



# Institute of Aeronautical Engineering (Autonomous) Dundigal, Hyderabad

## Department of Electronics And Communication Engineering

### PPT on JAVA PROGRAMMING

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# UNIT-1

## UNIT I

- OOP concepts: Classes and objects, data abstraction, encapsulation, inheritance, benefits of inheritance, polymorphism, constructors, methods, data types, variables, constants, scope and life time of variables, operators, operator hierarchy, expressions, type conversion and casting, enumerated types, control flow statements, arrays, parameter passing.

# Need for OOP Paradigm

- OOP is an approach to program organization and development, which attempts to eliminate some of the drawbacks of conventional programming methods by incorporating the best of structured programming features with several new concepts.
- OOP allows us to decompose a problem into number of entities called objects and then build data and methods (functions) around these entities.
- The data of an object can be accessed only by the methods associated with the object.

# Introduction

- **Object-oriented programming (OOP)** is a programming paradigm that uses “Objects “and their interactions to design applications.
- It simplifies the software development and maintenance by providing some concepts:
  - **Object**
  - **Class**
  - **Data Abstraction & Encapsulation**
  - **Inheritance**
  - **Polymorphism**
  - **Dynamic Binding**
  - **Message Passing**

# Object:

Objects are the basic runtime entities in the object oriented systems. They may represent a person, a place, a bank account, a table of data or any item that the program has to handle.

An object is an instance of a class that exists physically in the real world. Java is a collection of objects. An object is a root for the object oriented Programming language.

## Example: ]



# Class

- The entire set of data and code of an object can be made of a user defined data type with the help of a class.
- In fact, Objects are variables of the type class. Once a class has been defined, we can create any number of objects belonging to that class.
- **Classes** are data types based on which objects are created. Objects with similar properties and methods are grouped together to form a Class. Thus a Class represents a set of individual objects.

- Characteristics of an object are represented in a class as **Properties**. The actions that can be performed by objects become functions of the class and is referred to as **Methods**.
- A class is thus a collection of objects of similar type . for example: mango, apple, and orange are members of the class fruit . ex: fruit mango; will create an object mango belonging to the class fruit.



# Example for class

- **class Human**
- {
  - **private:**
  - **EyeColor IColor;**
  - **NAME personname;**
  - **public:**
  - **void SetName(NAME anyName);**
  - **void SetIColor(EyeColor eyecolor);**
- **};**

# DATA ABSTRACTION

- Abstraction refers to the act of representing essential features without including the background details or explanations. since the classes use the concept of data abstraction ,they are known as *abstraction data type(ADT)*.

For example, a class Car would be made up of an Engine, Gearbox, Steering objects, and many more components. To build the Car class, one does not need to know how the different components work internally, but only how to interface with them, i.e., send messages to them, receive messages from them, and perhaps make the different objects composing the class interact with each other.

# An example for abstraction

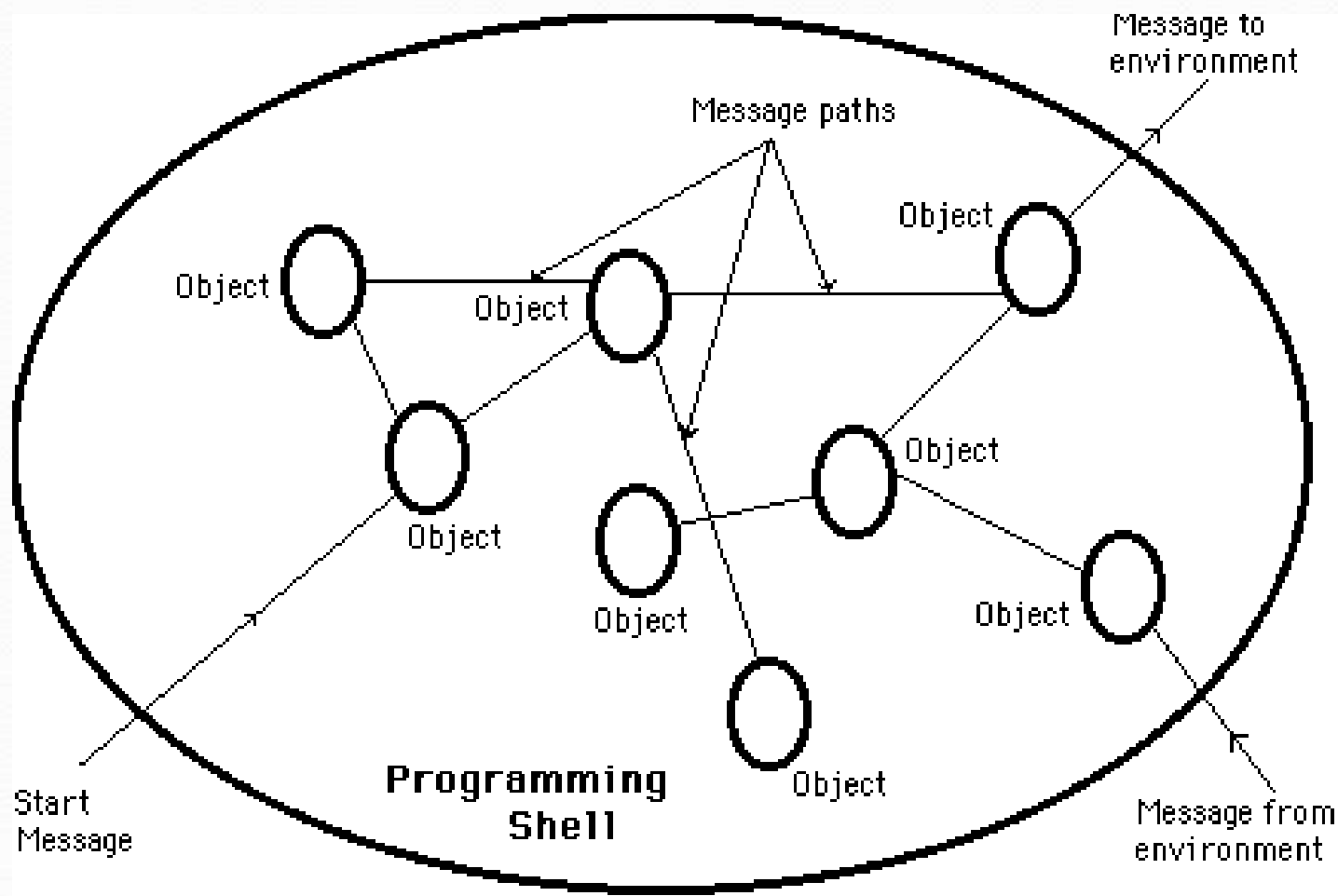
- **Humans manage complexity through abstraction.** When you drive your car you do not have to be concerned with the exact internal working of your car (unless you are a mechanic). What you are concerned with is interacting with your car via its interfaces like steering wheel, brake pedal, accelerator pedal etc. Various manufacturers of car has different implementation of car working but its basic interface has not changed (i.e. you still use steering wheel, brake pedal, accelerator pedal etc to interact with your car). **Hence the knowledge you have of your car is abstract.**

# Some of the Object-Oriented Paradigm are:

1. Emphasis is on data rather than procedure.
2. Programs are divided into objects.
3. Data Structures are designed such that they Characterize the objects.
4. Methods that operate on the data of an object are tied together in the data structure.
5. Data is hidden and can not be accessed by external functions.
6. Objects may communicate with each other through methods.

# A way of viewing world – Agents

- OOP uses an approach of treating a real world agent as an object.
- Object-oriented programming organizes a program around its data (that is, objects) and a set of well-defined interfaces to that data.
- An object-oriented program can be characterized as *data controlling access to code* by switching the controlling entity to data.



# Messages

- We all like to use programs that let us know what's going on. Programs that keep us informed often do so by displaying status and error messages.
- These messages need to be translated so they can be understood by end users around the world.

The Section discusses translatable text messages. Usually, you're done after you move a message String into a ResourceBundle.

- If you've embedded variable data in a message, you'll have to take some extra steps to prepare it for translation.

# Methods

- A method is a group of instructions that is given a name and can be called up at any point in a program simply by quoting that name.

- Drawing a Triangle require draw of three straight lines.

- This

instruction three times to draw a simple triangle.

- We can define a method to call this instruction three times and draw the triangle(i.e. create a method drawLine() to draw lines and this method is called repeatedly to achieve the needed task)

- The idea of methods appears in all programming languages, although sometimes it goes under the name functions and sometimes under the name procedures.

