CORE JAVA

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Java Fundamentals

Introduction to Java

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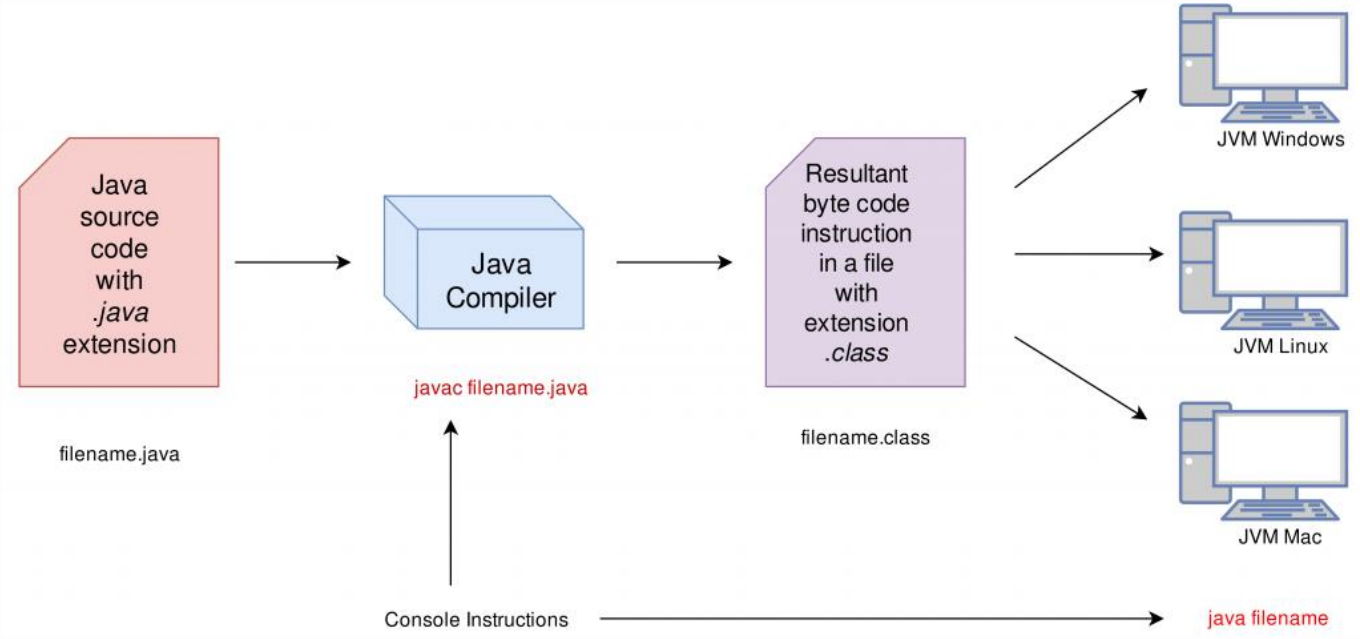
Brief History of Java

- Java was originally called “Oak”
- Java was meant to be a programming language specifically for appliances and various small devices
- The original specification:
  - Targeted set-top boxes for cable television that allowed users a control and interactivity when using the service
  - Java specification is owned by Sun Microsystems.
- The newly emerging Internet proved to be a much better platform for the specification:
  - The way the Net was being used had the same interactivity they planned for cable television customers

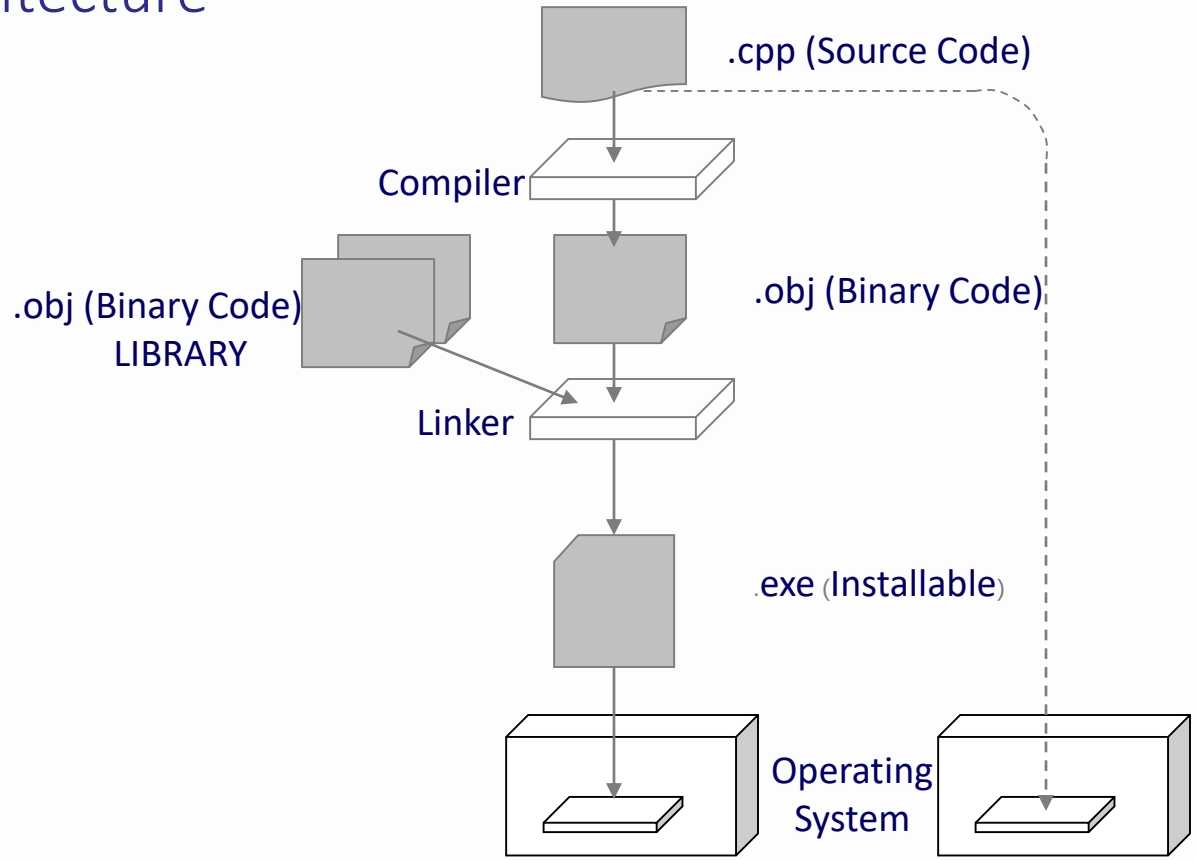
The Java Technology Platform

- Java applications run on a virtual machine environment that:
  - Isolates the underlying platform
  - Achieves portability and performance
  - Provides security
- Java source code is written as plain text files (.java) that are compiled as platform independent byte-codes (.class)
- Java byte-codes are interpreted and executed by the virtual machine that passes the instructions to the actual platform

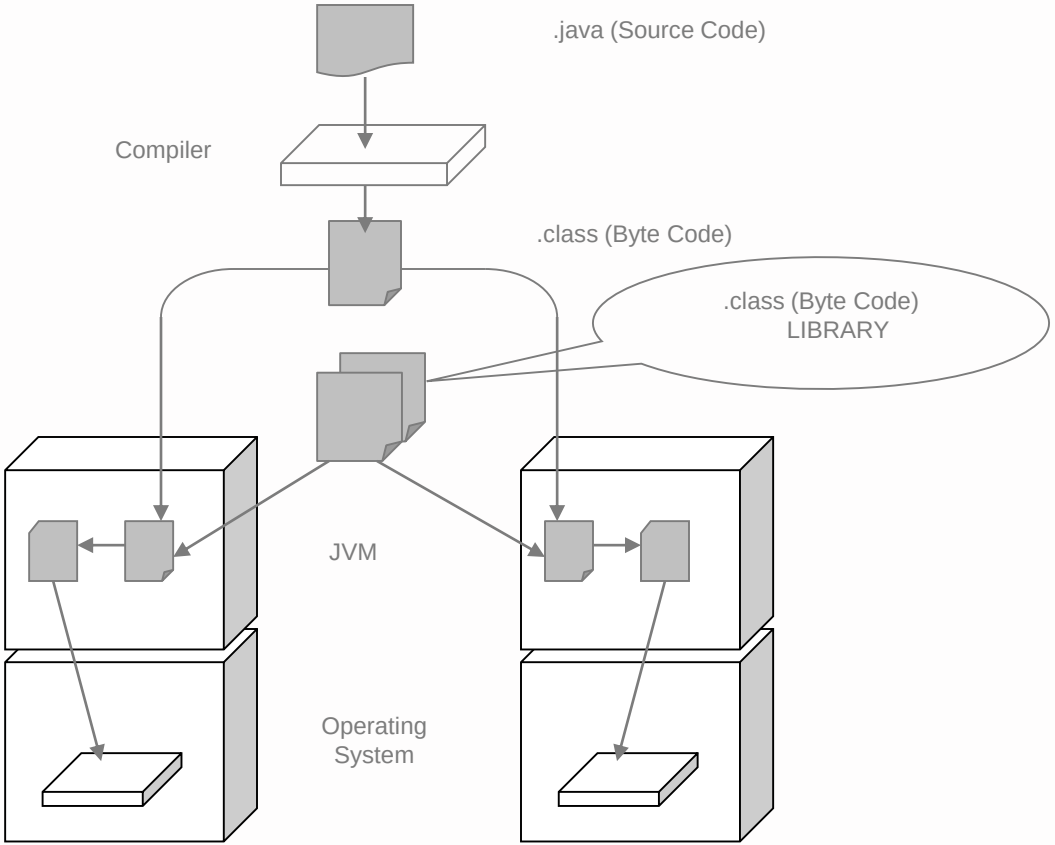
The Java Technology Platform



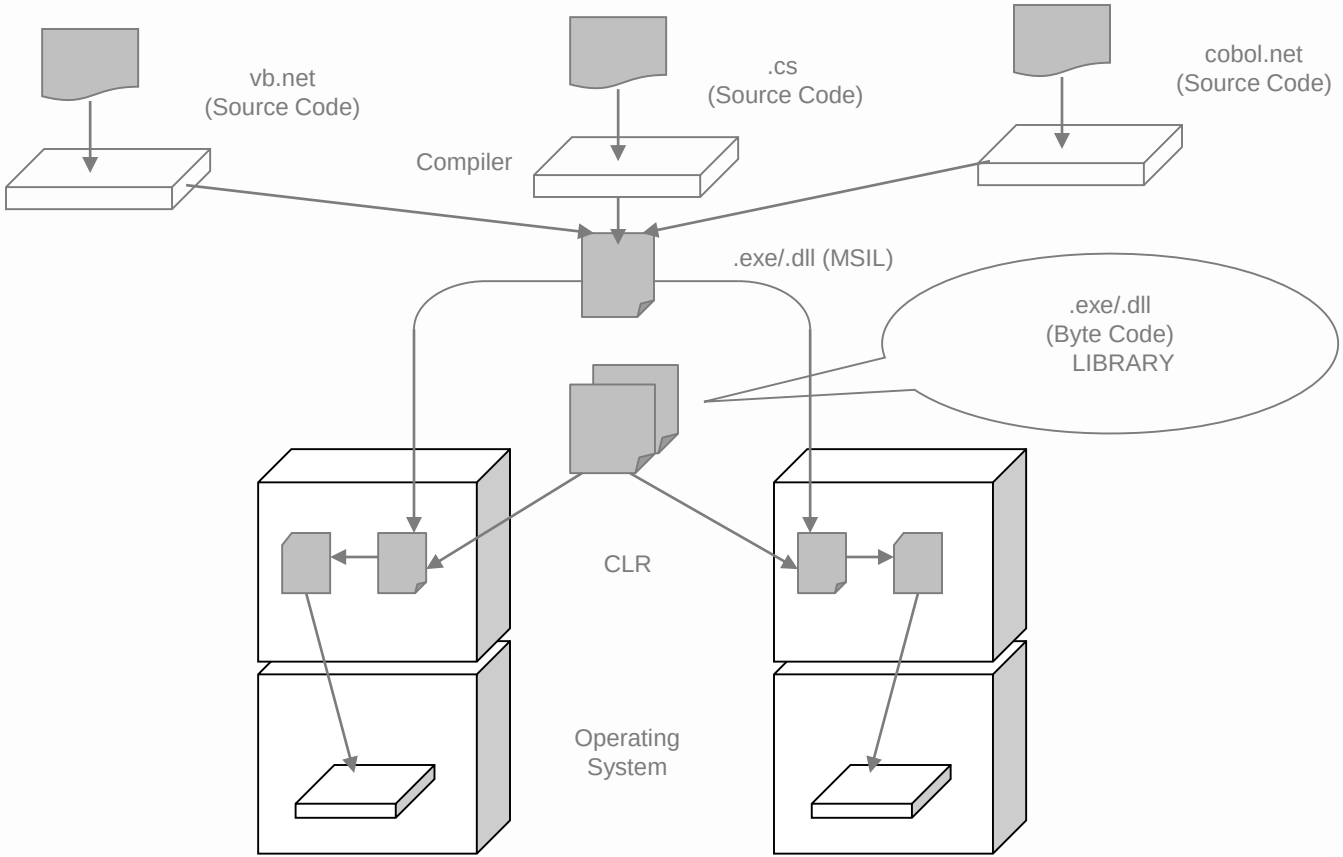
C++ Architecture



Java Architecture



.NET Architecture



Java Development Kit

- Java Development Kit (JDK):
  - Is a set of software, tools and libraries that need to be installed in order to start writing and compiling Java applications
  - Installs the virtual machine (runtime environment) needed in order to execute Java applications on the platform
    - The virtual machine can be downloaded separately from the JDK as a JRE (Java Runtime Environment) download

Integrated Development Environment

- Java source files are in text format and can be written using any text editor
- For greater productivity, an Integrated Development Environment (IDE) is highly recommended. An IDE:
  - Provides you with a set of tools that assist in developing, testing, and debugging Java applications
  - Popular IDEs are :
    - Eclipse
    - IntelliJ
    - NetBeans

A simple Java program

```
//File: SampleApp.java

class SampleApp  { // class name must match file name

   public static void main (String args[]) {
      System.out.println (“Welcome To Java …….”);
   }
}
```

Compile the java	> javac SampleApp.java
Execute the ".class" file	> java SampleApp

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Java Fundamentals

Language Fundamentals

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Java Keywords

- Java recognizes a set of keywords as part of the Java language
- Java keywords are used to support programming constructs, such as class declaration, variable declaration, and control flow

abstract	default	if	package	synchronized
assert	do	implements	private	this
boolean	double	import	protected	throw
break	else	instanceof	public	throws
byte	extends	int	return	transient
case	false	interface	short	true
catch	final	long	static	try
char	finally	native	strictfp	void
class	float	new	super	volatile
continue	for	null	switch	while

const goto

Primitive Data Types

Type	Bits	Lowest Value	Highest Value
boolean	(n/a)	false	true
char	16	'\u0000' [0]	'\uffff' [2^{16}-1]
byte	8	-128 [-2^{7}]	+127 [2^{7}-1]
short	16	-32,768 [-2^{15}]	+32,767 [2^{15}-1]
int	32	-2,147,483,648 [-2^{31}]	+2,147,483,647 [2^{31}-1]
long	64	-9,223,372,036,854,775,808 [-2^{63}]	+9,223,372,036,854,775,807 [2^{63}-1]
float	32	±1.40129846432481707e-45	±3.40282346638528860e+38
double	64	±4.94065645841246544e-324	±1.79769313486231570e+308

Data Types

- A primitive data type assigned a value:

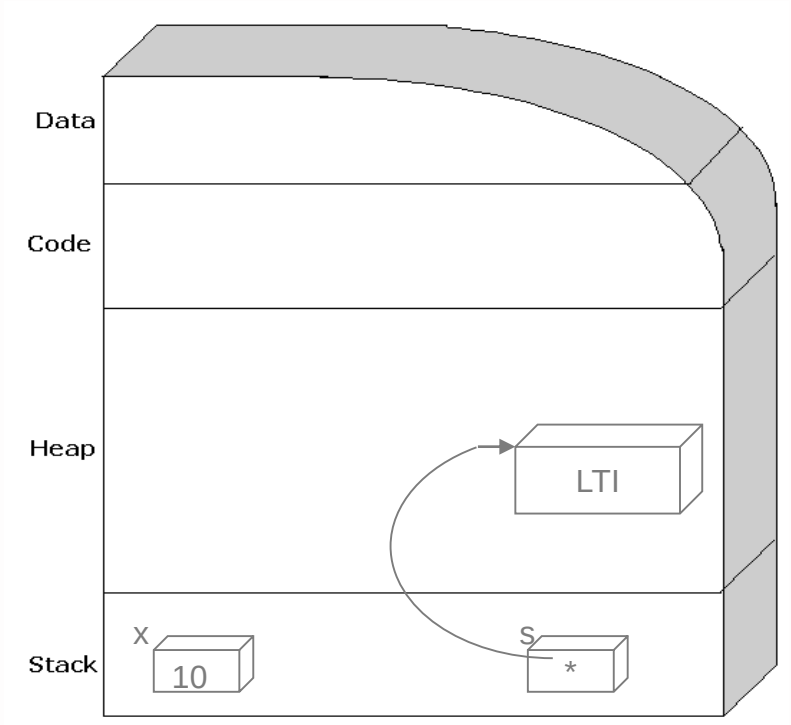
int x = 42;

- A reference data type assigned a value:

Date today = new Date();

Basic vs Reference Variables

```
class BasicVsReference {
 public static void main(String[] args) {
    int x = 10;
    String str = “LTI”;
  }
}
```



Parameter Passing

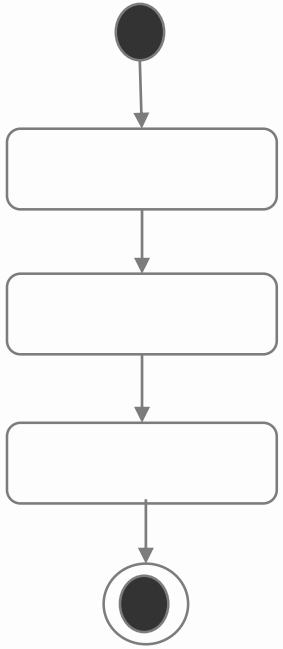
- Parameters in Java are Passed By Value

  - Passing Primitive Data Type Arguments
    - A copy of the value is passed to the method.
    - Any changes to the value exists only within the scope of the method.
    - When the method returns, any changes to the value are lost. The original value remains.

