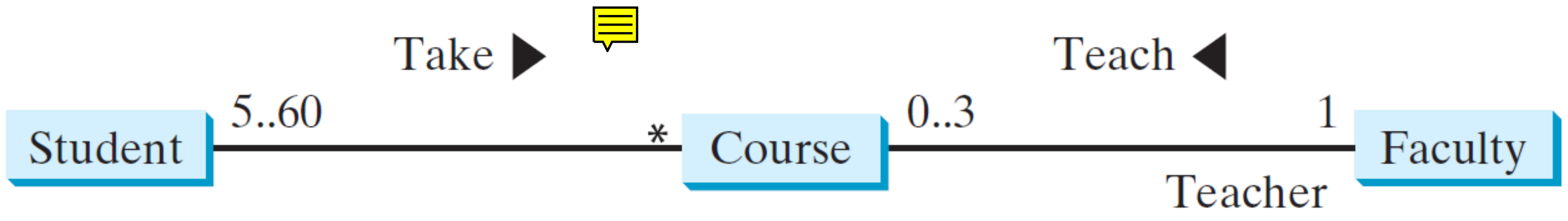
The common relationships among classes are *association*, *aggregation*, *composition*, and *inheritance*.

Here we explores association, aggregation, and composition. The inheritance relationship will be introduced in the next chapter.

Association

Association is a general binary relationship that describes an activity between two classes.

For example, consider a course, the students taking the course, and the faculty teaching the course:



- This UML diagram shows that a student may take any number of courses, a faculty member may teach at most three courses, a course may have from five to sixty students, and a course is taught by only one faculty member.
- A student taking a course is an association between the `Student` class and the `Course` class, and a faculty member teaching a course is an association between the `Faculty` class and the `Course` class.

Association

Associations are implemented by using data fields and methods.

```
public class Student {
  private Course[]
    courseList;

  public void addCourse(
    Course s) { ... }
}
```

```
public class Course {
  private Student[]
    classList;
  private Faculty faculty;

  public void addStudent(
    Student s) { ... }

  public void setFaculty(
    Faculty faculty) { ... }
}
```

```
public class Faculty {
  private Course[]
    courseList;

  public void addCourse(
    Course c) { ... }
}
```

- Relation “a student takes a course” is implemented using the `addCourse` method in the `Student` class and the `addStudent` method in the `Course` class.
- The relation “a faculty teaches a course” is implemented using the `addCourse` method in the `Faculty` class and the `setFaculty` method in the `Course` class.
- Note: There are many possible ways to implement relationships. For example, the student and faculty information in the `Course` class can be omitted, since they are already in the `Student` and `Faculty` class.

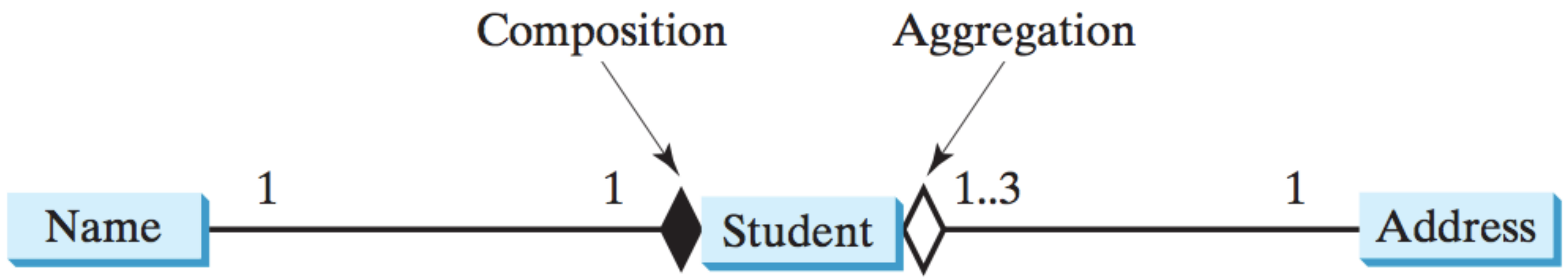
Aggregation and Composition

Aggregation is a special form of association. It represents an *ownership* relationship between two objects and models *has-a* relationships.

- The owner object is called an *aggregating object* and its class an *aggregating class*.
- The subject object is called an *aggregated object* and its class an *aggregated class*.

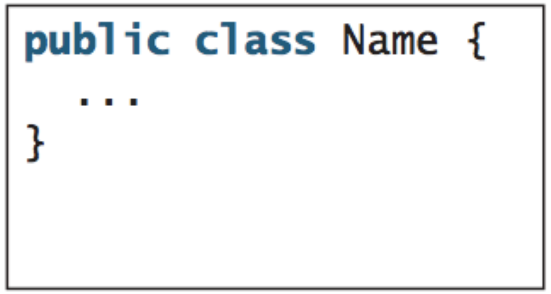
An object can be owned by several other aggregating objects. If an object is exclusively owned by an aggregating object, the relationship is referred to as a *composition*. For example:

- "a student *has an* address" is an *aggregation* relationship between a student and her address, since an address can be shared by several students.
- "a student *has a* name" is a *composition* relationship between a student and her name, since each student has one name.



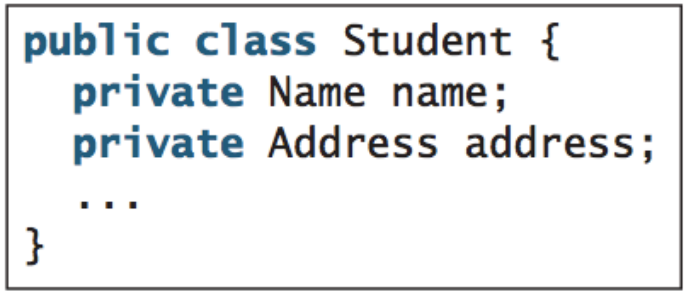
Aggregation and Composition

An aggregation/composition relationship is usually represented as a data field in the aggregating class.



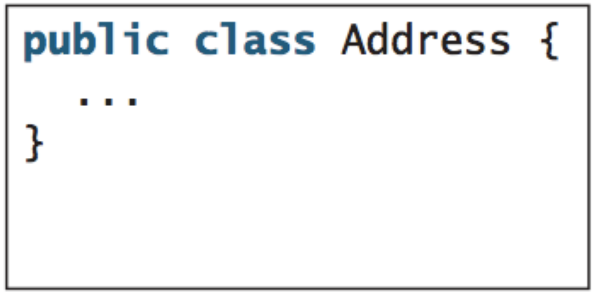
```
public class Name {
  ...
}
```

Aggregated class



```
public class Student {
  private Name name;
  private Address address;
  ...
}
```

Aggregating class



```
public class Address {
  ...
}
```

Aggregated class

For example:

- The relations “a student has a name” and “a student has an address” are implemented in the data field `name` and `address` in the `Student` class.

Aggregation and composition relationships are represented using classes in the same way.

Next Lectures…

This and previous lectures:

- Chapter 9 – introducing classes and objects.
- Chapter 10 – object-oriented vs. procedural programming paradigms, class relationships and design guidelines, strings.

Next lectures:

- Chapter 11 – inheritance and polymorphism