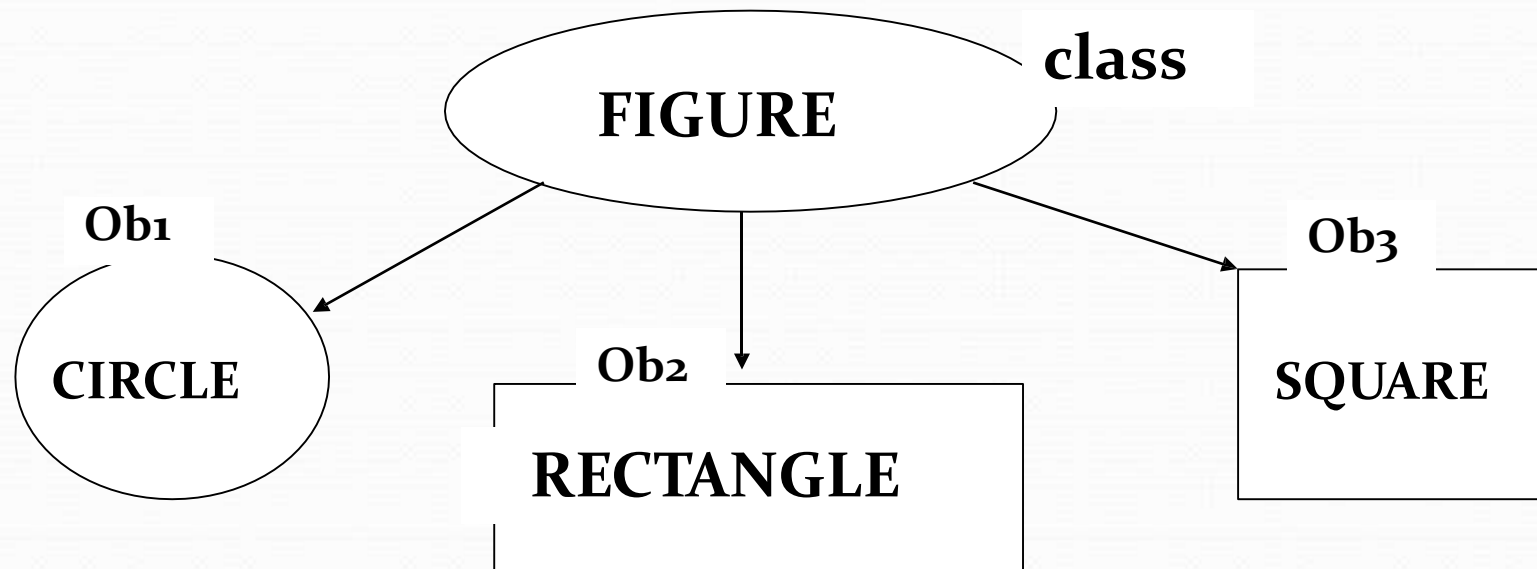
- The name methods is a throw-back to the language C++, from which Java was developed.

In C++, there is an object called a class which can contain methods.



# CLASSES

- Class is blue print or an idea of an Object
- From One class any number of Instances can be created
- It is an encapsulation of attributes and methods



# syntax of CLASS

```
class <ClassName>
{
    attributes/variables;
    Constructors();
    methods();
}
```

# INSTANCE

- Instance is an Object of a class which is an entity with its own attribute values and methods.
- Creating an Instance

```
ClassName refVariable;  
refVariable = new Constructor();
```

or

```
ClassName refVariable = new Constructor();
```

# Java Class Hierarchy

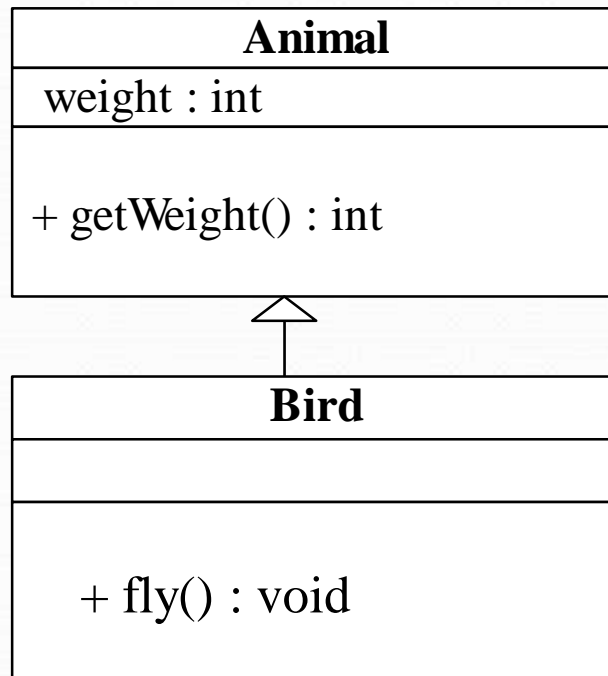
- In Java, class “Object” is the base class to all other classes
  - If we do not explicitly say extends in a new class definition, it implicitly extends Object
  - The tree of classes that extend from Object and all of its subclasses are is called the class hierarchy
  - All classes eventually lead back up to Object
  - This will enable consistent access of objects of different classes.

# Inheritance

- Methods allows to reuse a sequence of statements
- *Inheritance* allows to reuse classes by deriving a new class from an existing one
- The existing class is called the *parent class*, or *superclass*, or *base class*
- The derived class is called the *child class* or *subclass*.
- The child class inherits characteristics of the parent class(i.e the child class *inherits* the methods and data defined for the parent class

# Inheritance

- Inheritance relationships are often shown graphically in a *class diagram*, with the arrow pointing to the parent class



# Method Binding

- Objects are used to call methods.
- **MethodBinding** is an object that can be used to call an arbitrary public method, on an instance that is acquired by evaluating the leading portion of a method binding expression via a value binding.
- It is legal for a class to have two or more methods with the same name.  
Java has to be able to uniquely associate the invocation of a method with its definition relying on the number and types of arguments.
- Therefore the same-named methods must be distinguished:
  - 1) by the number of arguments, or
  - 2) by the types of arguments
- Overloading and inheritance are two ways to implement polymorphism.

# Method Overriding.

- There may be some occasions when we want an object to respond to the same method but have different behavior when that method is called.
- That means, we should override the method defined in the super class. This is possible by defining a method in a sub class that has the same name, same arguments and same return type as a method in the super class.
- Then when that method is called, the method defined in the sub class is invoked and executed instead of the one in the super class. This is known as overriding.