  - Passing Reference Data Type Arguments
    - A copy of the object's reference's value is being passed.
    - The values of the object's fields can be changed inside the method, if they have the proper access level.
    - When the method returns, the passed-in reference still references the same object as before. However, the changes in the object's fields will be retained.

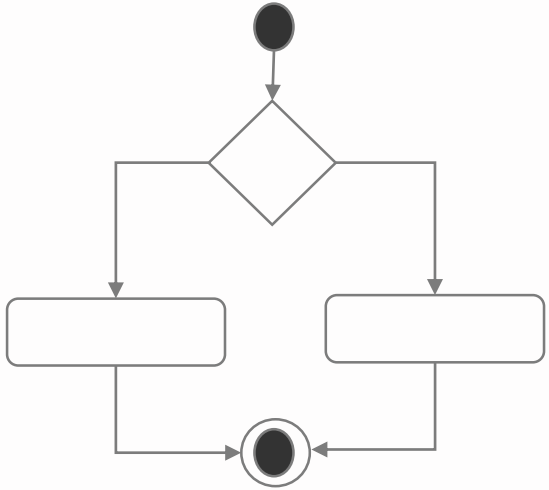
Types of Flow Control

- ***Sequential*** statements are executed in the order they are written
- This is the default flow of a program as instructions are executed in the order they appear



Types of Flow Control

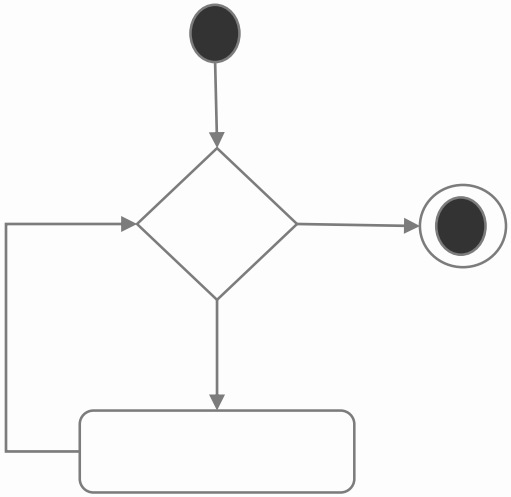
- Selection structures execute a certain branch based on the results of a boolean condition
- This flow is useful in decision-making scenarios and can be implemented by using the if-else or switch-case statements



Types of Flow Control

- Iteration structures execute instructions repeatedly based on a condition

- This type of flow control can be implemented by making use of the different loop statements:
  - for-loop
  - while-loop
  - do-while loop



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Java Fundamentals

Object Oriented Programming

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Overview of Object-Oriented Programming

- Object-Oriented Programming is a programming pattern that makes use of objects and their interactions to design and implement applications
- Objects are entities that serve as the basic building blocks of an object-oriented application
- An object is a self-contained entity with attributes and behaviors
- In some way everything can be an object.
- In general, an **object** is a person, place, thing, event, or concept.
- Because different people have different perceptions of the same object, what an object is depends upon the point of view of the observer.
  - That is, we describe an object on the basis of the features and behaviors that are important or relevant to us.

Abstraction

- An object is thus an abstraction.
- An object is an “abstraction of something in the problem domain, reflecting the capabilities of the system to keep information about it, interact with it, or both.” (Coad and Yourdon)
- An abstraction is a form of representation that includes only what is useful or interesting from a particular viewpoint.
  - e.g., a map is an abstract representation, since no map shows every detail of the territory it covers

Software Abstraction

- Abstraction is the process of reducing or simplifying information or a concept in order to retain that which is relevant to the current context
- Data is abstracted by high level language constructs, such as:
  - Numbers
  - Letters
  - Higher level data concepts
- Functionality is abstracted by presenting interfaces that hide complex logic or algorithms, such as:
  - Functions
  - Methods
- The mindset of an OO designer must be focused on creating small, simple re-usable components that can be combined to create more complex systems.

Types of Objects

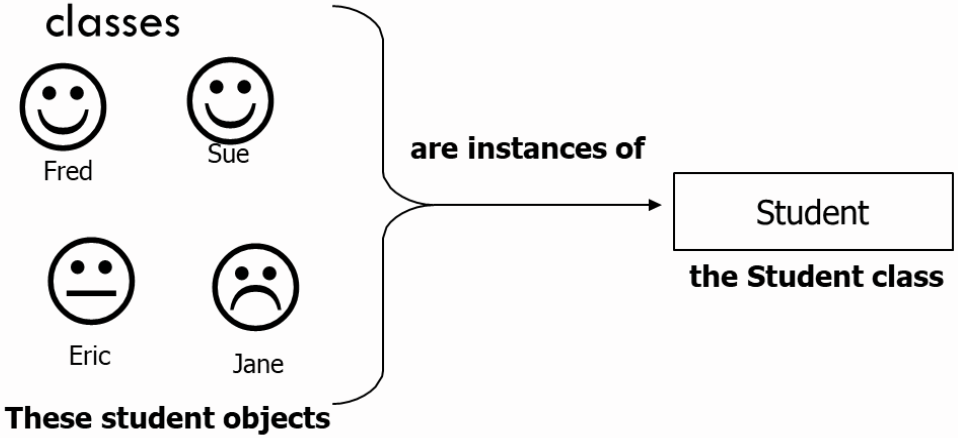
- Objects are usually classified as:
  - Objects representing physical things
    - e.g. students, furniture, buildings, classrooms
- Objects representing concepts
  - e.g., courses, departments, loan

Class

- We classify similar objects as a type of thing in order to categorize them and make inferences about their attributes and behavior. This classification is generally defined as a Class
- A *class* is a template for a specific object
- A *class* defines the attributes and methods that all objects belonging to the class have
- The attributes and methods of a class are called ‘fields’ or ‘members’
- An *instance* refers to an object that is a member of a particular class. All objects that belong to a class are instances of that class

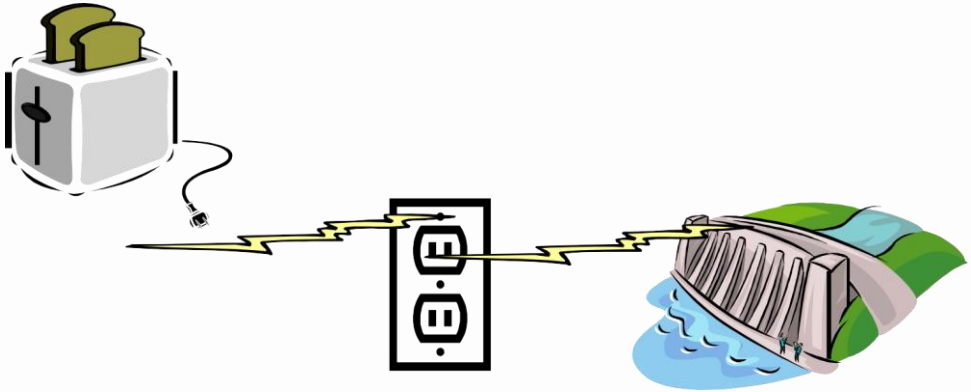
Class and Objects

- A class is thus a type of thing, and all specific things that fit the general definition of the class are things that belong to the class
  - A class is a "blueprint" or description for the objects
- An object is a specific instance of a class
  - Objects are thus instantiated (created/defined) from



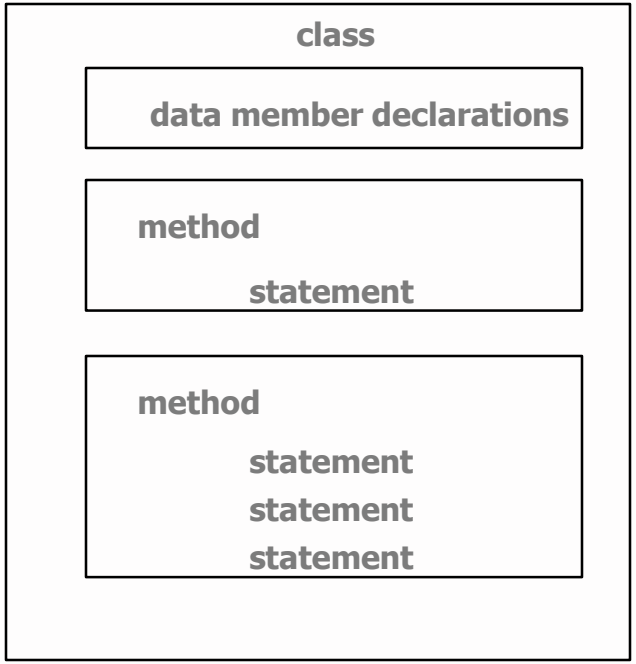
Interfaces

- The attributes and methods that a class provides to other classes constitute the class's interface
- The interface thus completely describes how users of that class interact with the class

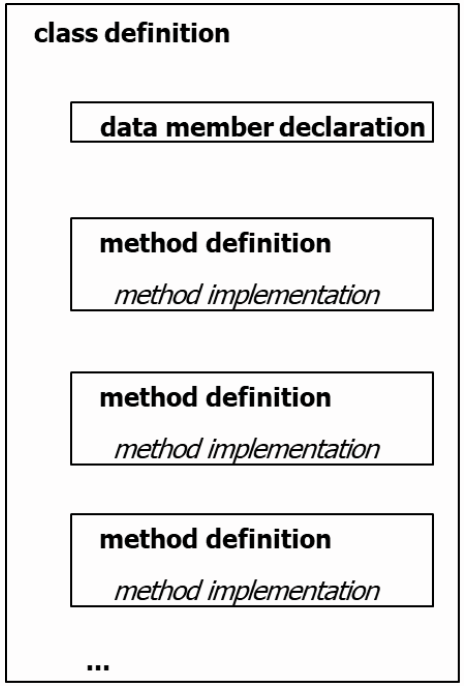


Class Definition

- Classes are the most fundamental structural element in Java or C#
  - Every program has at least one class defined
  - Data member declarations appear within classes
  - Methods appear within classes
  - Statements appear within methods and properties



Class Definition Example



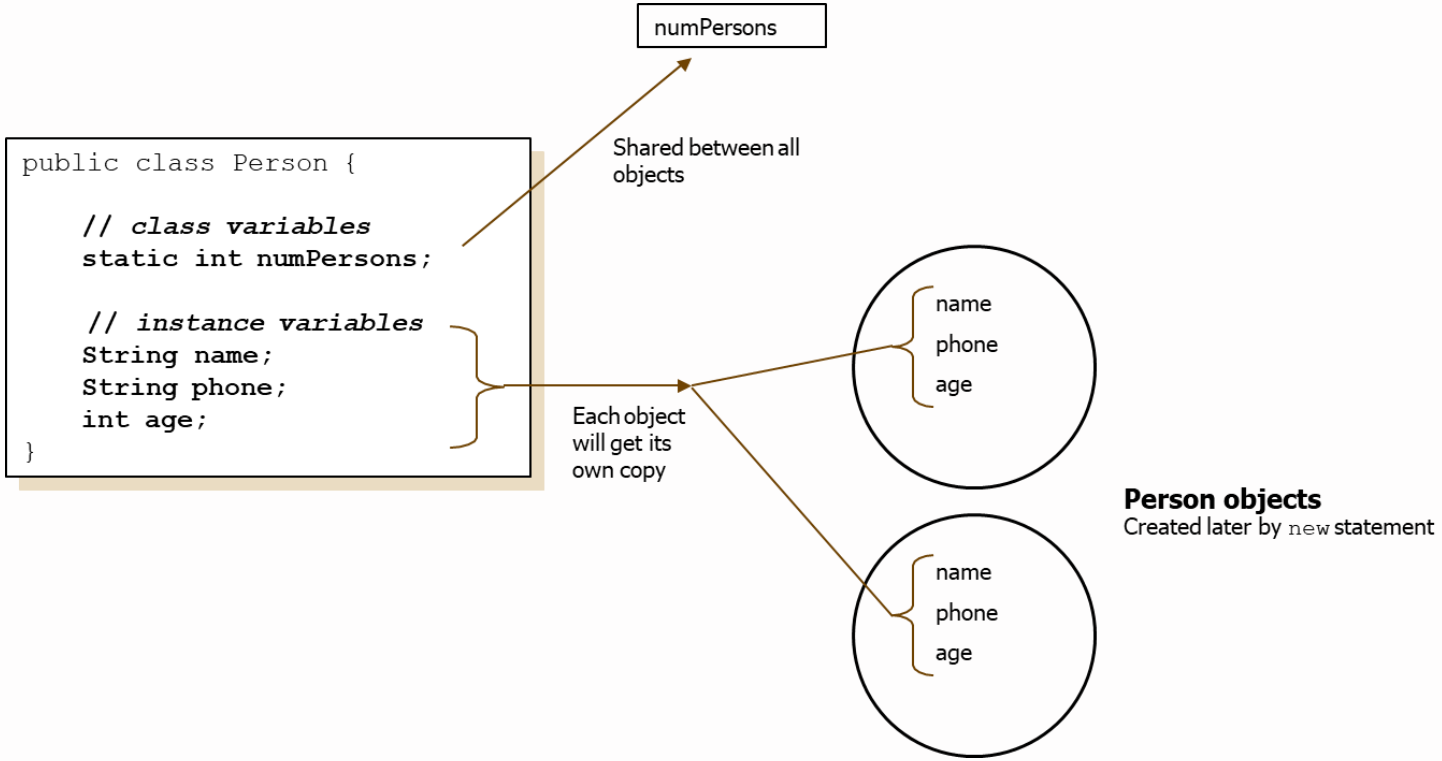

```
public class Rectangle {


    public double lowerLeftX,lowerLeftY;
    public double upperRightX,lowerRightY;


    public double width() {
        return upperRightX - lowerLeftX;
    }


    public double height() {
        return upperRightY - lowerLeftY;
    }


    public double area() {
        return width() * height();
    }
}
```

Call or **invoking** the *width* and *height* methods defined above.