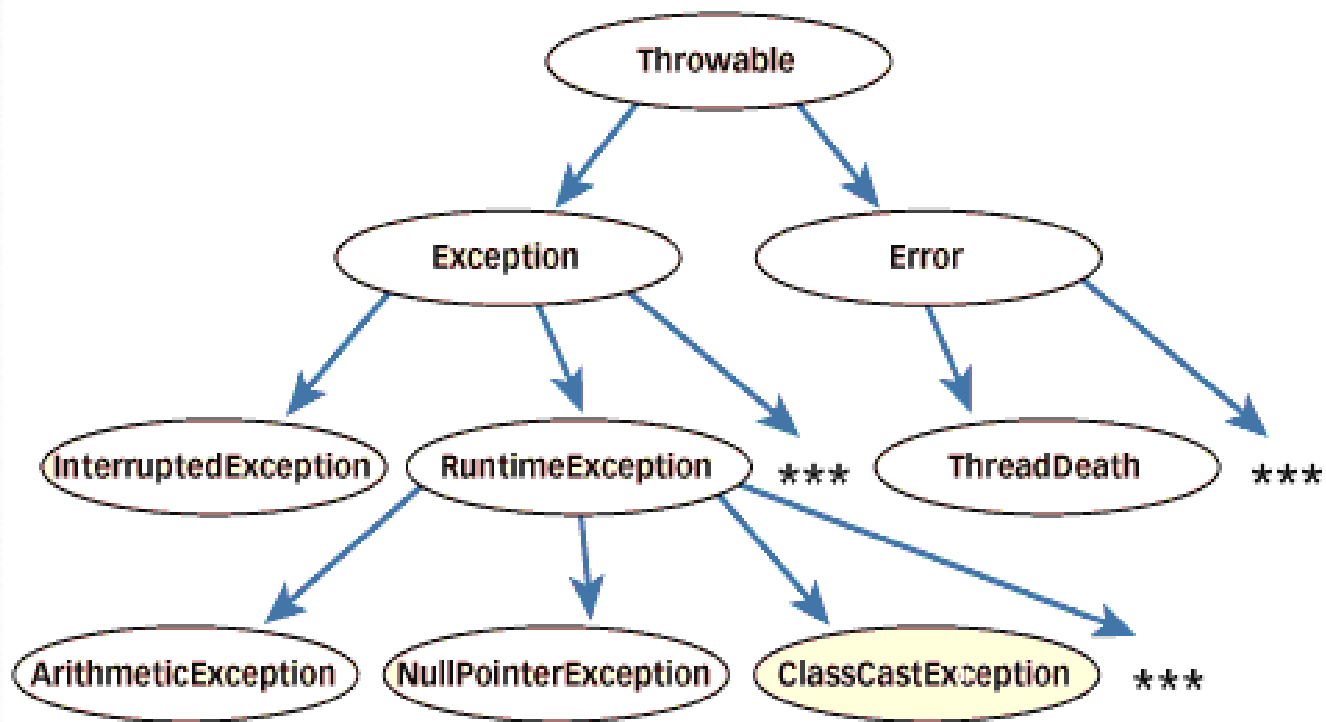


# Exceptions in Java

- Exception is an abnormal condition that arises in the code sequence.
- Exceptions occur during compile time or run time.
- “throwable” is the super class in exception hierarchy.
- Compile time errors occurs due to incorrect syntax.
- Run-time errors happen when
  - User enters incorrect input
  - Resource is not available (ex. file)
  - Logic error (bug) that was not fixed

# Exception classes

- In Java, exceptions are objects. When you throw an exception, you throw an object. You can't throw just any object as an exception, however -- only those objects whose classes descend from Throwable.
- Throwable serves as the base class for an entire family of classes, declared in `java.lang`, that your program can instantiate and throw.
- Throwable has two direct subclasses, `Exception` and `Error`.
- Exceptions are thrown to signal abnormal conditions that can often be handled by some catcher, though it's possible they may not be caught and therefore could result in a dead thread.
- Errors are usually thrown for more serious problems, such as `OutOfMemoryError`, that may not be so easy to handle. In general, code you write should throw only exceptions, not errors.
- Errors are usually thrown by the methods of the Java API, or by the Java virtual machine itself.



# Summary of OOPS

The following are the basic oops concepts: They are as follows:

1. Objects.
2. Classes.
3. Data Abstraction.
4. Data Encapsulation.
5. Inheritance.
6. Polymorphism.
7. Dynamic Binding.
8. Message Passing.

# Abstraction in Object-Oriented Programming

## Procedural Abstraction

- Procedural Abstractions organize instructions.



**Function Power**  
**Give me two numbers (base & exponent)**  
**I'll return  $\text{base}^{\text{exponent}}$**



**Implementation**

# Data Abstraction

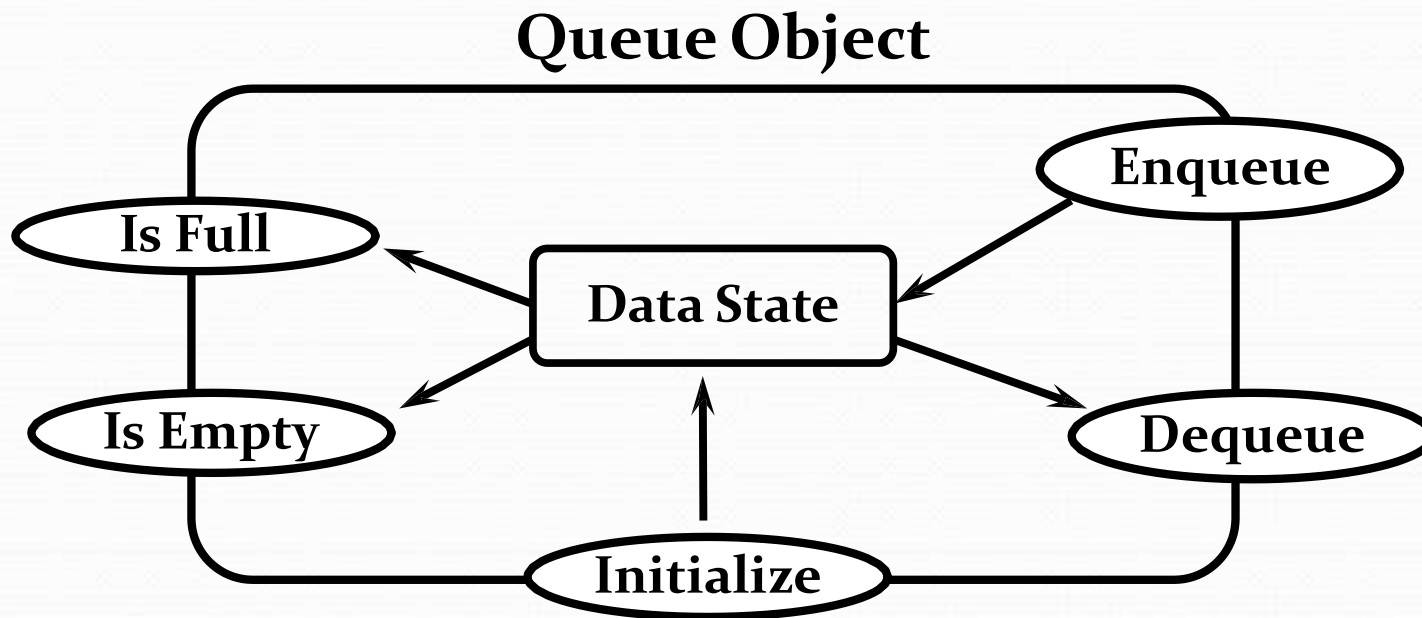
- Data Abstractions organize data.

StudentType

<b>Name (string)</b>
<b>Marks (num)</b>
<b>Grade (char)</b>
<b>Student Number (num)</b>

# Behavioral Abstraction

- Behavioral Abstractions combine procedural and data abstractions.



# Java History

- Computer language innovation and development occurs for two fundamental reasons:
  - 1) to adapt to changing environments and uses
  - 2) to implement improvements in the art of programming
- The development of Java was driven by both in equal measures.
- Many Java features are inherited from the earlier languages:

B → C → C++ → Java



## Before Java: C

- Designed by Dennis Ritchie in 1970s.
- Before C: BASIC, COBOL, FORTRAN, PASCAL
- C- structured, efficient, high-level language that could replace assembly code when creating systems programs.
- Designed, implemented and tested by programmers.

## Before Java: C++

- **Designed by Bjarne Stroustrup in 1979.**
- **Response to the increased complexity of programs and respective improvements in the programming paradigms and methods:**
  - 1) **assembler languages**
  - 2) **high-level languages**
  - 3) **structured programming**
  - 4) **object-oriented programming (OOP)**
- **OOP – methodology that helps organize complex programs through the use of inheritance, encapsulation and polymorphism.**
- **C++ extends C by adding object-oriented features.**

## **Java: History**

- **In 1990, Sun Microsystems started a project called Green.**
- **Objective: to develop software for consumer electronics.**
- **Project was assigned to James Gosling, a veteran of classic network software design. Others included Patrick Naughton, Chris Warth, Ed Frank, and Mike Sheridan.**
- **The team started writing programs in C++ for embedding into**
  - **toasters**
  - **washing machines**
  - **VCR's**
- **Aim was to make these appliances more “intelligent”.**

# Java: History (contd.)

- **C++ is powerful, but also dangerous. The power and popularity of C derived from the extensive use of pointers. However, any incorrect use of pointers can cause memory leaks, leading the program to crash.**
- **In a complex program, such memory leaks are often hard to detect.**

**Robustness is essential. Users have come to expect that Windows may crash or that a program running under Windows may crash.**

- **(“This program has performed an illegal operation and will be shut down”)**
- **However, users do not expect toasters to crash, or washing machines to crash.**

**A design for consumer electronics has to be *robust*.**

**Replacing pointers by references, and automating memory management was the proposed solution.**

## Java: History (contd.)

- Hence, the team built a new programming language called Oak, which avoided potentially dangerous constructs in C++, such as pointers, pointer arithmetic, operator overloading etc.
- Introduced automatic memory management, freeing the programmer to concentrate on other things.
- Architecture neutrality (Platform independence)
- Many different CPU's are used as controllers. Hardware chips are evolving rapidly. As better chips become available, older chips become obsolete and their production is stopped. Manufacturers of toasters and washing machines would like to use the chips available off the shelf, and would not like to reinvest in compiler development every two-three years.
- So, the software and programming language had to be architecture neutral.

# Java History

- Designed by James Gosling, Patrick Naughton, Chris Warth, Ed Frank and Mike Sheridan at Sun Microsystems in 1991.

The original motivation is not Internet: platform-independent software embedded in consumer electronics devices.

- With Internet, the urgent need appeared to break the fortified positions of Intel, Macintosh and Unix programmer communities.

Java as an “Internet version of C++”? No.


Java was not designed to replace C++, but to solve a different set of problems.


# The Java Buzzwords

- The key considerations were summed up by the Java team in the following list of buzzwords:
  - ❖ Simple
  - ❖ Secure
  - ❖ Portable
  - ❖ Object-oriented
  - ❖ Robust
  - ❖ Multithreaded
  - ❖ Architecture-neutral
  - ❖ Interpreted
  - ❖ High performance
  - ❖ Distributed
  - ❖ Dynamic

- **simple** – Java is designed to be easy for the professional programmer to learn and use.
- **object-oriented:** a clean, usable, pragmatic approach to objects, not restricted by the need for compatibility with other languages.
- **Robust:** restricts the programmer to find the mistakes early, performs compile-time (strong typing) and run-time (exception-handling) checks, manages memory automatically.
- **Multithreaded:** supports multi-threaded programming for writing program that perform concurrent computations



- 
- **Architecture-neutral:** Java Virtual Machine provides a platform independent environment for the execution of Java byte code
  - **Interpreted and high-performance:** Java programs are compiled into an intermediate representation – byte code:
    - a) can be later interpreted by any JVM
    - b) can be also translated into the native machine code for efficiency.

- 
- **Distributed:** Java handles TCP/IP protocols, accessing a resource through its URL much like accessing a local file.
  - **Dynamic:** substantial amounts of run-time type information to verify and resolve access to objects at run-time.
  - **Secure:** programs are confined to the Java execution environment and cannot access other parts of the computer.

- **Portability:** Many types of computers and operating systems are in use throughout the world—and many are connected to the Internet.
- For programs to be dynamically downloaded to all the various types of platforms connected to the Internet, some means of generating portable executable code is needed. The same mechanism that helps ensure security also helps create portability.
- Indeed, Java's solution to these two problems is both elegant and efficient.

# Data Types

- Java defines eight simple types:
  - 1) byte – 8-bit integer type
  - 2) short – 16-bit integer type
  - 3) int – 32-bit integer type
  - 4) long – 64-bit integer type
  - 5) float – 32-bit floating-point type
  - 6) double – 64-bit floating-point type
  - 7) char – symbols in a character set
  - 8) boolean – logical values true and false

- byte: 8-bit integer type.

Range: -128 to 127.

Example: byte b = -15;

Usage: particularly when working with data streams.

- short: 16-bit integer type.

Range: -32768 to 32767.

Example: short c = 1000;

Usage: probably the least used simple type.

- **int**: 32-bit integer type.

Range: -2147483648 to 2147483647.

Example: `int b = -50000;`

Usage:

- 1) Most common integer type.
- 2) Typically used to control loops and to index arrays.
- 3) Expressions involving the byte, short and int values are promoted to int before calculation.

- **long:** 64-bit integer type.

Range: -9223372036854775808 to  
9223372036854775807.

Example: `long l = 1000000000000000000;`

Usage: 1) useful when `int` type is not large enough to hold the desired value

- **float:** 32-bit floating-point number.

Range:  $1.4e-045$  to  $3.4e+038$ .

Example: `float f = 1.5;`

Usage:

1) fractional part is needed

2) large degree of precision is not required

- **double:** 64-bit floating-point number.

Range:  $4.9e-324$  to  $1.8e+308$ .

Example: `double pi = 3.1416;`

Usage:

- 1) accuracy over many iterative calculations
- 2) manipulation of large-valued numbers



**char:** 16-bit data type used to store characters.

Range: 0 to 65536.

Example: `char c = 'a';`

Usage:

- 1) Represents both ASCII and Unicode character sets;  
Unicode defines a character set with characters found in (almost) all human languages.
- 2) Not the same as in C/C++ where char is 8-bit and represents ASCII only.

- **boolean:** Two-valued type of logical values.

Range: values true and false.

Example: `boolean b = (1<2);`

Usage:

- 1) returned by relational operators, such as `1<2`
- 2) required by branching expressions such as `if` or `for`

# Variables

- declaration – how to assign a type to a variable
- initialization – how to give an initial value to a variable
- scope – how the variable is visible to other parts of the program
- lifetime – how the variable is created, used and destroyed
- type conversion – how Java handles automatic type conversion
- type casting – how the type of a variable can be narrowed down

# Variables

- Java uses variables to store data.
- To allocate memory space for a variable JVM requires:
  - 1) to specify the data type of the variable
  - 2) to associate an identifier with the variable
  - 3) optionally, the variable may be assigned an initial value
- All done as part of variable declaration.

# Basic Variable Declaration

- datatype identifier [=value];
- datatype must be
  - A simple datatype
  - User defined datatype (class type)
- Identifier is a recognizable name conform to identifier rules
- Value is an optional initial value.

# Variable Declaration

- We can declare several variables at the same time:

type identifier [=value][, identifier [=value] ...];

Examples:

```
int a, b, c;
```

```
int d = 3, e, f = 5;
```

```
byte g = 22;
```

```
double pi = 3.14159;
```

```
char ch = 'x';
```

# Variable Scope

- Scope determines the visibility of program elements with respect to other program elements.
- In Java, scope is defined separately for classes and methods:
  - 1) variables defined by a class have a global scope
  - 2) variables defined by a method have a local scope

A scope is defined by a block:

```
{
```

```
...
```

```
}
```

A variable declared inside the scope is not visible outside:

```
{
```

```
int n;
```

```
}
```

```
n = 1; // this is illegal
```

# Variable Lifetime

- Variables are created when their scope is entered by control flow and destroyed when their scope is left:
  - A variable declared in a method will not hold its value between different invocations of this method.
  - A variable declared in a block loses its value when the block is left.
- Initialized in a block, a variable will be re-initialized with every re-entry. Variables lifetime is confined to its scope!



# Arrays

An array is a group of liked-typed variables referred to by a common name, with individual variables accessed by their index.

Arrays are:

- 1) declared
- 2) created
- 3) initialized
- 4) used

Also, arrays can have one or several dimensions.

# Array Declaration

- Array declaration involves:
  - 1) declaring an array identifier
  - 2) declaring the number of dimensions
  - 3) declaring the data type of the array elements
- Two styles of array declaration:

`type array-variable[];`

or

`type [] array-variable;`

# Array Creation

- After declaration, no array actually exists.
- In order to create an array, we use the new operator:

```
type array-variable[];
```

```
array-variable = new type[size];
```

- This creates a new array to hold size elements of type type, which reference will be kept in the variable array-variable.

# Array Indexing

- Later we can refer to the elements of this array through their indexes:
- `array-variable[index]`
- The array index always starts with zero!
- The Java run-time system makes sure that all array indexes are in the correct range, otherwise raises a run-time error.