Types of members

- Two types of members (data members and methods):
  - **static** or **class** members
    - a member that is shared by all objects of that class
    - it is called a class member because it belongs to the class, not to a given object
    - it is called a static member because it is declared with the static keyword
- **instance members**
  - Each instance/object of the class will have a copy of each instance member

Example



Constructors

- When an object of a class is created (via new), a special method called a constructor is always invoked
  - You can supply your own constructor, or let the compiler supply one (that does nothing)
  - Constructors are often used to initialize the instance variables for that class
- Two characteristics:
  - constructor method has same name as the class
  - Constructor method never returns a value and must not have a return type specified (not even void)

Example

```
public class Person {

    // data members
    public String _name;
    public String _phone;
    public int _age;

    // class constructor
    public Person()
    {
        _age = -1;
    }

    // class methods

    // instance methods
}
```

```
...
Person employee = new Person();

Person boss = new Person();

...
```

Each time a Person object is created, the class constructor is called (and as a result, employee._age and boss._age is initialized to -1)

Encapsulation

- Perhaps the most important principle in OO is that of encapsulation (also known as information hiding or implementation hiding)
  - This is the principle of separating the implementation of an class from its interface and hiding the implementation from its clients
  - Thus, someone who uses a software object will have knowledge of what it can do, but will have no knowledge of how it does it
  - Benefits
    - Maximizes maintainability
      - making changes to the implementation of a well encapsulated class should have no impact on rest of system
    - Decouples content of information from its form of representation
      - thus the user of an object will not become tied to format of the information

Encapsulation

- Encapsulation is implemented through access protection
  - Every class, data member and method in a Java or C# program is defined as either public, private, protected or unspecified/default

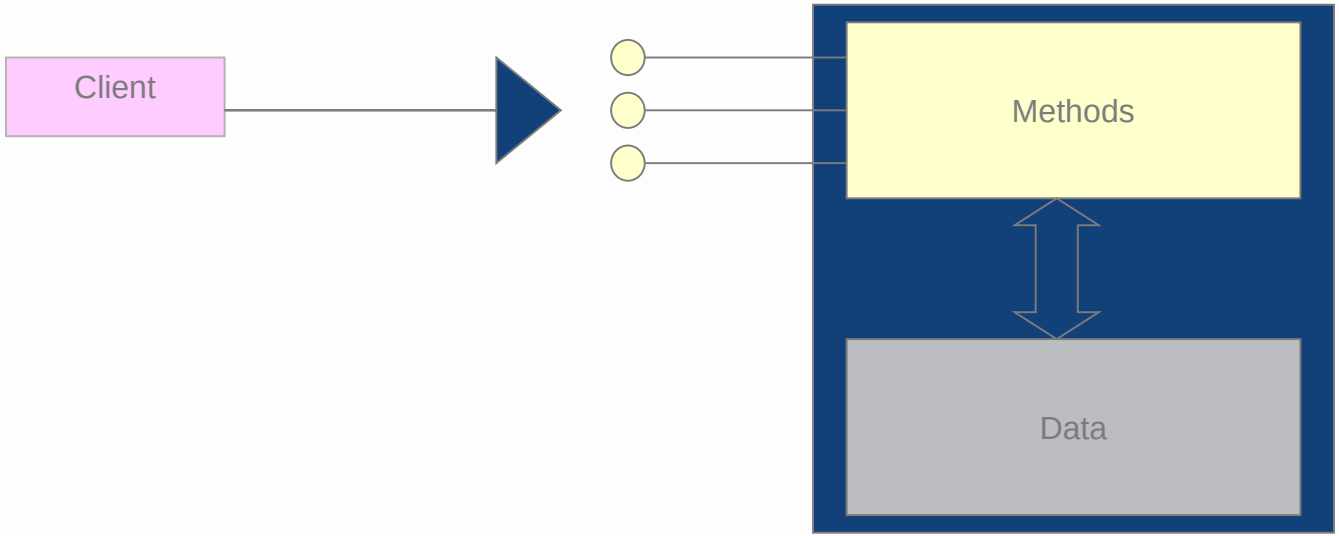
```
class ScopeClass
{
  private int aPrivate = 1;
  int aUnknown = 2;
  public int aPublic = 3;
}
```

```
class ScopeTest
{
  public static void main(String[] args)
  {
    ScopeClass aScope = new ScopeClass();

    System.out.println("Scope Test");
    System.out.println("aPrivate=" + aScope.aPrivate);
    System.out.println("aUnknown=" + aScope.aUnknown);
    System.out.println("aPublic=" + aScope.aPublic);
  }
}
```

→ Generates a compile error

Encapsulation

- An encapsulated object can be thought of as a black box or an abstraction
- Its inner workings are hidden to the client, which only invokes the interface methods



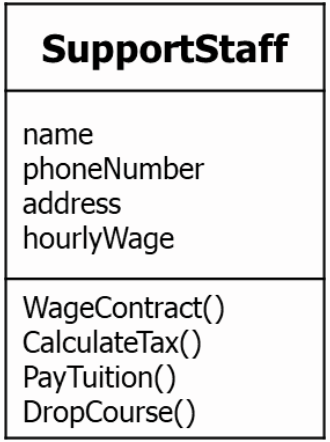
Class Relationships

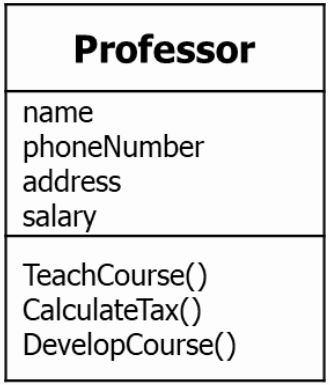
- Classes do not exist by themselves themselves, but exist in relationships with other classes
- Kinds of relationship
  - Generalization (Inheritance)
  - Aggregation
  - Association
  - Dependency

Defining Inheritance

- **Inheritance** is the representation of an is a, is like, is kind of relationship between two classes
  - e.g., a Student is a Person, a Professor is kind of a Person
- With inheritance, you define a new class that encapsulates the similarities between two classes
- *A superclass*/base class/parent class – the class from which the attributes and behavior are derived
- *A subclass/*derived class/child class – a class that derives attributes and behavior from another class
- Inheritance is one of the language constructs that encourages the *re-use* of code by allowing the behavior of existing classes to be extended and specialized

Example





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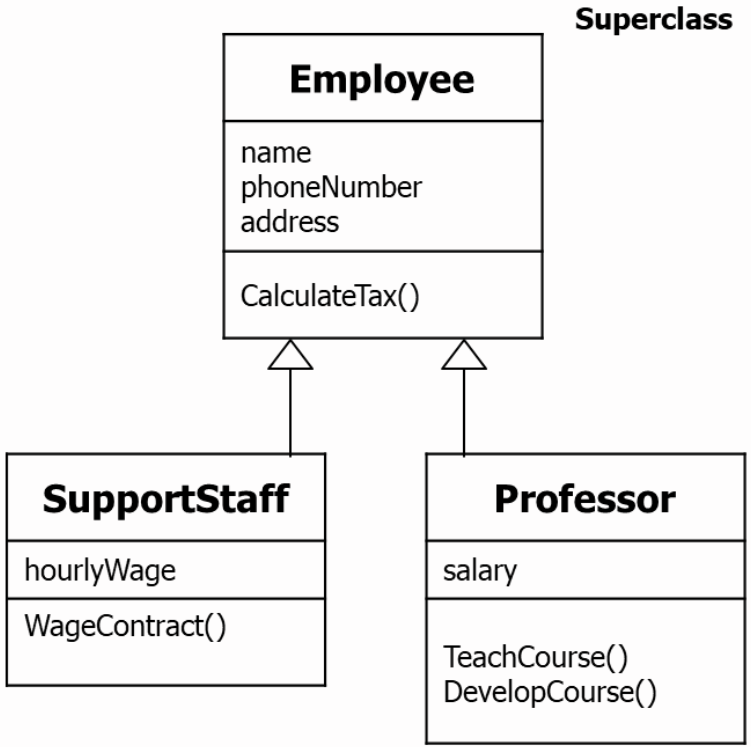
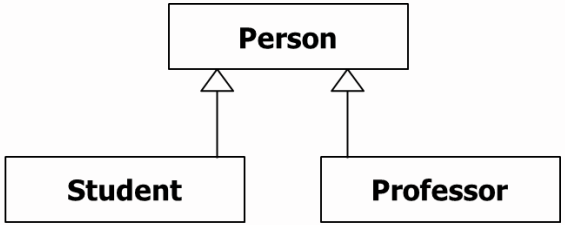


Example



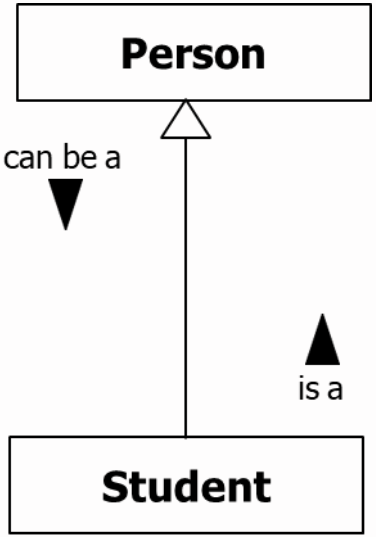

```
public class Person
{
  // data members and methods here
}
```

```
public class Student extends Person
{

}
```

```
public class Professor extends Person
{

}
```



Abstract and Concrete classes

- An ***Abstract Class*** is a class that provides common behavior across a set of subclasses, but is not itself designed to have instances of its own
- An abstract class is one that can not have objects instantiated from it
- An abstract class is designed as a template for other classes to follow by dictating behavior that must be implemented by its subclasses
- A concrete class is one that can have objects instantiated from it
- Defined using the 'abstract' class modifier

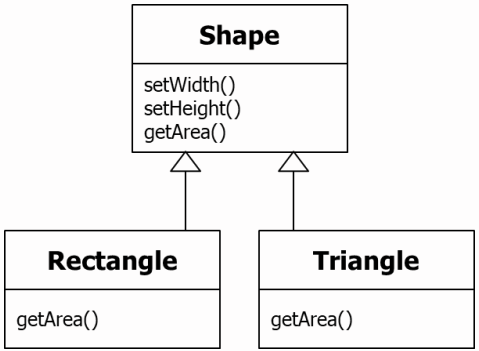
```
public class abstract Food {

        public abstract double calculateCalories();

}
```

Polymorphishm

- Polymorphism is:
- the ability to change the behavior of the application depending upon the type of an object
- the ability to manipulate objects of distinct classes using only the knowledge of their shared members
- It allows us to write several versions of a method in different classes of a subclass hierarchy and give them all the same name
- The subclass version of an attribute or method is said to override the version from the superclass



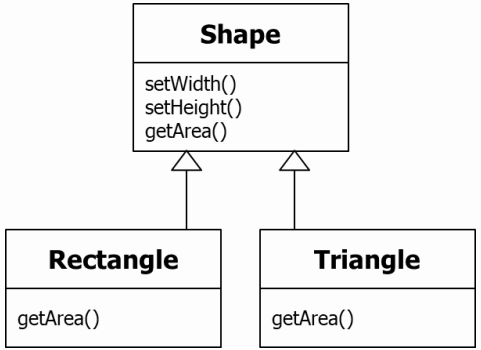
Example

```
public class Shape {
   double width, height;
   public abstract double getArea();

   public void setWidth(double newWidth) {
      width = newWidth;
   }
   public void setHeight(double newHeight) {
      height = newHeight;
   }
}
```

```
public class Rectangle extends Shape {
   public double getArea() {
     return (width * height);
   }
}
```

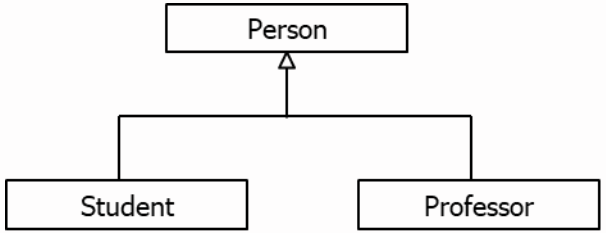
```
public class Triangle extends Shape {
   public double getArea() {
     return (0.5 * width * height);
   }
}
```



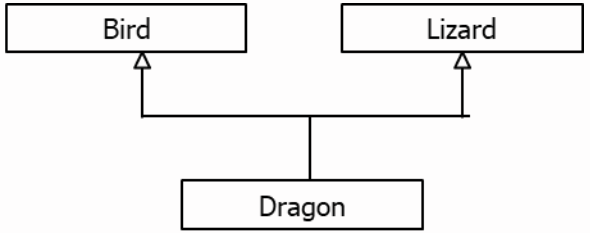

```
...
Rectangle myRect = new Rectangle();
myRect.setWidth(5);
myRect.setHeight(4);
System.out.println myRect.getArea();
...
```

Single and multiple inheritance

- When a class inherits from only one other class, this is called single inheritance
- When a class inherits from two or more classes, this is called multiple inheritance
  - Most OO languages do not support multiple inheritance (Java, C#, Smalltalk do not, but C++ does)



Single Inheritance



Multiple Inheritance

Defining Java Interface

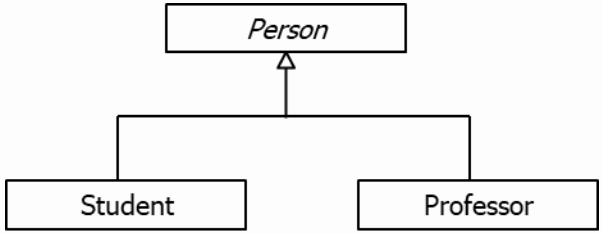
- An ***Interface*** defines a contract by specifying a set of method templates that an implementing class needs to follow
- An interface provides only a form for a class but no implementation
- An interface defines *what* a class can do but not *how* the class will do it

Implementing Interfaces

- A class implementing interfaces is required to override the inherited methods
- Interfaces are implemented using the `implements` keyword
- Rules on implementing the interface methods
  1. Must have the same method signature and return type
  2. Cannot narrow the method accessibility
  3. Cannot specify broader checked exceptions
- Interface variables are implicitly `public final static`
- Interface methods are implicitly `public abstract`

Substitutability

- Substitutability refers to the principle that subtypes must be substitutable for their supertypes
  - That is, if I write code assuming I have the superclass, it should work with any subclass
  - e.g., if I wrote code assuming I have a Person object, it should work even if I have a Student or Professor object
  - Substitutability is possible due to the polymorphic nature of inheritance

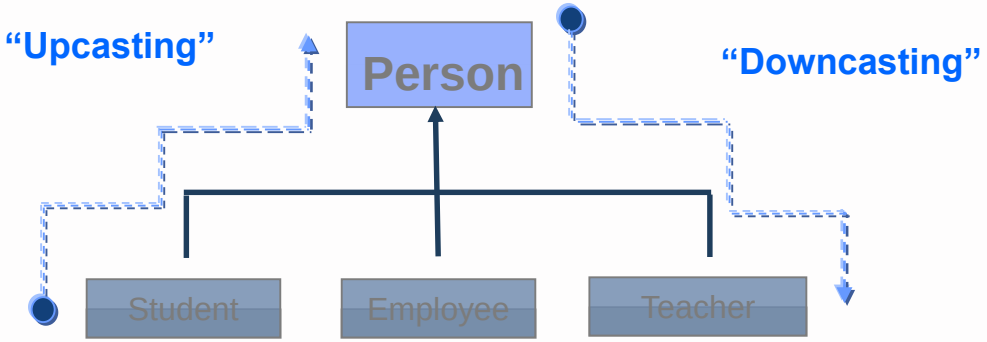


Reference Casting

- *Upcasting* is conversion up the inheritance hierarchy
- To upcast a **Student** object, all you need to do is assign the object to a reference variable of type **Person.** Note that the **p** reference variable cannot access the members that are only available in **Student**

* *Assuming Student is a subclass of Person*

Person p = new Student(); //upcasting

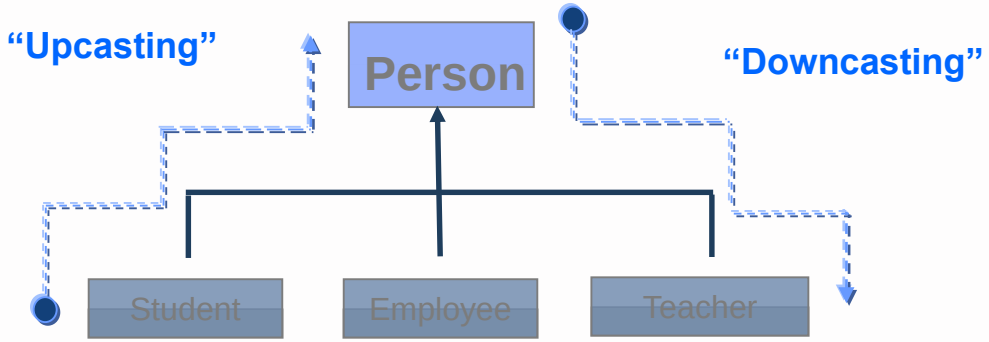


Reference Casting

- *Downcasting* is conversion down the inheritance hierarchy
- *To downcast* **Person** references an object of type **Student**, you can cast it back to **Student.** This time, it is called downcasting because you are casting an object to a class down the inheritance hierarchy
- Downcasting requires that you write the Student type in brackets