# Array Initialization

- Arrays can be initialized when they are declared:
- `int monthDays[] = {31,28,31,30,31,30,31,31,30,31,30,31};`
- Note:
  - 1) there is no need to use the new operator
  - 2) the array is created large enough to hold all specified elements

# Multidimensional Arrays

- Multidimensional arrays are arrays of arrays:

1) declaration: `int array[][];`

2) creation: `int array = new int[2][3];`

3) initialization

```
int array[][] = { {1, 2, 3}, {4, 5, 6} };
```

# Operators Types

- Java operators are used to build value expressions.
- Java provides a rich set of operators:
  - 1) assignment
  - 2) arithmetic
  - 3) relational
  - 4) logical
  - 5) bitwise

# Arithmetic assignments

<code>+=</code>	<code>v += expr;</code>	<code>v = v + expr ;</code>
<code>-=</code>	<code>v -=expr;</code>	<code>v = v - expr ;</code>
<code>*=</code>	<code>v *= expr;</code>	<code>v = v * expr ;</code>
<code>/=</code>	<code>v /= expr;</code>	<code>v = v / expr ;</code>
<code>%=</code>	<code>v %= expr;</code>	<code>v = v % expr ;</code>



# Basic Arithmetic Operators

+	$op1 + op2$	ADD
-	$op1 - op2$	SUBSTRACT
*	$op1 * op2$	MULTIPLY
/	$op1 / op2$	DIVISION
%	$op1 \% op2$	REMAINDER

# Relational operator

==	Equals to	Apply to any type
!=	Not equals to	Apply to any type
>	Greater than	Apply to numerical type
<	Less than	Apply to numerical type
>=	Greater than or equal	Apply to numerical type
<=	Less than or equal	Apply to numerical type

# Logical operators

&	op1 & op2	Logical AND
	op1   op2	Logical OR
&&	op1 && op2	Short-circuit AND
	op1    op2	Short-circuit OR
!	! op	Logical NOT
^	op1 ^ op2	Logical XOR

# Bit wise operators

~	~op	Inverts all bits
&	op1 & op2	Produces 1 bit if both operands are 1
	op1  op2	Produces 1 bit if either operand is 1
^	op1 ^ op2	Produces 1 bit if exactly one operand is 1
>>	op1 >> op2	Shifts all bits in op1 right by the value of op2
<<	op1 << op2	Shifts all bits in op1 left by the value of op2

# Expressions

- An *expression* is a construct made up of variables, operators, and method invocations, which are constructed according to the syntax of the language, that evaluates to a single value.
- Examples of expressions are in bold below:

```
int number = 0;
```

```
anArray[0] = 100;
```

```
System.out.println ("Element 1 at index 0: " +  
anArray[0]);
```

```
int result = 1 + 2; // result is now 3 if(value1 ==  
value2)
```

```
System.out.println("value1 == value2");
```

# Control Statements

- Java control statements cause the flow of execution to advance and branch based on the changes to the state of the program.
- Control statements are divided into three groups:
- 1) selection statements allow the program to choose different parts of the execution based on the outcome of an expression
- 2) iteration statements enable program execution to repeat one or more statements
- 3) jump statements enable your program to execute in a non-linear fashion

# Selection Statements

- Java selection statements allow to control the flow of program's execution based upon conditions known only during run-time.
- Java provides four selection statements:
  - 1) if
  - 2) if-else
  - 3) if-else-if
  - 4) switch

# Iteration Statements

- Java iteration statements enable repeated execution of part of a program until a certain termination condition becomes true.
- Java provides three iteration statements:
  - 1) while
  - 2) do-while
  - 3) for



# Jump Statements

- Java jump statements enable transfer of control to other parts of program.
- Java provides three jump statements:
  - 1) break
  - 2) continue
  - 3) return
- In addition, Java supports exception handling that can also alter the control flow of a program.

# Type Conversion

- Size Direction of Data Type
  - Widening Type Conversion (Casting down)
    - Smaller Data Type → Larger Data Type
  - Narrowing Type Conversion (Casting up)
    - Larger Data Type → Smaller Data Type
- Conversion done in two ways
  - Implicit type conversion
    - Carried out by compiler automatically
  - Explicit type conversion
    - Carried out by programmer using casting

# Type Conversion

- Widening Type Conversion
  - Implicit conversion by compiler automatically

byte -> short, int, long, float, double

short -> int, long, float, double char

-> int, long, float, double

int -> long, float, double

long -> float, double

float -> double

# Type Conversion

- Narrowing Type Conversion
  - Programmer should describe the conversion explicitly

```
byte -> char short
      -> byte, char char
      -> byte, short
int   -> byte, short, char
long  -> byte, short, char, int
float -> byte, short, char, int, long double
      -> byte, short, char, int, long, float
```

# Type Conversion

- byte and short are always promoted to int
- if one operand is long, the whole expression is promoted to long
- if one operand is float, the entire expression is promoted to float
- if any operand is double, the result is double

# Type Casting

- General form: `(targetType) value`
- Examples:
  - 1) integer value will be reduced module bytes range:

```
int i;  
byte b = (byte) i;
```
  - 2) floating-point value will be truncated to integer value:

```
float f;  
int i = (int) f;
```

# Simple Java Program

- A class to display a simple message:

```
class MyProgram
{
    public static void main(String[] args)
    {
        System.out.println("First Java program.");
    }
}
```

# What is an Object?

- Real world objects are things that have:

- 1) state

- 2) behavior

Example: your dog:

- state – name, color, breed, sits?, barks?, wags tail?, runs?
- behavior – sitting, barking, wagging tail, running
- A software object is a bundle of variables (state) and methods (operations).



# What is a Class?

- A class is a blueprint that defines the variables and methods common to all objects of a certain kind.
- Example: 'your dog' is a object of the class Dog.
- An object holds values for the variables defines in the class.
- An object is called an instance of the Class

# Object Creation

- A variable is declared to refer to the objects of type/class String:  
`String s;`
- The value of `s` is null; it does not yet refer to any object.
- A new String object is created in memory with initial “abc” value:
- `String s = new String(“abc”);`
- Now `s` contains the address of this new object.

# Object Destruction

- A program accumulates memory through its execution.
- Two mechanisms to free memory that is no longer needed by the program:
  - 1) manual – done in C/C++
  - 2) automatic – done in Java
- In Java, when an object is no longer accessible through any variable, it is eventually removed from the memory by the garbage collector.
- Garbage collector is part of the Java Run-Time Environment.

# Class

- A basis for the Java language.
- Each concept we wish to describe in Java must be included inside a class.
- A class defines a new data type, whose values are objects:
- A class is a template for objects
- An object is an instance of a class

# Class Definition

- A class contains a name, several variable declarations (instance variables) and several method declarations. All are called members of the class.
- General form of a class:

```
class class-name {
    type instance-variable-1;
    ...
    type instance-variable-n;
    type method-name-1(parameter-list) { ... }
    type method-name-2(parameter-list) { ... }
    ...
    type method-name-m(parameter-list) { ... }
}
```

# Example: Class Usage

```
class Box {  
    double width;  
    double height;  
    double depth;  
}  
class BoxDemo {  
    public static void main(String args[]) {  
        Box mybox = new Box();  
        double vol;  
        mybox.width = 10;  
        mybox.height = 20;  
        mybox.depth = 15;  
        vol = mybox.width * mybox.height * mybox.depth;  
        System.out.println ("Volume is " + vol);  
    } }  
}
```

# Constructor

- A constructor initializes the instance variables of an object.
- It is called immediately after the object is created but before the new operator completes.
  - 1) it is syntactically similar to a method:
  - 2) it has the same name as the name of its class
  - 3) it is written without return type; the default return type of a class
- constructor is the same class When the class has no constructor, the default constructor automatically initializes all its instance variables with zero.

# Example: Constructor

```
class Box {  
    double width;  
    double height;  
    double depth;  
    Box() {  
        System.out.println("Constructing Box");  
        width = 10; height = 10; depth = 10;  
    }  
    double volume() {  
        return width * height * depth;  
    }  
}
```



# Parameterized Constructor

```
class Box {  
    double width;  
    double height;  
    double depth;  
    Box(double w, double h, double d) {  
        width = w; height = h; depth = d;  
    }  
    double volume()  
    { return width * height * depth;  
    }  
}
```

# Methods

- General form of a method definition:

```
type name(parameter-list) {  
    ... return value;  
    ...  
}
```

- Components:

- 1) type - type of values returned by the method. If a method does not return any value, its return type must be void.
- 2) name is the name of the method
- 3) parameter-list is a sequence of type-identifier lists separated by commas
- 4) return value indicates what value is returned by the method.

## Example: Method

- Classes declare methods to hide their internal data structures, as well as for their own internal use: Within a class, we can refer directly to its member variables:

```
class Box {  
    double width, height, depth;  
    void volume() {  
        System.out.print("Volume is ");  
        System.out.println(width * height * depth);  
    }  
}
```

# Parameterized Method

- Parameters increase generality and applicability of a method:
- 1) method without parameters  

```
int square() { return 10*10; }
```
- 2) method with parameters  


```
int square(int i) { return i*i; }
```
- Parameter: a variable receiving value at the time the method is invoked.
- Argument: a value passed to the method when it is invoked.