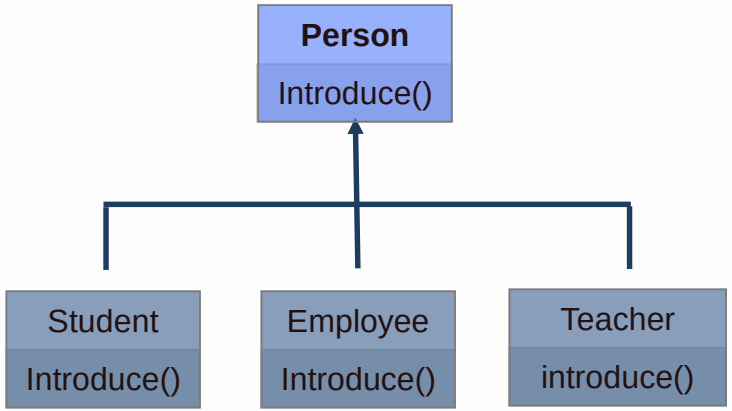
  * *Assuming p is actually pointing to a Student object (as above)*

  Student s = (Student)p;



Virtual Methods

- A virtual method is a method whose actual implementation is dynamically determined during runtime
- All java methods(except static methods and final methods) are ‘virtual’ and can be overridden by methods and fields that belong to the sub class
- abstract methods can be considered as pure virtual methods in Java



Virtual Method Invocation

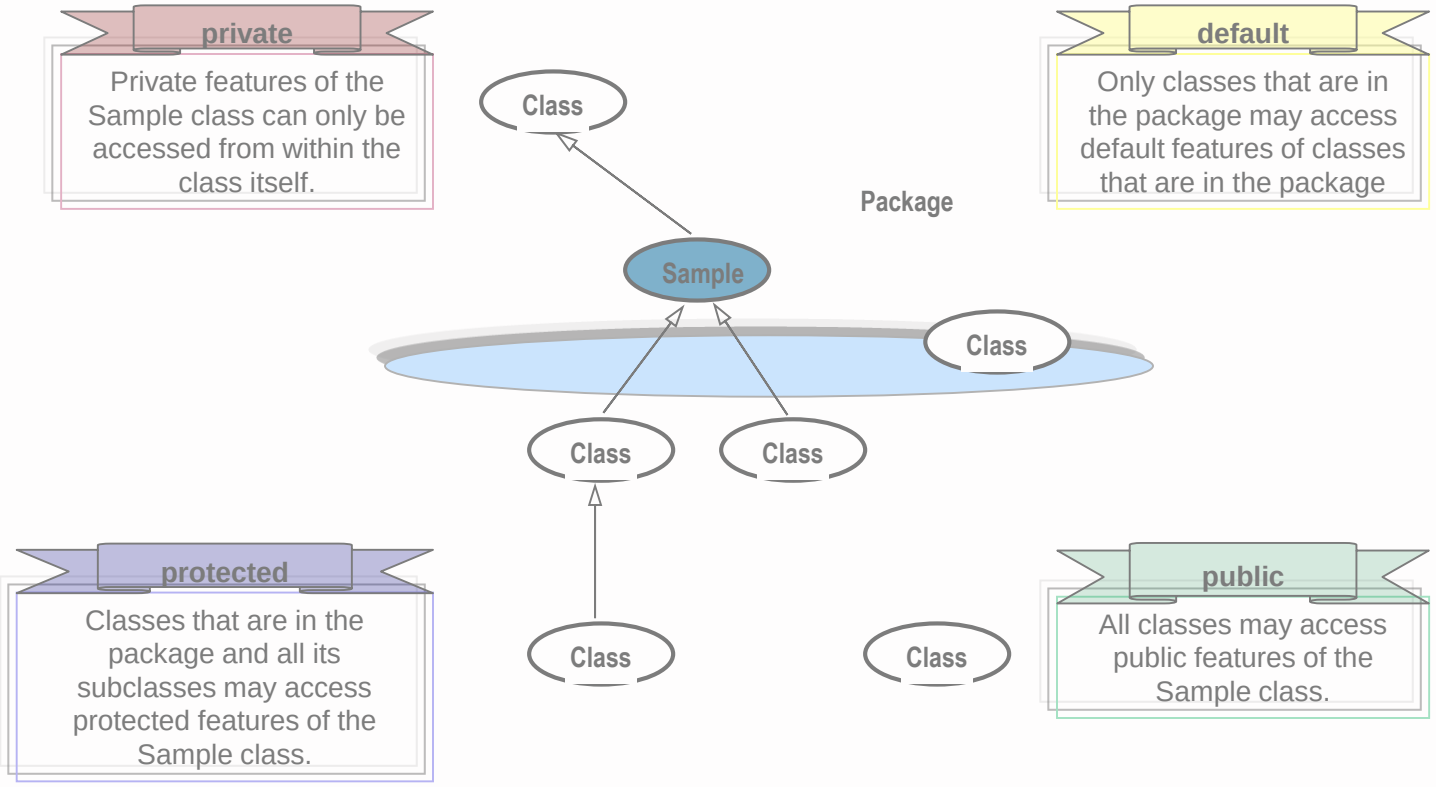
- A reference type variable can point to instances of its own type, or its subtypes through casting

```
Person p = new Employee();
```

- When calling an object's methods through a reference variable, the implementation called is the one used by the object and not necessarily the reference variable

```
p.introduce();
```

Access Modifiers Diagram



Garbage Collection

- The ‘new’ keyword explicitly allocates resources for an object, but there is no explicit way of telling the system to ‘de-allocate’ an object
- Garbage collection is the process of automatically clearing up the memory being used by objects that will no longer be used by the program
- Invocation of the garbage collector is automatically determined by the Java Virtual Machine, depending on the need to do so
- An application can ‘suggest’ that the system initiate garbage collection using *System.gc() or Runtime.getRuntime().gc()*

Garbage Collection

- Garbage collection is used by Java to:
  - Recover resources (particularly memory) that are much needed by an application
  - Avoid dangling pointers
  - Ensure program integrity
- Dangling pointers are the occurrence of having variables or references pointing to objects in memory that are not of the appropriate type or value

Garbage Collection

- Objects are safe from garbage collection if there is at least one reference variable that refers to the object

Person him = new Person();

- Objects are eligible for garbage collection when there are no more identifiers that refer to the object

him = null;

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Java Fundamentals

Exception handling

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Introduction

- If the requirement is:
  - *Open a file*
  - *Read a line from the file*
- *What we will have to end up doing is:*
  - *Open a file*
  - *If the file doesn't exist, inform the user*
  - *If you don't have permission to use the file, inform the user*
  - *If the file isn't a text file, inform the user*
  - *Read a line from the file*
  - *If you couldn't read a line, inform the user*
  - *etc. etc..*

Introduction

- When developing applications, errors can occur due to multiple reasons:
  - Design errors or coding errors
  - Errors caused by the user of the application
  - External factors like disk, network, database, server, … failure, etc…
- It is our responsibility to produce quality code that does not fail unexpectedly
  - Consequently, we must design error handling into our programs.
- In Java, **exception handling** is the general term used for handling errors which occur during the execution of the program
- There are four important predefined classes in that part of the class hierarchy:
  - Throwable
  - Error
  - Exception & RuntimeException

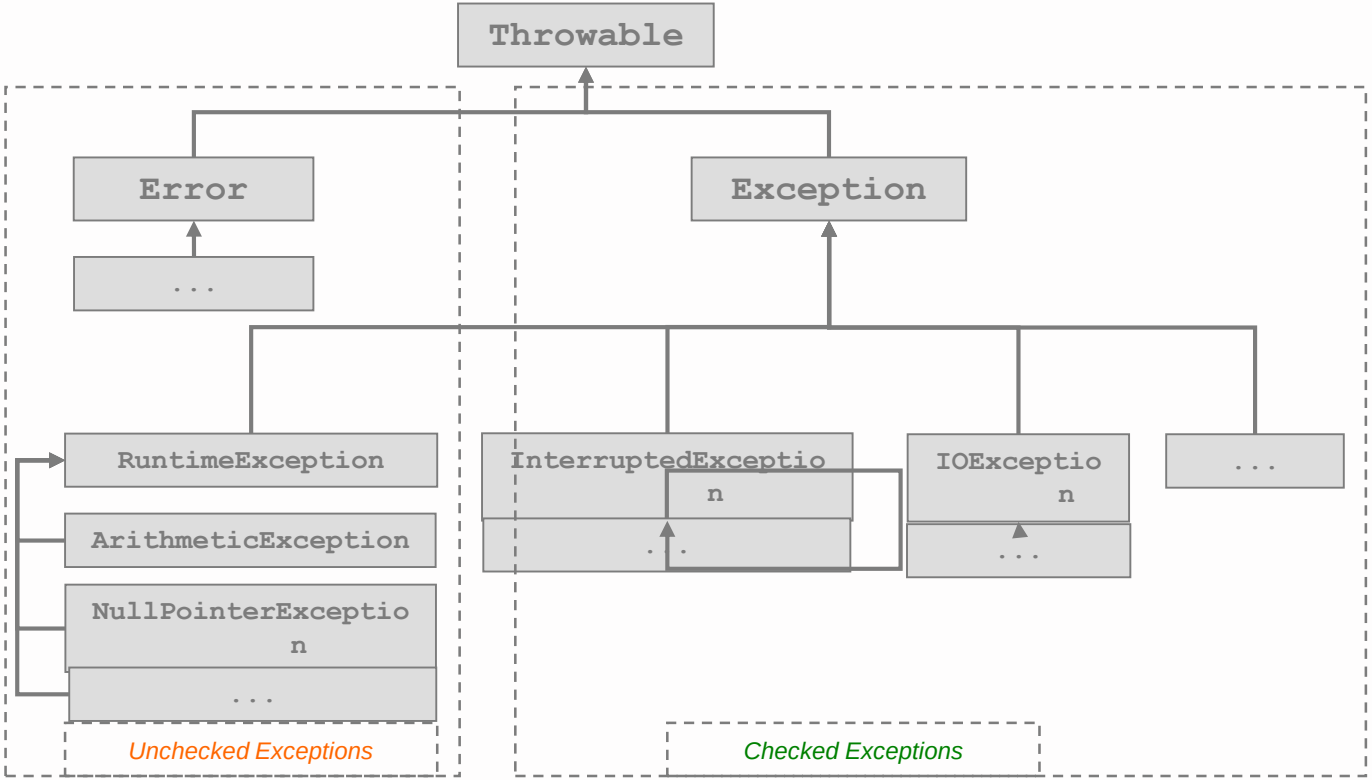
Exception Handling

- Exceptions fall into two categories:
  - Checked Exceptions
  - Unchecked Exceptions
- Checked exceptions
  - Checked exceptions are inherited from the core Java class Exception. They represent exceptions that are frequently considered “non fatal” to program execution
  - Checked exceptions must be handled in the code by default.
- Unchecked exceptions
  - Unchecked exceptions represent error conditions that are considered to be infrequent in the execution of a program
  - Unchecked exceptions need not be compulsorily be handled in the code

Errors

- Errors represent critical errors that should not occur and that the application is not expected to recover from
- Errors are typically generated from mistakes in program logic or design and should be handled through correction of design or code
- Errors are unchecked in nature similar to RuntimeException
- Examples: OutOfMemoryError, StackOverFlowError

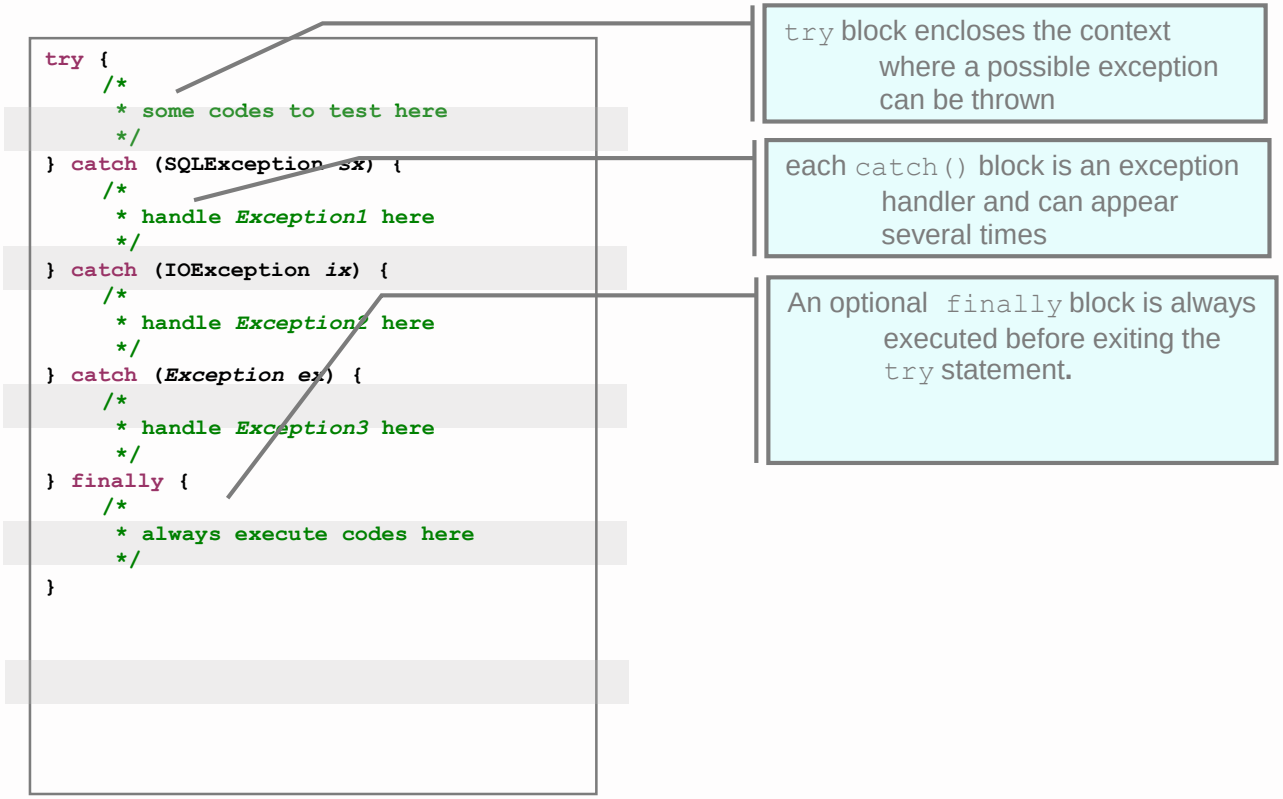
Exception Class Hierarchy



Handling Exceptions

- Exception handling mechanism is built around the *throw-and-catch* paradigm:
  - "*to throw*" means an exception has occurred
  - "*to catch*" means to deal with or handle an exception
- If an exception is not caught, it is *propagated* to the call stack until a handler is found
- Statements or methods called that declare that they might throw a checked Exception is required to be handled

Using try-catch-finally Blocks



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Java Fundamentals

Core Java API: Collections

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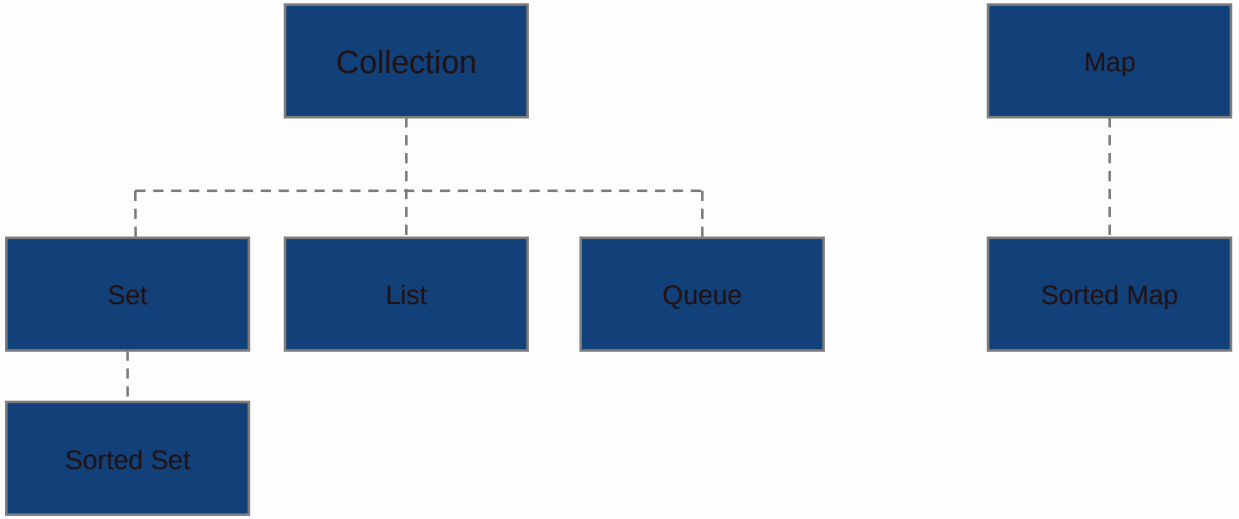
Overview of the Java Collections API

- The Java Collections API is a set of interfaces and implementations included in the Java standard library
- A Collection or a Container is an object that groups together multiple elements into a single unit
- Each collection implements different storage, retrieval and manipulate behaviors
- The API contains *Interfaces* that specifies the abstract behavior of each collection
- The API contains concrete *implementations* of the interfaces
- Each concrete implementation uses different algorithms and behavior

Overview of the Java Collections API(cont.)



Collection Interface

- Root of the collections hierarchy.
- The *Collection* interface represents general purpose behavior for the interfaces in the hierarchy
- Does not have a concrete implementation
- Used in order to obtain a general reference to any kind of Collection

Set Interface

- A Set is a Collection that does not allow duplicate entries
- A Set Has the same methods as the Collection interface
- Can contain at least 1 null element
- Commonly used implementations are HashSet, LinkedHashSet and TreeSet
- Elements in a HashSet and LinkedHashSet are not sorted
- Elements in a TreeSet are sorted

List Interface

- A List is an ordered collection of elements
- May contain duplicates
- An element's indexing is similar to arrays, with the first element in index 0
- Contains methods that allow manipulation of elements based on it's position in the sequence
- Common implementations are ArrayList and LinkedList

Queue Interface

- A Queue is a collection for holding elements typically in a First-In-First-Out order
- Has versions for a set of methods inherited from the Collections interface that return special values instead returning an exception when failing

	Throws Exception	**Returns special value**
Insert	add()	offer()
Remove	remove()	poll()
Examine	element()	peek()

Map Interface

- A Map is a collection that pairs a *key* to an element contained in the collection
- The key and the element can be any Object
- A key is assigned to an element when it is added to the map using the put(<key>, <element>)
- The key is used to retrieve an element from the Map using the get(<key>) method

Ordering

- A collection can be sorted using the Collections.sort() method
- Elements in a collection implement the *Comparable* interface which defines the sorting order
- Elements that do not implement the *Comparable* interface cannot be sorted and will throw an exception

Comparable Interface

- The *Comparable* Interface can be implemented by any class that wants to define its *natural ordering*
- Classes that implement the Comparable interface will need to define the compareTo(Object) method which defines how an instance of the class orders against the specified object
- The compareTo(Object) method should return:
  - 0 if the instance and the specified object are equal
  - A negative integer if the instance is ‘less’ than the specified object
  - A positive integer if the instance is ‘greater’ than the specified object

Comparator Interface

- The *Comparator* interface is similar to the Comparable interface except that it accepts two objects to be compared as parameters
- The *Comparator* interface can be implemented to compare two objects that are not *Comparable*
- Classes implementing the *Comparator* interface will need to override the *compare(Object A, Object B)* method to return the following:
  - 0 if A and B are equal
  - A negative number if A is ‘less’ than B
  - A positive number if A is ‘greater’ than B

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Java Fundamentals

Concurrency

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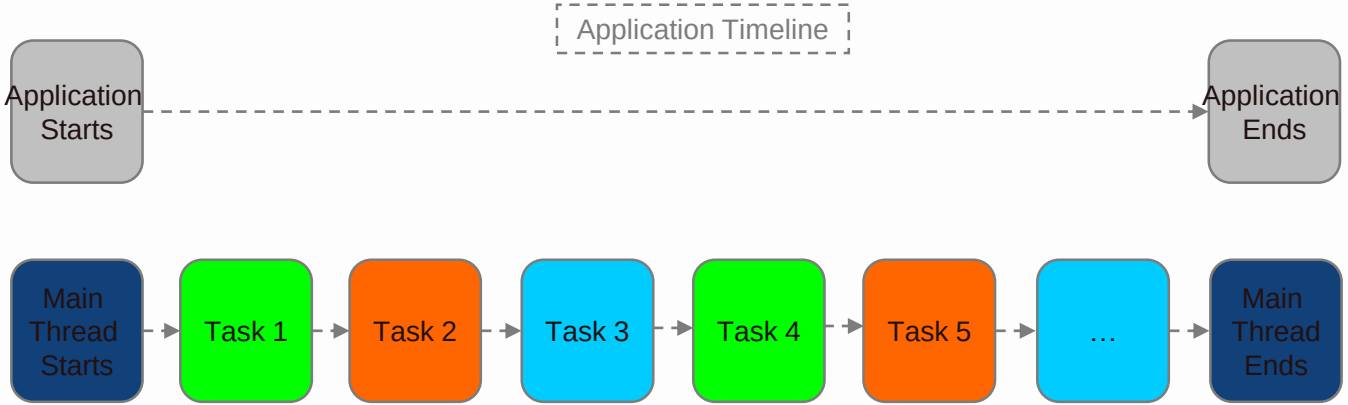
What is a Thread?

- The term *thread* is short for *thread of execution*
- A thread of execution is a sequence of instructions that is executed one after another in its own call stack
- A thread executes instructions one at a time; the thread must execute and finish the current instruction before moving on to the next one
- From a developer's perspective an application begins with 1 main thread that is usually started when the *public static void main(String[])* method is called

Single Thread Application (Diagram)

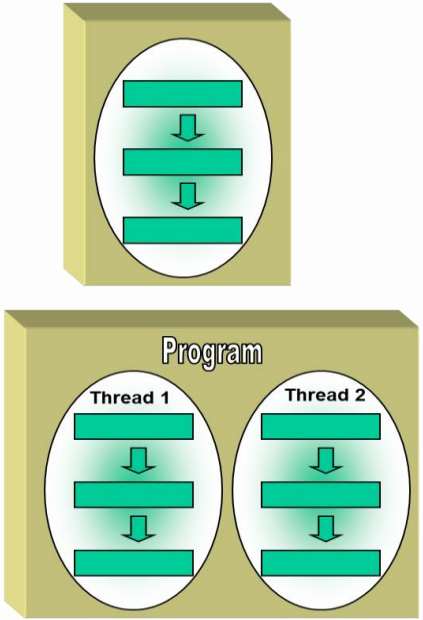
- Statements are executed one at a time in the appropriate sequence depending on program flow
- One statement must finish execution before the next statement can begin execution



Concurrency

- An application that is able to manage and coordinate multiple tasks simultaneously or pseudo-simultaneously is called a *concurrent application.*

- Concurrency allows tasks to execute without waiting for the other tasks to complete through a defined system of task switching and scheduling.

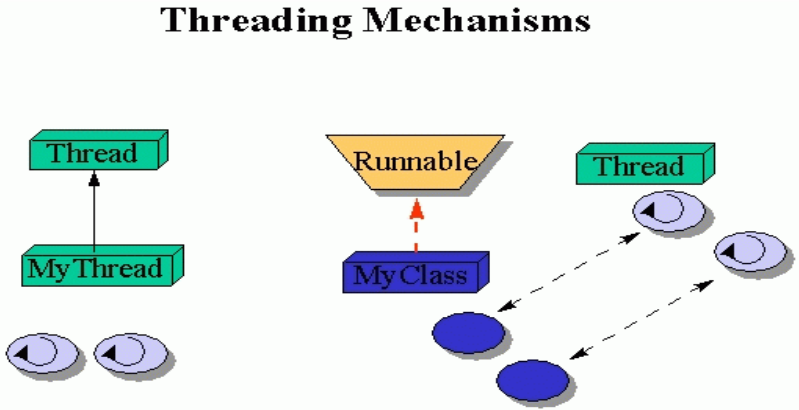


Concurrency in Java

- The most common way of implementing concurrency in a Java application is through multiple threads
- Java by nature is multithreaded as all applications have several background threads running in addition to the application code
- Each thread can create and start new threads
- The application terminates when the main thread and all application created threads finish execution
- Multiple threaded applications make use of thread switching and scheduling that allow multiple threads to make use of the system's resources
- The actual algorithm for thread scheduling depends heavily on the native operating system

Creating a Thread

- An instance of the Thread class is needed to create and execute the new thread
- The code that the thread will execute can be defined through either of the following:
  - Subclass the Thread class, override its public void run() method
  - Pass a *Runnable* object with an overridden public void run() method to a Thread object's constructor
- Call the Thread instance's *start()* method to start the thread.



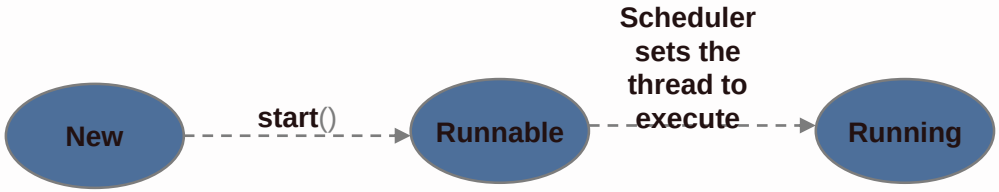
Thread Lifecycle

- When a thread is created (but not started) it is at its create state

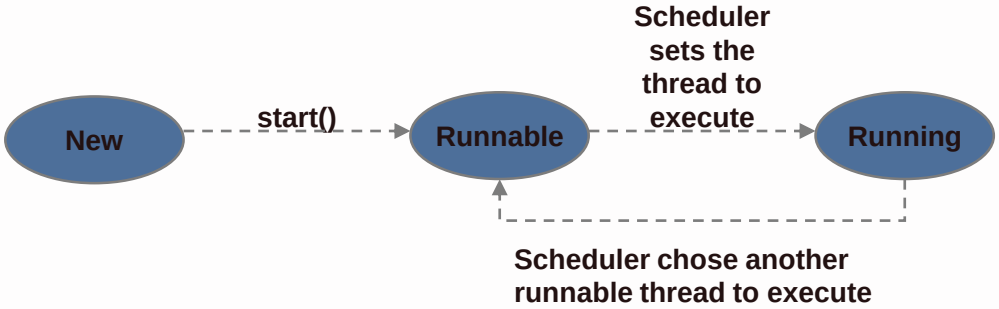
- When a thread invokes its start() method, it is now *alive* and is placed in a *runnable pool* where all living threads wait their turn to be run by the scheduler

Thread Lifecycle (cont.)

- The thread scheduler chooses a thread to execute from the threads in the pool

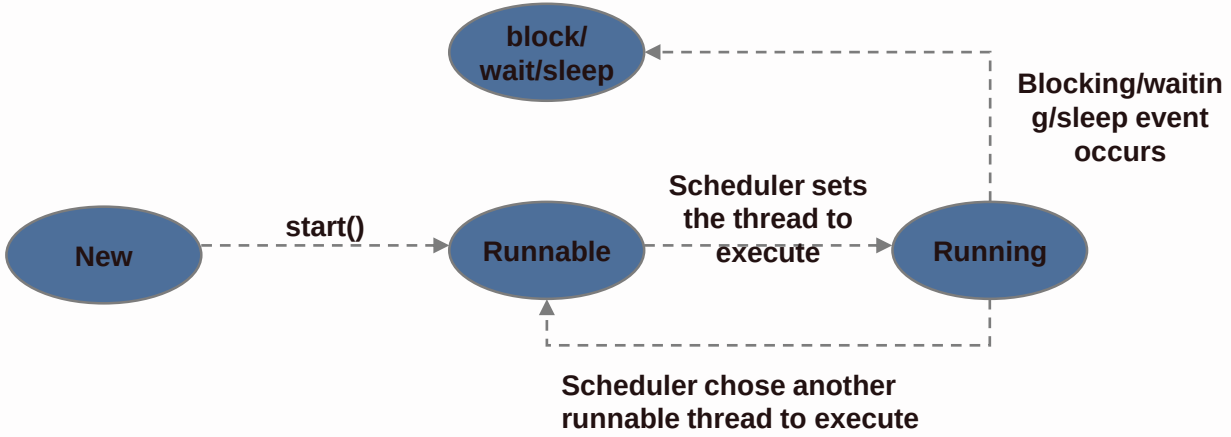


- If another thread is chosen by the scheduler to execute before it finishes, it goes back to the thread pool to await its turn again



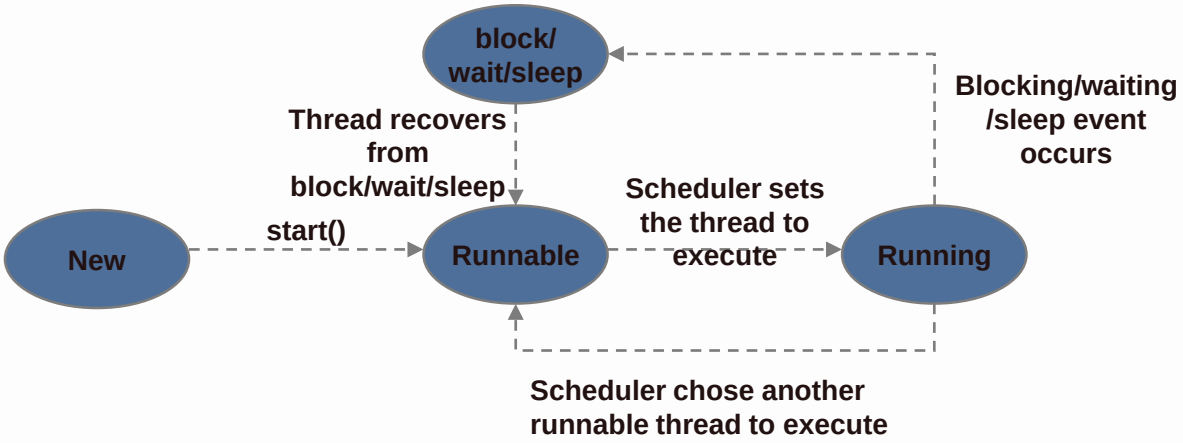
Thread Lifecycle (cont.)

- A thread may also block, wait or sleep while it was running causing it to enter a state where it is alive, but not runnable
  - blocking: thread is waiting for a resource or an event
  - waiting: thread is waiting for a signal from another thread
  - sleep: the thread pauses itself for a specified duration



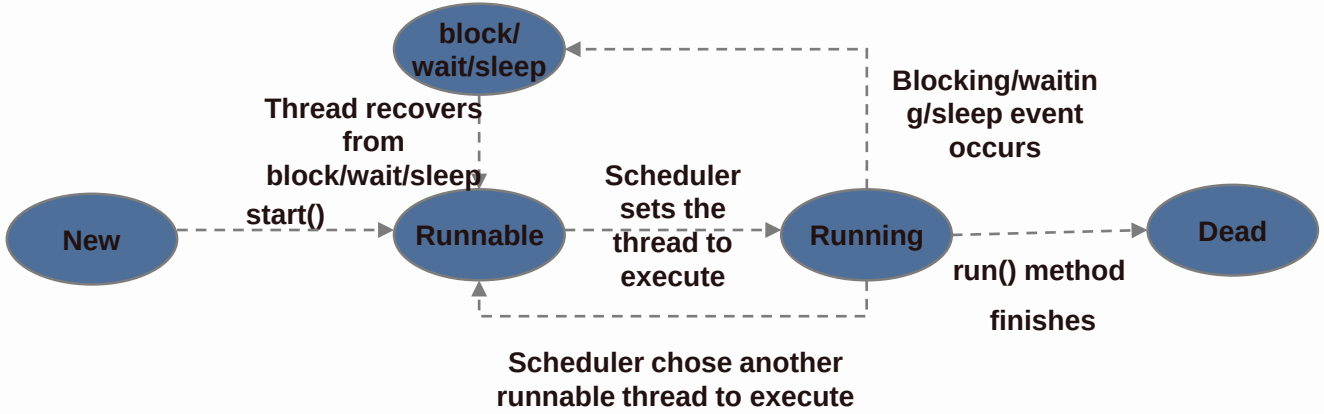
Thread Lifecycle (cont.)