# Access Control: Data Hiding and Encapsulation

- Java provides control over the *visibility* of variables and methods.
- *Encapsulation*, safely sealing data within the *capsule* of the class Prevents programmers from relying on details of class implementation, so you can update without worry
- Helps in protecting against accidental or wrong usage.
- Keeps code elegant and clean (easier to maintain)

# Access Modifiers: Public, Private, Protected

- *Public*: keyword applied to a class, makes it available/visible everywhere. Applied to a method or variable, completely visible.
- Default (No visibility modifier is specified): it behaves like public in its package and private in other packages.
- *Default Public* keyword applied to a class, makes it available/visible everywhere. Applied to a method or variable, completely visible.

- 
- *Private* fields or methods for a class only visible within that class. Private members are *not* visible within subclasses, and are *not* inherited.
  - *Protected* members of a class are visible within the class, subclasses and *also* within all classes that are in the same package as that class.

# Visibility

```
public class Circle {  
    private double x,y,r;  
  
    // Constructor  
    public Circle (double x, double y, double r) {  
        this.x = x;  
        this.y = y;  
        this.r = r;  
    }  
    //Methods to return circumference and area  
    public double circumference() { return 2*3.14*r;}  
    public double area() { return 3.14 * r * r; }  
}
```



# String Handling

- **String** is probably the most commonly used class in Java's class library. The obvious reason for this is that strings are a very important part of programming.
- The first thing to understand about strings is that every string you create is actually an object of type **String**. Even string constants are actually **String** objects.
- For example, in the statement  
`System.out.println("This is a String, too");`  
the string "This is a String, too" is a **String** constant

- Java defines one operator for **String** objects: +.
- It is used to concatenate two strings. For example, this statement
- `String myString = "I" + " like " + "Java.";`  
results in **myString** containing  
"I like Java."

- The **String** class contains several methods that you can use.

Here are a few. You can

- test two strings for equality by using

**equals( )**. You can obtain the length of a string by calling the **length( )** method. You can obtain the character at a specified index within a string by calling **charAt( )**. The general forms

- of these three methods are shown here:

```
String strOb1 = "First String";  
String strOb2 = "Second String";  
String strOb3 = strOb1;  
System.out.println("Length of strOb1: " +  
                    strOb1.length());
```

```
System.out.println ("Char at index 3 in strOb1: " +  
strOb1.charAt(3));  
if(strOb1.equals(strOb2))
```

```
System.out.println("strOb1 == strOb2");  
else  
System.out.println("strOb1 != strOb2");  
if(strOb1.equals(strOb3))  
System.out.println("strOb1 == strOb3");  
else  
System.out.println("strOb1 != strOb3");  
}}}
```

**This program generates the following output:**

```
Length of strOb1: 12  
Char at index 3 in strOb1: s  
strOb1 != strOb2  
strOb1 == strOb3
```



# UNIT-II



## UNIT II

**Inheritance:** Inheritance hierarchies, super and subclasses, member access rules

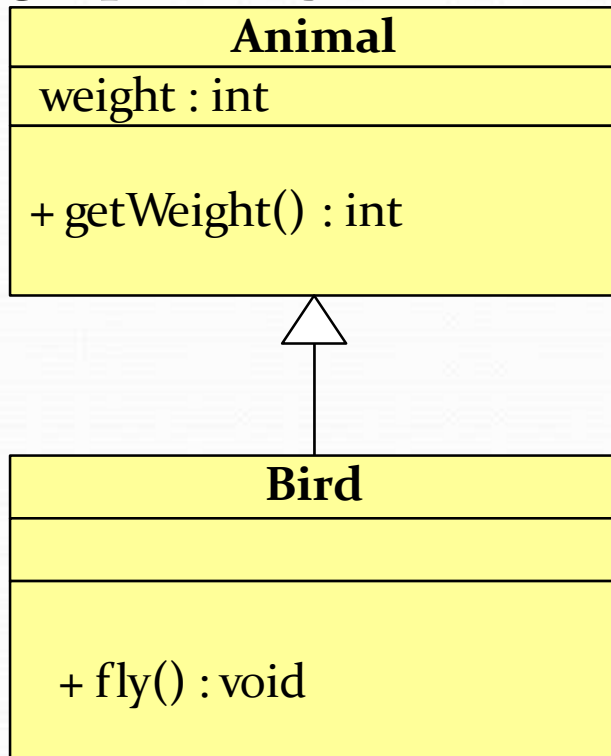
**Polymorphism:** Dynamic binding, method overriding, abstract classes and methods.

# Inheritance

- Methods allows a software developer to reuse a sequence of statements
- *Inheritance* allows a software developer to reuse classes by deriving a new class from an existing one
- The existing class is called the *parent class*, or *superclass*, or *base class*
- The derived class is called the *child class* or *subclass*.
- As the name implies, the child inherits characteristics of the parent
- That is, **the child class inherits the methods and data defined for the parent class**

# Inheritance

Inheritance relationships are often shown pointing to the parent class graphically in a *class diagram*, with the arrow



**Inheritance should create an is-a relationship, meaning the child is a more specific version of the parent**



# Deriving Subclasses

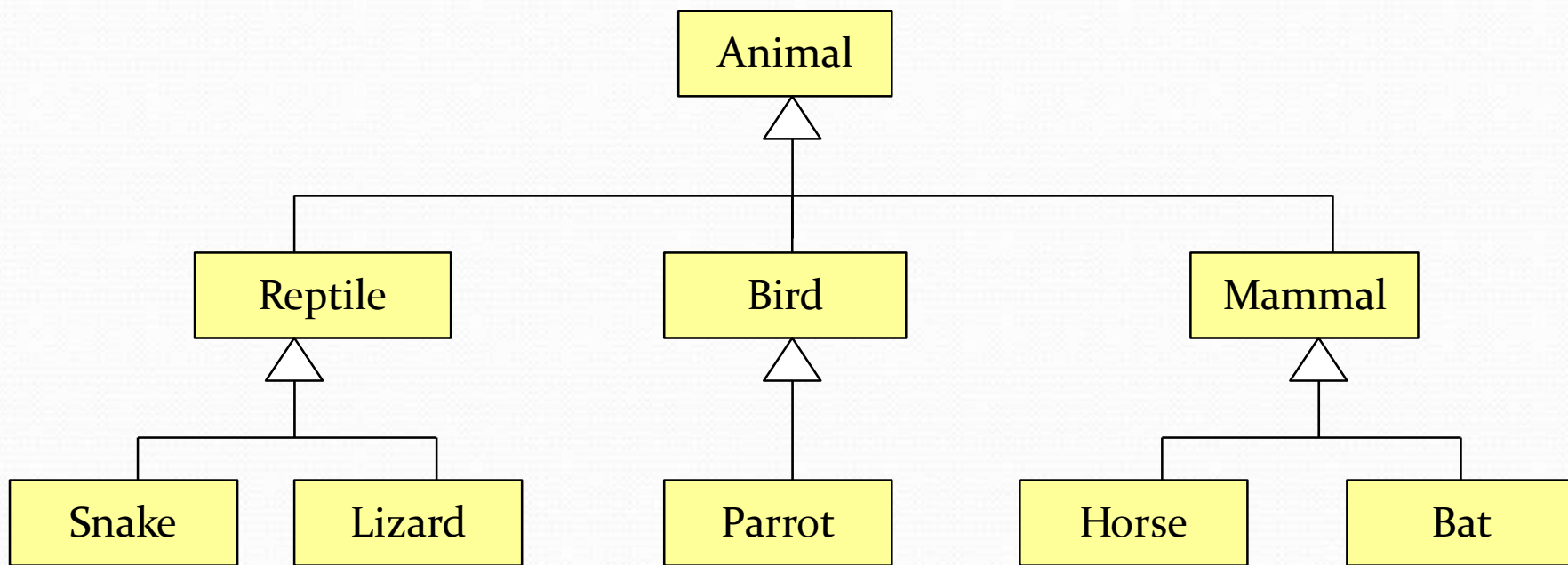
- In Java, we use the reserved word `extends` to establish an inheritance relationship

```
class Animal
{
    // class contents
    int weight;
    public void int getWeight() {...}
}
```

```
class Bird extends Animal
{
    // class contents
    public void fly() {...};
}
```

# Class Hierarchy

- A child class of one parent can be the parent of another child, forming *class hierarchies*



- At the top of the hierarchy there's a default class called Object.