- After a thread recovers from blocking, waiting or sleeping, it returns to a *Runnable* state and waits in the pool to be executed again



Thread Lifecycle (cont.)

- If the thread finishes its execution by exiting its run() method, it is now a ‘dead’ thread



Managing Threads

- Basic Concepts
- Setting Thread Priority
- Pausing Threads
- Yielding a Thread
- Joining a Thread
- Synchronizing Threads

Basic Concepts

- The application often has very little control in determining the behavior of threads
- The application can influence the behavior of threads, but it cannot have direct control
- A variety of factors are taken in by the thread scheduler in determining which threads to execute, such as:
  - Availability of a CPU resources
  - Activity or inactivity of the thread
  - Designated priority
- Application logic should never be designed to rely on predicting thread behavior
- After a thread is caused to block, wait or sleep, it returns to the *runnable* state not the *running* state, making it impossible to determine exactly when it will run again

Thread Priority

- Normally a thread with higher priority will be scheduled to run before a thread with a lower priority, but this is not always the case
- The scheduler may choose to run a lower priority thread for efficiency reasons or if the thread itself causes the scheduler to choose another thread
- Implementation of thread priority varies depending on the underlying platform, and thus should never be considered as a factor when designing application logic

Setting Thread Priority

- A Java thread inherits its default priority from the thread that created it
- A thread can set its priority by calling its *setPriority(int)* method
- Valid values are defined as integers ranging between Thread.MIN_PRIORITY and Thread.MAX_PRIORITY

Pausing a Thread

- Calling *Thread.sleep(duration)* stops the current thread from executing and places it in a state that prevents it from being chosen by the scheduler
- Putting a thread to sleep guarantees that it will not run and will not be eligible run for the specified duration
- When a thread wakes up after being put to sleep, it will be placed in a *Runnable* state, and NOT the *Running* state

Yielding a Thread

- The Thread.yield() method is intended to cause the current thread to go back to a *runnable* state, ideally allowing the scheduler to choose another thread to execute
- Yielding a thread does NOT guarantee that another thread will be chosen to run; there is still a chance that the thread that yielded will be chosen again

Joining a Thread

- A thread can be told to “join a thread at the end” by calling the join() method of another *live* thread object
- This guarantees that the *current* thread will enter a *blocked* state while the thread object it joined finishes
- After the joined thread finishes execution, the current thread returns to a *runnable* state

Thread Interference

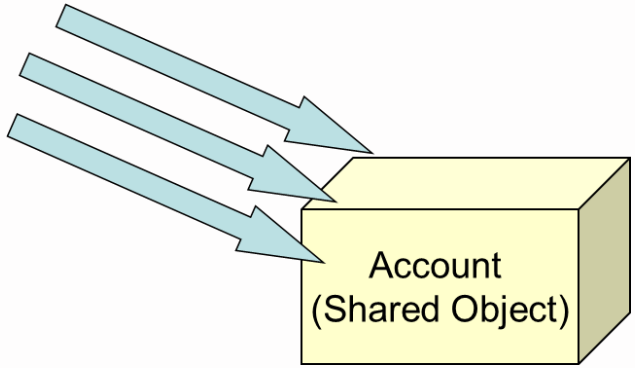
- Threads communicate and pass data to each other by accessing the fields of objects that they share
- Because of this shared nature it is possible for threads to *interfere* with each other with regards to the objects that they share
- Thread interfering with one another with regards to shared objects can result in inconsistent views on the data that they share

Synchronization and Locks

- Synchronization is one of the tools to avoid thread interference and memory consistency errors when multiple threads try to access a shared resource
- Shared Resources
  - If one thread tries to read the data and other thread tries to update the same data, it leads to inconsistent state. This can be prevented by synchronizing access to the data
- Sections of code can be synchronized so that only one thread at a time can execute that section of code
- Synchronization relies on the concept of a ‘lock’ that a Thread has to acquire before being allowed to execute a section of code
- When a thread invokes a synchronized method, it automatically acquires the Intrinsic Lock for that method’s object and releases it when the method returns

Example of multiple threads sharing the same object

```
class  InternetBankingSystem
{
        public static void main (String args[])
        {
                Account accountObject = new Account();
                MyThread t1 = new MtThread(accountObject);
                MyThread t2 = new MtThread(accountObject);
                MyThread t3 = new MtThread(accountObject);
                t1.start();
                t2.start();
                t2.start();
                // some more operations
        } //end main
    } // end class MyThread
```



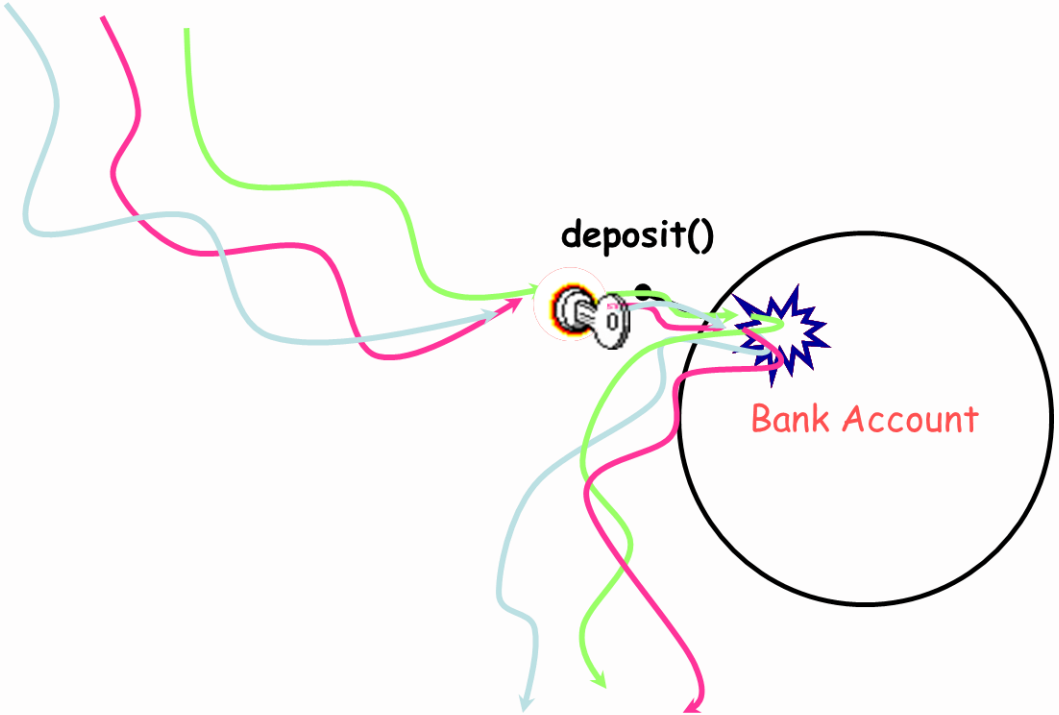
synchronized keyword

```
class  Account {
        float balance;

        // if 'synchronized' is removed, the outcome is unpredictable
        public synchronized void deposit (float amt) {
                balance +=amt;
        }

        public synchronized void withdraw (float amt) {
                if (condition)
                {
                        //some operations
                        balance -=amt;
                }
        }
}
```

Cont'd…



Coordinating Threads

- Threads will often need to coordinate with one another to accomplish their tasks
- One of the more common coordination scenarios is a thread that needs to finish a section of code before another thread can proceed
- One way to accomplish this coordination is by making the dependent thread ‘wait’ until it has been ‘notified’ by the other thread that it can proceed
- Objects have a wait/notify mechanism that allows threads to coordinate with each other
- The wait() method of an object tells the current thread acting on the object to block
- The thread waiting on the object will continue once the object’s notify() method has been executed by another thread
- The wait() and notify() methods of an object can only be executed by a thread that has exclusive lock on the object

About Explicit Locks

- To address the limitations of Intrinsic Locks, Explicit locks from Java 5 onwards can be implemented to provide more flexibility

- Features of Explicit Locks:
  - Ability to interrupt a thread waiting for a specific lock
  - A thread can give a timeout value for attempting to acquire the lock
  - Read/write locks are supported– multiple threads can hold a lock simultaneously for read only access.
  - The traditional wait/notify metaphor is extended to allow conditions
  - Support for fairness by following the first-in-first-out order if more than one thread is waiting for a lock
  - The ability to lock beyond the scope of a block: for example, one method can pass a lock object to another thread
  - Ability to query the status and properties of a specific lock programmatically (i.e., number of threads waiting to acquire the lock)

Thread Synchronization revisited

- When multiple threads share an object and that object is modified by one or more of the threads, indeterminate results may occur
- The problem can be solved by giving one thread at a time exclusive access to code that manipulates the shared object. During that time, other threads desiring to manipulate the object are kept waiting. When the thread with exclusive access to the object finishes manipulating it, one of the threads that was kept waiting is allowed to proceed. In this fashion, each thread accessing the shared object excludes all other threads from doing so simultaneously. This is called **mutual exclusion**
- Java uses locks to perform synchronization. Any object can contain an object that implements the **Lock** interface (package java.util.concurrent.locks)
  - **ReentrantLock, ReentrantReadWriteLock** are the commonly used class from this package
- Also new techniques were introduced like **Semaphore, CountdownLatch, CyclicBarrier,** etc… provide new techniques for managing synchronization issues in our code

ArrayBlockingQueue

- Java 5 includes a fully-implemented circular buffer class named **ArrayBlockingQueue** in package java.util.concurrent, which implements the **BlockingQueue** interface
- The BlockingQueue interface implements the Queue interface and declares methods **put** and **take**, the blocking equivalents of Queue methods offer and poll, respectively
- Method **put** will place an element at the end of the BlockingQueue, waiting if the queue is full
- Method **take** will remove an element from the head of the BlockingQueue, waiting if the queue is empty
- Class ArrayBlockingQueue implements the BlockingQueue interface using an array. This makes the data structure fixed size, meaning that it will not expand to accommodate extra elements

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Java Fundamentals

Core Java API: I/O

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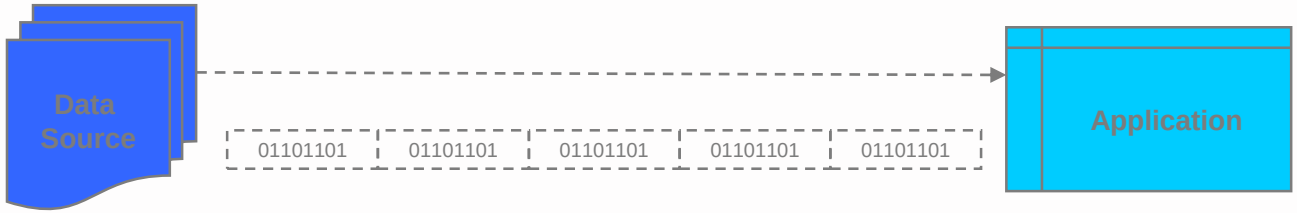
I/O Streams

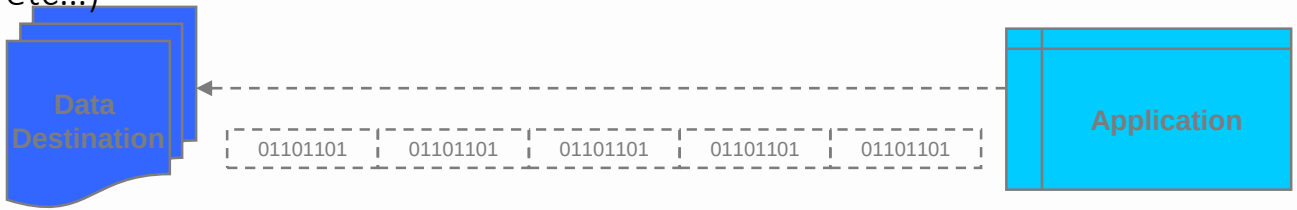
- The standard **java.io package**, is defined in terms of *streams*
- Streams are ordered sequences of data that have a
  - source (input stream), or
  - destination (output stream)
- Sending data from the application to a data destination is called *writing* to a stream
- Retrieving data from a data source is called *reading* from a stream
- Streams should be ‘opened’ for reading, then ‘closed’ after

I/O Streams (cont.)

- Reading from a data source (can be a file, a socket, a database, keyboard etc…)



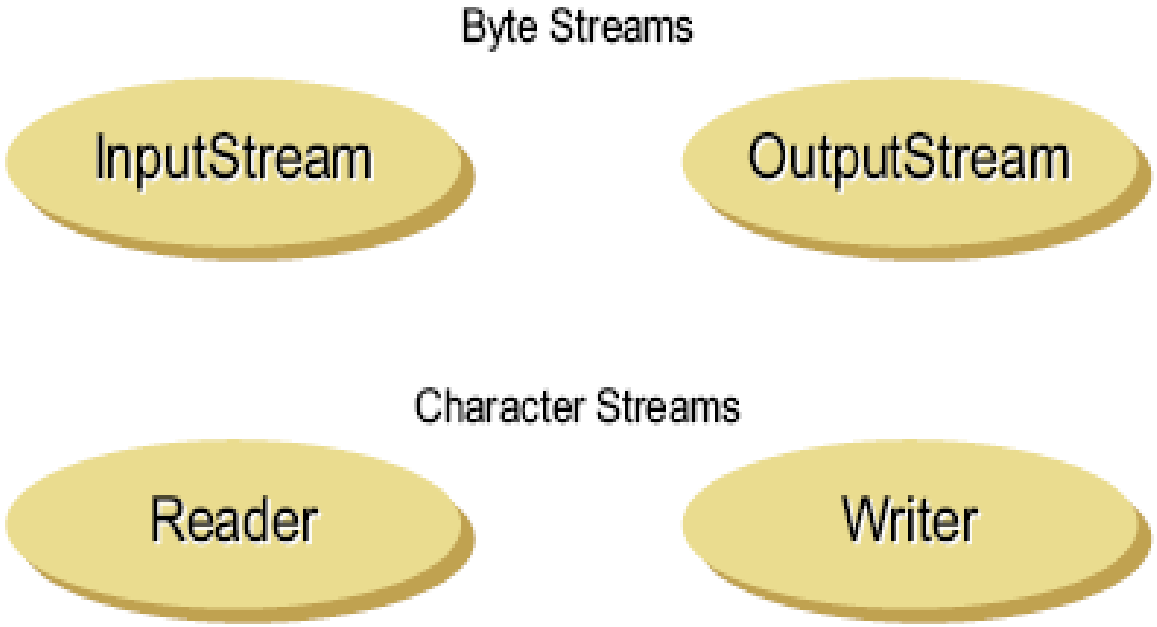
- Writing to a data destination (can be a file, a socket, a printer, a monitor etc…)



Java I/O Package (cont.)