# Class Hierarchy

- Good class design puts all common features as high in the hierarchy as reasonable
- **inheritance is transitive**
  - An instance of class Parrot is also an instance of Bird, an instance of Animal, ..., and an instance of class Object
- The class hierarchy determines how methods are executed:
  - Previously, we took the simplified view that when variable  $v$  is an instance of class  $C$ , then a procedure call  $v.proci()$  invokes the method  $proci()$  defined in class  $C$
  - However, if  $C$  is a child of some superclass  $C'$  (and hence  $v$  is both an instance of  $C$  and an instance of  $C'$ ), the picture becomes more complex, because methods of class  $C$  can *override* the methods of class  $C'$  (next two slides).

# Defining Methods in the Child Class: Overriding by Replacement

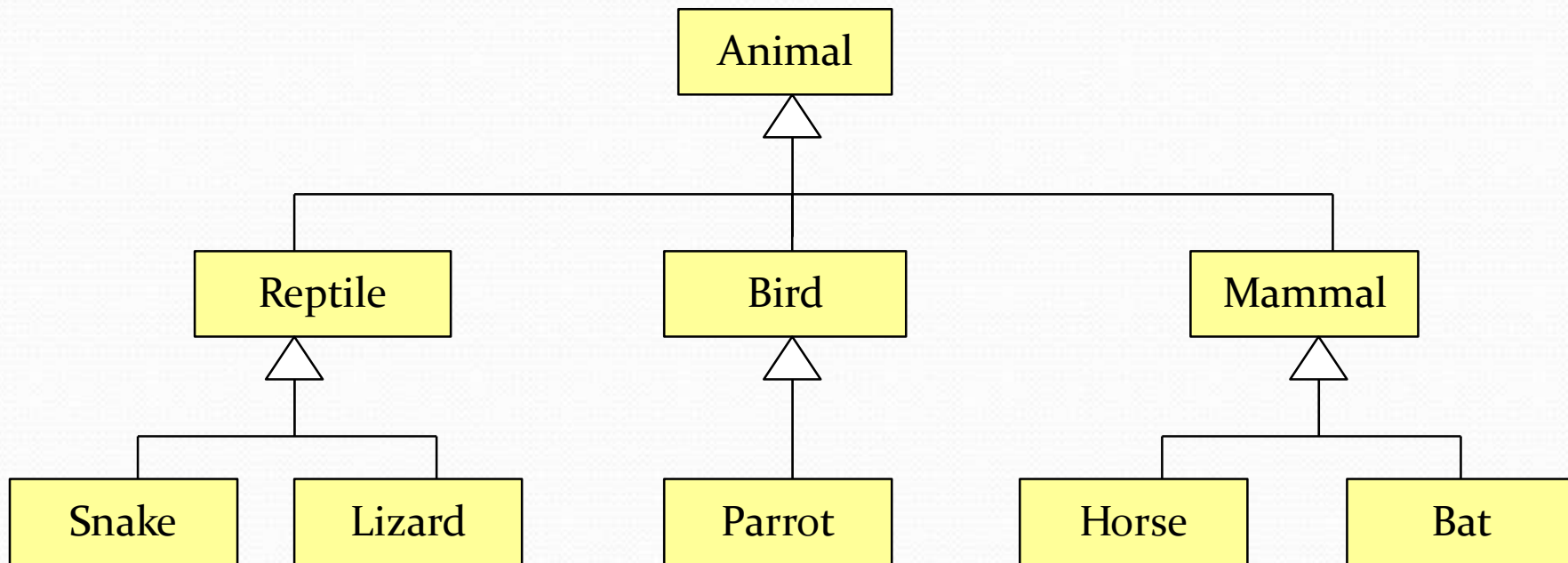
- A child class can *override* the definition of an inherited method in favor of its own
  - that is, a child can redefine a method that it inherits from its parent
  - the new method must have the same signature as the parent's method, but can have different code in the body
- In java, all methods except of constructors override the methods of their ancestor class by *replacement*. E.g.:
  - the Animal class has method eat()
  - the Bird class has method eat() and Bird extends Animal
  - variable *b* is of class Bird, i.e. Bird b = ...
  - b.eat() simply invokes the eat() method of the Bird class
- If a method is declared with the `final` modifier, it cannot be overridden

# Defining Methods in the Child Class: Overriding by Refinement

- Constructors in a subclass *override* the definition of an inherited constructor method by *refining* them (instead of replacing them)
  - Assume class Animal has constructors  
Animal(), Animal(int weight), Animal(int weight, int lifespan)
  - Assume class Bird which extends Animal has constructors  
Bird(), Bird(int weight), Bird(int weight, int lifespan)
  - Let's say we create a Bird object, e.g. Bird b = Bird(5)
  - This will invoke *first* the constructor of the Animal (the superclass of Bird) and *then* the constructor of the Bird
- This is called *constructor chaining*: If class C<sub>0</sub> extends C<sub>1</sub> and C<sub>1</sub> extends C<sub>2</sub> and ... C<sub>n-1</sub> extends C<sub>n</sub> = Object then when creating an instance of object C<sub>0</sub> first constructor of C<sub>n</sub> is invoked, then constructors of C<sub>n-1</sub>, ..., C<sub>2</sub>, C<sub>1</sub>, and finally the constructor of C
  - The constructors (in each case) are chosen by their signature, e.g. (), (int), etc...
    - If no constructor with matching signature is found in any of the class C<sub>i</sub> for i>0 then the default constructor is executed for that class
    - If no constructor with matching signature is found in the class C<sub>0</sub> then this causes a compiler error

# Recap: Class Hierarchy

- In Java, a **class can extend a single other class**  
(If none is stated then it implicitly extends an Object class)



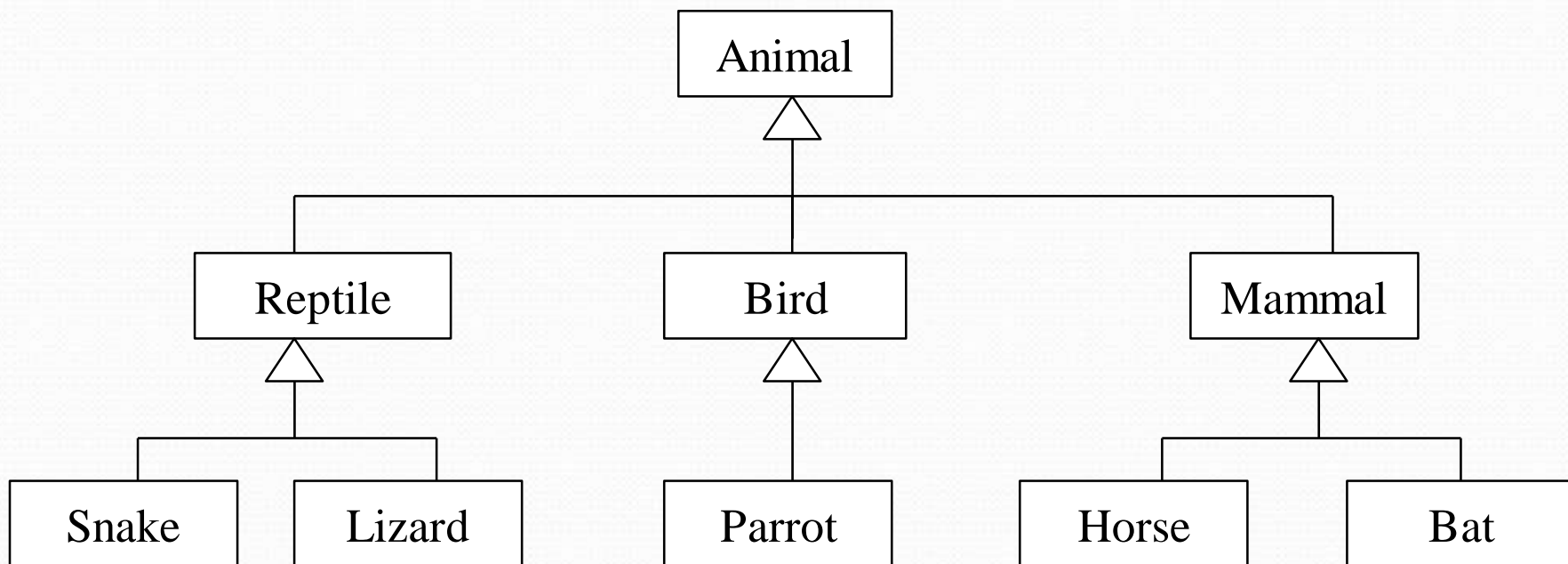
- Imagine what would happen to method handling rules if every class could extend two others...  
(Answer: It would create multiple problems!)