- The central classes in the package are Abstract **InputStream** and **OutputStream,** which are base classes for reading from and writing to byte streams, respectively
- Abstract **Reader** and **Writer** classes serve as base classes for various specialized stream subclasses that deals with characters
- The package also has a few miscellaneous classes to support interactions with the host **file system**

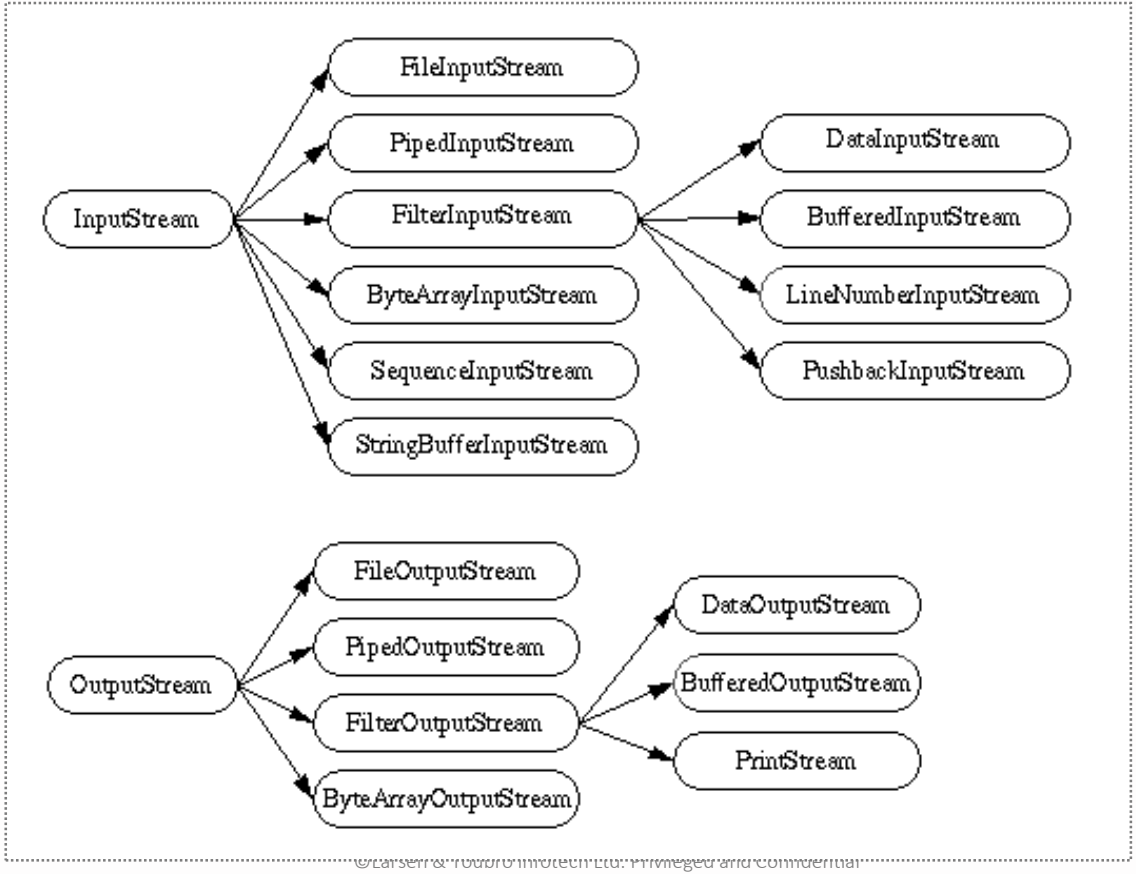
Streams



Streams

- 2 kinds
  - character streams
    - Read and write 16-bit Unicode characters
    - Reader and Writer
    - Should be used for reading/writing text information
  - byte streams Read and write 8-bit (= 1 byte) characters
    - InputStream and OutputStream
    - Should be used for reading/writing images or sound files
    - Used for Object serialization

Java I/O Package (cont.)



Console IO

- These are the statements for displaying simple text messages to the user

System.out.print(...)

System.out.println(...)

- The **System.out** object is an instance of the **PrintStream** class, which is a type of output stream used for outputting characters
- The **System.in** object is an instance of an **InputStream** class, which allows reading of raw bytes from a data source

Reading from the Keyboard

- The **System.in** object is already created, open, and ready for use
- System.in is an instance of *InputStream* and will read keyboard entries as individual bytes
- Wrapping System.in with an instance of *InputStreamReader* allows us to read the entries as *characters*
- Wrapping the *InputStreamReader* with a *BufferedReader* to allow the reading and buffering of multiple characters and lines of text

File IO

- Objects of type File are used to represent the actual files (but not the data in the files) or directories that exist on a computer's physical disk

  *File thisFile = **new** File(“sample.txt");*

- *FileReader* and *FileWriter* classes can be used to wrap File objects for reading and writing
- BufferedWriter can be used to write lines of characters to a file

  *Writer output = **new** BufferedWriter(**new** FileWriter(“sample.txt”));*

Serialization

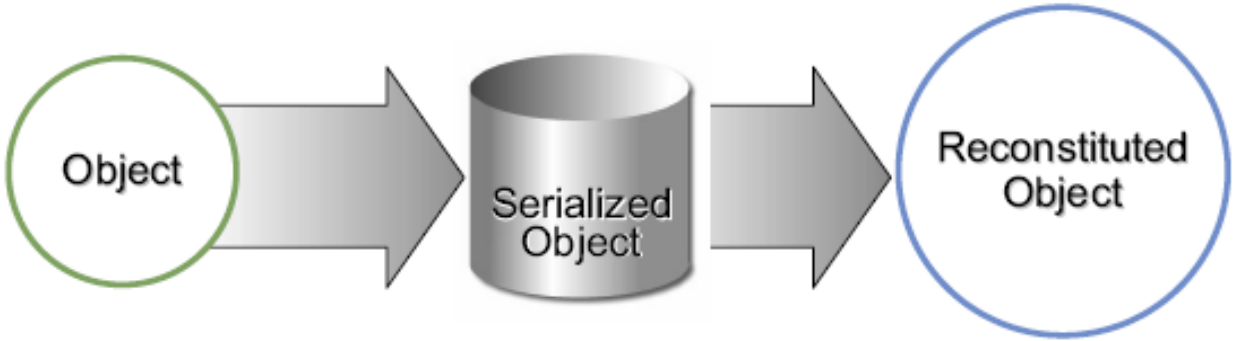
- Serialization allows instances of an object to be represented as a stream, which can then be written to a data source/destination
- The interface *Serializable* needs to be implemented by any class whose instances are allowed to be serialized
- The field modifier ‘transient’ is used to mark class members that should NOT be serialized along with the other state attributes of the object

Serialization

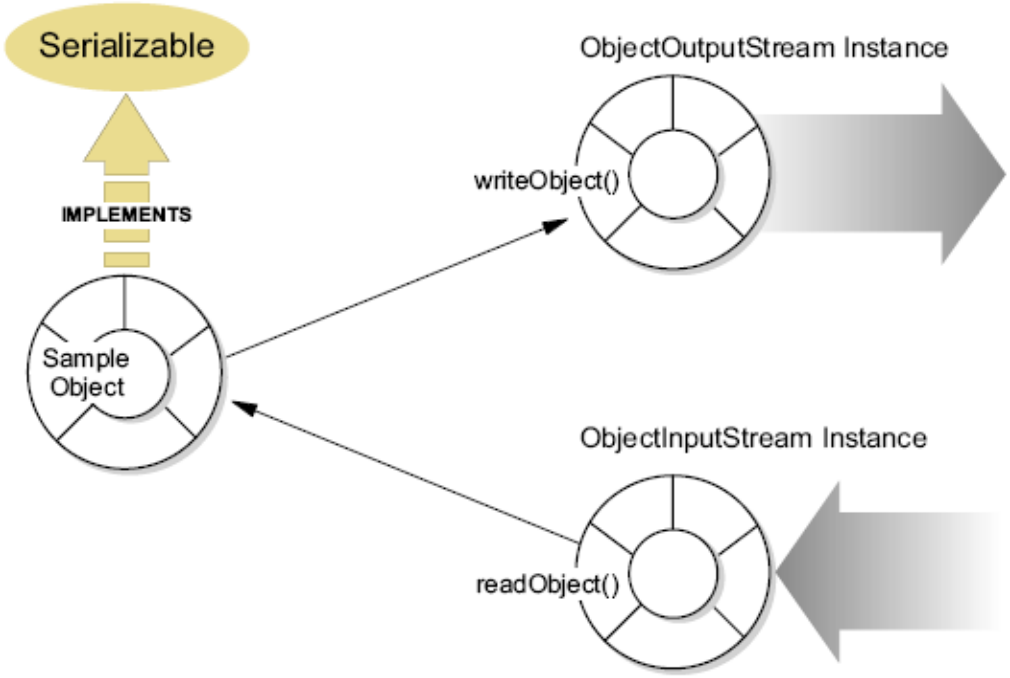
Serialization provides a standard way to save and restore object graphs between sessions on the same or different systems.

Serialization saves the following:

- Object type
- Internal information
- References to other objects



Marking an Object for Serialization



Serialization (cont.)

- To write an object to a stream, use an instance of the *ObjectOutputStream* class and chain it to an output stream destination

```
ObjectOutputStream out = new ObjectOutputStream(new FileOutputStream(target));

out.writeObject(aSerializableObject);
```

- To read a serialized object, use an instance of an *ObjectInputStream* class chained to an input stream from a data source.

```
ObjectInputStream in = new ObjectInputStream(new FileInputStream(target));

Object savedObject = in.readObject();
```

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Java Fundamentals

Core Java API: JDBC

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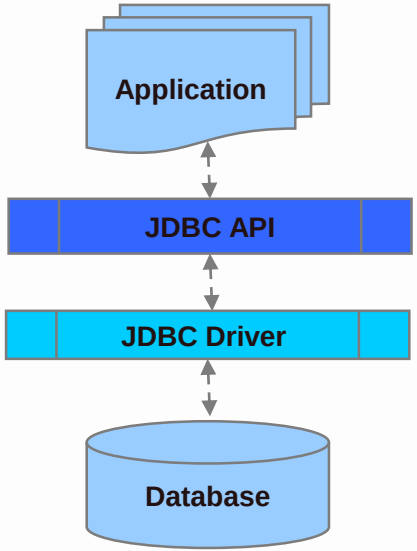
JDBC Overview

- JDBC (Java Database Connectivity) is the Java industry standard for database-independent connectivity between the Java language and other databases
- JDBC provides a comprehensive API that provides the application the ability to connect to databases, send SQL statements, and process results

Database Drivers

- Database Drivers or JDBC Drivers are required to connect to different databases. The JDBC requires different drivers for each database
- JDBC drivers provide the connection to the database and implement the protocol necessary for sending queries and retrieving results

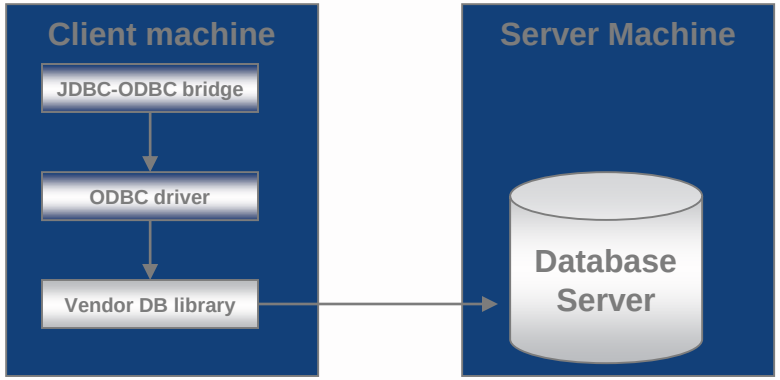


Database Drivers Types

- Type 1 JDBC-ODBC Bridge + ODBC Driver
- Type 2 Native API / Partly Java technology-enabled driver
- Type 3 Pure Java Driver for Database Middleware
- Type 4 Direct to Database Pure Java Driver

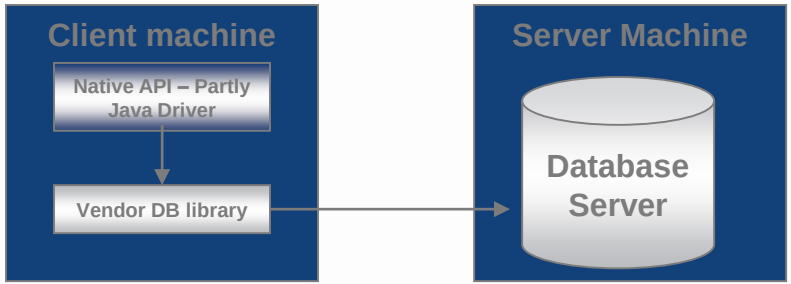
Type 1 Driver

- JDBC – ODBC Bridge
  - Translates all JDBC calls into ODBC (Open Database Connectivity)
- Need to have ODBC client installed on the machine



Type 2 Driver

- Native-API/Partly Java driver
  - Converts JDBC calls into db-specific calls
  - Communicates directly with the db server
  - Requires some binary code be present on the client machine.
  - Better performance than type 1 driver

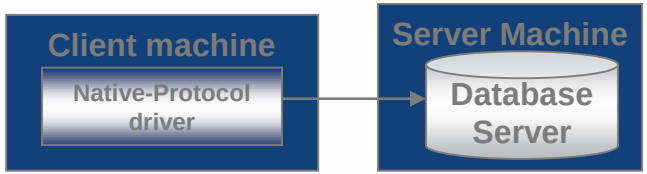


Type 3 Driver

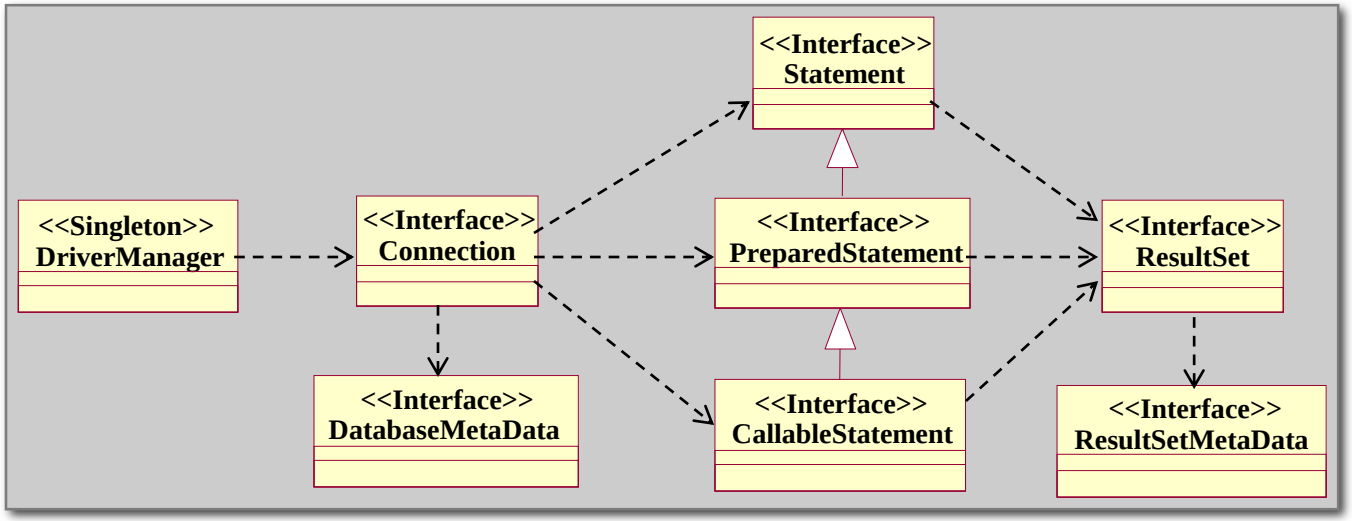
- Net-protocol – 100% Java driver
- Follows a three-tiered approach
  - JDBC database requests passed to the middle-tier server
  - Middle-tier server translates the request to the database-specific native-connectivity interface
    - May use a type 1 or type 2 JDBC driver
  - Request forwarded to the database server

Type 4 Driver

- Native protocol - 100% Java
- Converts JDBC calls into the vendor-specific DBMS protocol
- Client applications communicate directly with the database server
- Best performance
- Need a different driver for each database



JDBC API



Retrieving a Connection Object

- A **`Connection`** object defines a connection or session with a specific database.
- It is where SQL statements are executed and results are returned.
- Before a **`Connection`** object can be used, the **`java.sql.Connection`** class has to be imported first.

Retrieving a Connection Object (cont.)

- A database driver can be loaded by using the **`Class.forName()`** method

Syntax : *Class.forName("JDBCDriver_Name");*

Example : *Class.forName("oracle.jdbc.driver.OracleDriver");*

- A **`Connection`** object has three (3) important parts:
  - The URL or location of the data source
  - The username
  - The password

Retrieving a Connection Object (cont.)

- A connection can be established by using the **`getConnection()`** method
- Creating a connection by using the URL, username and password as parameters

```
Connection  myConnection = DriverManager.getConnection ( URL, username, password );
```

- Creating a connection by using the URL; In this case, the URL already includes the username and password

```
Connection  myConnection = DriverManager.getConnection ( URL );
```

Creating Query Statements

- A **`Statement`** is the message that the JDBC sends to the data source to either manipulate or request data from the data source
- Before a **`Statement`** object can be used, the **`java.sql.Statement`** class has to be imported first

Creating Query Statements (cont.)

- A **`Statement`** is created by using the following syntax:

Syntax : *Statement <identifier> = <Connection_Object>.createStatement();*

Sample : *Connection myConn = DriverManager.getConnection(…);*

Statement myStatement = myConn.createStatement();

- A **`Statement`** needs to use a **`Connection`** object to identify which connection the statement will be associated with

Creating Query Statements (cont.)

- A **`Statement`** can be executed by using either the **`execute()`**, **`executeQuery()`** and **`executeUpdate()`** methods

Syntax : *<Statement_Object>.executeQuery("SQL Statement goes here");*

Sample :

```
Connection myConn = DriverManager.getConnection(…);
Statement myStatement = myConn.createStatement();
myStatement.executeQuery("Select * from aTable");
```

Creating Query Statements

- After a **`Statement`** has been executed, it returns different kinds of data depending on the type of execute used
- **`execute()`** returns a **`boolean`** value and is used to execute SQL statements written as a **`String`** object
- **`executeUpdate()`** returns an **`int`** value pertaining to the number of rows affected and is used to execute DDL SQL statements
- **`executeQuery()`** returns a **`ResultSet`** object and is used to execute SELECT SQL statements

Transactions

- Transaction management is vital for operations that modify or update the records in the database
- Transaction management allows the application to confirm the execution of a group of SQL statements by ‘committing’ the changes
- Should an exception occur, the transaction can be ‘rolled-back’ to undo the changes that were made
- Setting the *Connection.setAutoCommit()* method of the Connection object to *false* will prevent the statements from being committed until an explicit *Connection.commit*() is executed by the application
- The *Connection.rollback()* method can be executed should an event occur requiring the changes made so far to be undone

Using PreparedStatement

- **`PreparedStatement`** is a Java object, which represents a precompiled SQL statement
- **`PreparedStatement`** is usually used for SQL statements that take parameters, although it can also execute SQL statements that have no parameters
- Before a Statement object can be used, the **`java.sql.PreparedStatement`** class has to be imported first

Using PreparedStatement (cont.)

- A **`PreparedStatement`** is useful when an SQL statement has to be executed multiple times
- A **`PreparedStatement`** is precompiled, hence it is immediately executed by the DBMS, unlike **`Statement,`** which has to be compiled first

Syntax :

PreparedStatement <identifier> = <connection>.prepareStatement("<SQL Statement goes here>");

Example :

Connection myConn = DriverManager.getConnection(…);

*PreparedStatement pStmt = myConn.prepareStatement("Select * from Dogs Where breed = ?");*

Using PreparedStatement (cont.)

- The question mark (?) serves as a wildcard or parameter and can be replaced with a value

- The wildcard can be replaced by using the appropriate methods for a particular data type, including but not limited to:
  - setString()
  - setInt()
  - setDouble()
  - setDate()
  - …

Java 6 JDBC 4.0 features

- Auto-loading of JDBC driver class
- Connection management enhancements
- Support for RowId SQL type
- DataSet implementation of SQL using Annotations
- SQL exception handling enhancements
- SQL XML support
- There are also other features such as improved support for large objects (BLOB/CLOB) and National Character Set Support.

Auto-Loading of JDBC Driver

- In JDBC 4.0, we no longer need to explicitly load JDBC drivers using Class.forName()
- When the method getConnection is called, the DriverManager will attempt to locate a suitable driver from among the JDBC drivers that were loaded at initialization and those loaded explicitly using the same class loader as the current application
- The DriverManager methods getConnection and getDrivers have been enhanced to support the Java SE Service Provider mechanism (SPM)
- According to SPM, a service is defined as a well-known set of interfaces and abstract classes, and a service provider is a specific implementation of a service. It also specifies that the service provider configuration files are stored in the META-INF/services directory

Auto-Loading of JDBC Driver (Cont'd…)

- JDBC 4.0 drivers must include the file

  META-INF/services/java.sql.Driver

  This file contains the name of the JDBC driver's implementation of java.sql.Driver

  For example, to load the JDBC driver to connect to a Apache Derby database, the META-INF/services/java.sql.Driver file would contain the following entry:

  org.apache.derby.jdbc.EmbeddedDriver

Connection Management

- Prior to JDBC 4.0, we relied on the JDBC URL to define a data source connection
- Now with JDBC 4.0, we can get a connection to any data source by simply supplying a set of parameters (such as host name and port number) to a standard connection factory mechanism
- New methods were added to Connection and Statement interfaces to permit improved connection state tracking and greater flexibility when managing Statement objects in pool environments

RowId Support

- The RowID interface was added to JDBC 4.0 to support the ROWID data type which is supported by databases such as Oracle and DB2
- RowId is useful in cases where there are multiple records that don't have a unique identifier column and you need to store the query output in a Collection (such Hashtable) that doesn't allow duplicates
- We can use ResultSet's getRowId() method to get a RowId and PreparedStatement's setRowId() method to use the RowId in a query
- It shouldn't be shared between different Connection and ResultSet objects

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Java Fundamentals

Unit Testing

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Introduction to JUnit

- Testing is the process of checking the functionality of the application whether it is working as per requirement shared
- Junit is the DeFacto framework for developing unit test in Java
- Promotes the idea of "first testing then coding”
- Unit testing is the testing of single entity (class or method)
- A Unit Test Case is a part of code which ensures that the another part of code (method) works as expected
- There must be at least two test cases for each requirement: one positive test and one negative test

JUnit

- JUnit tests
  - “substitute the use of main() to check the program behavior”
  - All we need to do is write methods annotated with @Test annotation for writing various test cases

```
import org.junit.*;
import static org.junit.Assert.*;

public class name {
    ...

    @Test
    public void name() {   // a test case method
        ...
    }
}
```

JUnit assertion methods

`assertTrue(`**test**`)`	fails if the boolean test is `false`
`assertFalse(`**test**`)`	fails if the boolean test is `true`
`assertEquals(`**expected**`, `**actual**`)`	fails if the values are not equal
`assertSame(`**expected**`, `**actual**`)`	fails if the values are not the same (by ==)
`assertNotSame(`**expected**`, `**actual**`)`	fails if the values *are* the same (by ==)
`assertNull(`**value**`)`	fails if the given value is *not* `null`
`assertNotNull(`**value**`)`	fails if the given value is `null`
`fail()`	causes current test to immediately fail

- Each method can also be passed a string to display if it fails:
  - e.g. `assertEquals("message", expected, actual)`
  - Why is there no `pass` method?

ArrayIntList JUnit test

```
import org.junit.*;
import static org.junit.Assert.*;

public class TestArrayIntList {
    @Test
    public void testAddGet1() {
        ArrayIntList list = new ArrayIntList();
        list.add(42);
        list.add(-3);
        list.add(15);
        assertEquals(42, list.get(0));
        assertEquals(-3, list.get(1));
        assertEquals(15, list.get(2));
    }

    @Test
    public void testIsEmpty() {
        ArrayIntList list = new ArrayIntList();
        assertTrue(list.isEmpty());
        list.add(123);
        assertFalse(list.isEmpty());
        list.remove(0);
        assertTrue(list.isEmpty());
    }
    ...
```

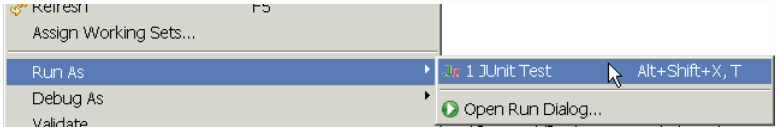
Running a test

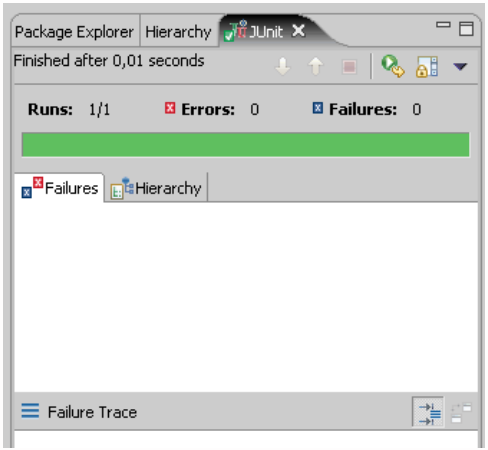
- Right click it in the Eclipse Package Explorer at left; choose:

  Run As → JUnit Test

- The JUnit bar will show green if all tests pass, red if any fail.

- The Failure Trace shows which tests failed, if any, and why.





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Java Fundamentals

Reflection API

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Introduction

- Reflection is commonly used by programs which require the ability to examine or modify the runtime behavior of applications running in the Java virtual machine. Reflection API can be used for different purposes:
  - Examining classes and objects
    - One can use Reflection API to collect metadata about an Object/Class at the runtime. For ex: in eclipse, when we use the contentassist feature, it shows all possible options dynamically.
  - Manipulating classes and objects
    - One can use Reflection API to dynamically instantiate objects, access fields, invoke methods, manipulate arrays, etc.. For ex: a WebServer like Tomcat uses Reflection API to dynamically execute the service() method of the corresponding servlet based on the
    - URL submitted at the runtime

java.lang.Class class

- Class instance is the entry point in the Reflection API
- For every type of object, the Java virtual machine instantiates an immutable instance of java.lang.Class which provides methods to examine runtime properties of the object including its members and type information
- To get a hold of the Class of an object, we can use any of these different approach:
  - Class c = obj.getClass();
  - Class c = String.class;
  - Class c = Class.forName("java.lang.String");
  - Class c = int.class; //for using primitives in Reflection API

Collecting information

- After we get hold of a Class instance, we can now start introspecting the target class by using the different methods provided by Class class:
  - Method[] methods = c.getMethods();
  - Constructor[] constructors = c.getConstructors();
  - Field[] fields = c.getFields();
- Similarly many other methods are available to collect information about the package, parent class, implemented interfaces and annotations used

Invoking methods dynamically

```
class Calculator {
public int add(int x, int y) {
return x + y;
}
}

Class calc = Calculator.class;
Object calcObj = calc.newInstance();
Method addMethod =
calc.getMethod("add", int.class, int.class);
Object retValue = addMethod.invoke(calcObj, 10, 20);
System.out.println(retValue);
```

- This is one of the most important feature of Reflection API, the power to invoke operations dynamically. We can invoke constructors, access fields, invoke methods, dynamically

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Java Fundamentals

Important Language Features

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Inner and Anonymous Classes

- An inner class is a class declared within another class and can be assigned an access modifier just like other class fields
- An inner class has private access to the other fields of a class
- There are two additional types of inner classes:
  - *local inner class* – an inner class within the body of a method
  - *anonymous inner classes* – an inner class within the body of a method without naming it

Generics Overview

- *Generics* allow classes or methods to declare during compile time what type of objects they are meant to work with without having the class/method definition
- Generics is one way of avoiding lengthy type casts in order to convert objects form one class to another

Generics Overview (Cont'd…)

- The class below declares that the <E> can be parameterized by a class type during instantiation

```
public class GenericSample <E>{
    private E field;
    public void setValue(E arg){
                        this.field =arg;
    }
    public E getValue(){
                        return field;
    }
}
```

- The following instantiates the class parameterized with a String

```
GenericSample<String> g1 = new GenericSample<String>();
```

Generics Overview (Cont'd…)

- That particular instance will be created as if *GenericSample* had *String* in all places where *E* was placed
- Many collections have been updated to take advantage of generics instead of using the generic *Object* class

```
List<String> stringList =  new ArrayList<String>;

stringList.add("Hello");

stringList.add(new Integer(1)); //Illegal now with generics, but previously legal without using generics
```

Bounded Type Parameters

- Wildcard notations can be used to indicate the boundaries in a class hierarchy
- The notation <*E* extends *Class Type*> indicates that type is a subclass of *Class Type*

```
//Allows only sublasses of "Number" to be passed
public class GenericSample <E extends Number>{
   private E field;
   public void setValue(E arg){
                        this.field =arg;
   }
   public E getValue(){
                        return field;
   }
}
```

WildCards

- The notation ? can be used to indicate an unknown class. This is similar to using *Object* as a parameter
- The notation <? *extends ClassType*> indicates a type that is a subclass of *ClassType*
- The notation <? super *ClassType*> indicates a type that is are parent classes of *ClassType*

Enhanced For-Loop

- *Enhanced For-Loop* reduces the need for iterators when going through an array or a collection
- It allows you to iterate through a collection without having to create an Iterator or without having to calculate beginning and end conditions for a counter variable

```
int[] sqr = {0,1,4,9,16,25};
    for (int i : sqr) {
      System.out.printf(ii);
    }
  }
```

Autoboxing

- *Autoboxing* eliminates the drudgery of manual conversion between primitive types (such as int) and wrapper types (such as Integer).
- Any primitive variable can accept an instance whose type is the corresponding primitive wrapper.
- Any primitive wrapper reference variable can accept the corresponding primitive value as a value;

```
Float f = 9.9f;
int i = new Integer(99); //unboxing
Integer y = 20; //boxing
```

Variable Arguments (Varargs)

- Variable arguments allow methods to take in multiple arguments of the same type without specifying the number of arguments during runtime

```
public void listNames(String… names) {
        for (String i : names) {
        System.out.println(i);
        }
}
```

- The method will be able to accept a series of Strings as a parameters that will be converted into an array

Typesafe Enums

- An *enum type* is a type whose *fields* consist of a fixed set of constants
- The most simple use is to list a series of constants and contained by an *enum* type
- *enum Seasons{*

SPRING, SUMMER, FALL, WINTER

}

```
for(Seasons s : Seasons.values()){
   System.out.println(s);
}
```

Typesafe Enums (cont.)

- An *enum* class is a full-fledged class that can be given fields and behaviors just like any other class.
- The constants declared can be initialized through a private or default constructor.

```
public enum EnumSample {
   ONE(1),TWO(2),THREE(3),FOUR(4);
    private int x;

   private EnumSample(int x){
                        this.x = x;
   }

   public int getX(){
                        return x;
   }
}
```

Static Imports

- A *static import* declaration enables programmers to refer to imported static members as if they were declared in the class that uses them
- A *static import* declaration has two forms:
  - Single static import - imports a particular static member
  - Static import on demand – imports all static members of a class

Annotations

- *Annotations* provide data about a program that is not part of the program itself
- Annotations can be used to pass information to the compiler about the source code
- Various software tools can use annotations to generate additional information, resources, or code based on the annotation

Annotations Syntax

- Annotations are marked by the '@' symbol and by convention belong in their own line

  @Override

- Annotations can be given a single 'value'

  @SuppressWarnings("unchecked")

  @SuppressWarnings(value = "unchecked")

- Annotations can be given multiple named-value pairs

  @Author(

  name = "John Doe",

  date = "7/23/2008"

)

Compiler Annotations

- @Override
  - Indicates that the annotated method is required to override a method from its parent class
  - The compiler will generate errors when the superclass method being annotated is not overridden
- @Deprecated
  - Marks a certain target element, like a method, as deprecated or outdated
  - The compiler will generate warnings when source code that calls deprecated methods is compiled
- @SuppressWarnings
  - Used to tell the compiler to ignore warnings like ‘deprecation’

Defining Annotations

- Custom annotations are similar to declaring a class/interface source
- Custom annotations are defined by using the ‘@’ symbol followed by the *interface* keyword
- These can be accessed by the source code using imports just like any other class or interface

Defining Annotations (cont.)

- Many annotations have no elements except the annotation name itself

```
public @interface MyAnnotation{}
```

- Single element annotation possess a single element

```
public @interface MyAnnotation{
        String myStringValue();
}
```

- Multi-value annotations can have multiple elements

```
public @interface MyAnnotation{
        String myStringValue();
        int myIntValue();
```

Defining Annotations (Cont'd...)

- Method declarations should not have any parameters
- Method declarations should not have any throws clauses
- Return types are limited to the following:
  - Primitives
  - String
  - Class
  - Enum
  - Array of the above types

Defining Annotations (Cont'd…)

- @Target – Defines what elements an annotation can be applied to:
  - @Target(ElementType.TYPE)—can be applied to a class or interface
  - @Target(ElementType.FIELD)—can be applied to a field or property
  - @Target(ElementType.METHOD)—can be applied to a method level annotation
  - @Target(ElementType.PARAMETER)—can be applied to the parameters of a method
  - @Target(ElementType.CONSTRUCTOR)—can be applied to constructors
  - @Target(ElementType.LOCAL_VARIABLE)—can be applied to local variables
  - @Target(ElementType.ANNOTATION_TYPE)—indicates that the declared type itself is an annotation type
- @Retention – Defines how long an annotation is maintained
  - RetentionPolicy.SOURCE: source level and will be ignored by the compiler
  - RetentionPolicy.CLASS: retained by the compiler at compile time, but ignored by the VM
  - RetentionPolicy.RUNTIME: retained by the VM so they can be read only at run-time


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