# Hierarchical Abstraction

- An essential element of object-oriented programming is *abstraction*.
- Humans manage complexity through abstraction. For example, people do not think of a car as a set of tens of thousands of individual parts. They think of it as a well-defined object with its own unique behavior.
- This abstraction allows people to use a car without being overwhelmed by the complexity of the parts that form the car. They can ignore the details of how the engine, transmission, and braking systems work.
- Instead they are free to utilize the object as a whole.

# Class Hierarchy

- A child class of one parent can be the parent of another child, forming *class hierarchies*



- At the top of the hierarchy there's a default class called *Object*.



# Class Hierarchy

- Good class design puts all common features as high in the hierarchy as reasonable
- The class hierarchy determines how methods are executed
- inheritance is transitive
  - An instance of class Parrot is also an instance of Bird, an instance of Animal, ..., and an instance of class Object

# Base Class **Object**

- In Java, all classes use inheritance.
- If no parent class is specified explicitly, the base class **Object** is implicitly inherited.
- All classes defined in Java, is a child of **Object** class, which provides minimal functionality guaranteed to be common to all objects.
- Methods defined in Object class are;
  1. equals(Object obj): Determine whether the argument object is the same as the receiver.
  2. getClass(): Returns the class of the receiver, an object of type Class.
  3. hashCode(): Returns a hash value for this object. Should be overridden when the equals method is changed.
  4. toString(): Converts object into a string value. This method is also often overridden.

## Base class

- 1) a class obtains variables and methods from another class
- 2) the former is called subclass, the latter super-class (Base class)
- 3) a sub-class provides a specialized behavior with respect to its super-class
- 4) inheritance facilitates code reuse and avoids duplication of data

## Extends

- Is a keyword used to inherit a class from another class

- ```
class One
{
    int a=5;
}
class Two extends One
{
    int b=10;
}
```

# Subclass, Subtype and Substitutability

- A subtype is a class that satisfies the principle of substitutability.
- A subclass is something constructed using inheritance, whether or not it satisfies the principle of substitutability.
- The two concepts are independent. Not all subclasses are subtypes, and (at least in some languages) you can construct subtypes that are not subclasses.
- Substitutability is fundamental to many of the powerful software development techniques in OOP.
- The idea is that, declared a variable in one type may hold the value of different type.
- Substitutability can occur through use of inheritance, whether using **extends**, or using **implements** keywords.

## Subclass, Subtype, and Substitutability

When new classes are constructed using inheritance, the argument used to justify the validity of substitutability is as follows;

- Instances of the subclass must possess all data fields associated with its parent class.
- Instances of the subclass must implement, through inheritance at least, all functionality defined for parent class. (Defining new methods is not important for the argument.)
- Thus, an instance of a child class can mimic the behavior of the parent class and should be *indistinguishable* from an instance of parent class if substituted in a similar situation.

# Subclass, Subtype, and Substitutability

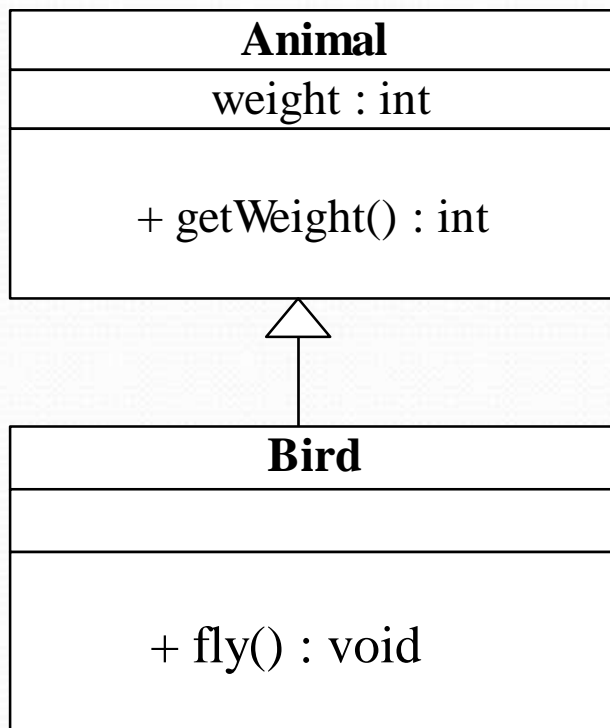
- The term *subtype* is used to describe the relationship between types that explicitly recognizes the principle of *substitution*. A type B is considered to be a subtype of A if an instances of B can legally be assigned to a variable declared as of type A.
- The term *subclass* refers to inheritance mechanism made by `extends` keyword.
- Not all *subclasses* are *subtypes*. *Subtypes* can also be formed using *interface*, linking types that have no inheritance relationship.

# Subclass

- Methods allows to reuse a sequence of statements
- *Inheritance* allows to reuse classes by deriving a new class from an existing one
- The existing class is called the *parent class*, or *superclass*, or *base class*
- The derived class is called the *child class* or *subclass*.
- As the name implies, the child inherits characteristics of the parent(i.e the child class *inherits* the methods and data defined for the parent class

# Subtype

- Inheritance relationships are often shown graphically in a *class diagram*, with the arrow pointing to the parent class





# Substitutability (Deriving Subclasses)

- In Java, we use the reserved word `extends` to establish an inheritance relationship

```
class Animal
{
    // class contents
    int weight;
    public void int getWeight() {...}
}
```

```
class Bird extends Animal
{
    // class contents
    public void fly() {...};
}
```

# Defining Methods in the Child Class: Overriding by Replacement

- A child class can *override* the definition of an inherited method in favor of its own
  - that is, a child can redefine a method that it inherits from its parent
  - the new method must have the same signature as the parent's method, but can have different code in the body
- In java, all methods except of constructors override the methods of their ancestor class by replacement. E.g.:
  - the Animal class has method eat()
  - the Bird class has method eat() and Bird extends Animal
  - variable *b* is of class Bird, i.e. Bird b = ...
  - b.eat() simply invokes the eat() method of the Bird class
- If a method is declared with the `final` modifier, it cannot be overridden

# Forms of Inheritance

Inheritance is used in a variety of way and for a variety of differen purposes .

- Inheritance for Specialization
- Inheritance for Specification
- Inheritance for Construction
- Inheritance for Extension
- Inheritance for Limitation
- Inheritance for Combination

One or many of these forms may occur in a single case.

# Forms of Inheritance

## ( - *Inheritance for Specialization* - )

Most commonly used inheritance and sub classification is for specialization.

Always creates a subtype, and the principles of substitutability is explicitly upheld.

It is the most ideal form of inheritance.

An example of subclassification for specialization is;

```
public class PinBallGame extends Frame {  
  
    // body of class  
  
}
```

# Specialization

- By far the most common form of inheritance is for specialization.
  - Child class is a specialized form of parent class
  - Principle of substitutability holds
- A good example is the Java hierarchy of Graphical components in the AWT:
  - Component
    - Label
    - Button
    - TextComponent
      - TextArea
      - TextField
    - CheckBox
    - ScrollBar

## Forms of Inheritance

### (- *Inheritance for Specification* -)

This is another most common use of inheritance. Two different mechanisms are provided by Java, ***interface*** and ***abstract***, to make use of *subclassification for specification*. Subtype is formed and substitutability is explicitly upheld.

Mostly, not used for refinement of its parent class, but instead is used for definitions of the properties provided by its parent.

```
class FireButtonListener implements ActionListener {
```

```
// body of class
```

```
}
```

```
class B extends A {
```

```
// class A is defined as abstract specification class
```

```
}
```

# Specification

- The next most common form of inheritance involves specification. The parent class specifies some behavior, but does not implement the behavior
  - Child class implements the behavior
  - Similar to Java interface or abstract class
  - When parent class does not implement actual behavior but merely defines the behavior that will be implemented in child classes
- Example, Java, `MouseListener` and `MouseListeners` and so on specify behavior, but must be subclassed.

# Forms of Inheritance

## ( - *Inheritance for Construction* - )

Child class inherits most of its functionality from parent, but may change the name or parameters of methods inherited from parent class to form its interface.

This type of inheritance is also widely used for code reuse purposes. It simplifies the construction of newly formed abstraction but is not a form of subtype, and often violates substitutability.

Example is ***Stack*** class defined in Java libraries.



# Construction

- The parent class is used only for its behavior, the child class has no *is-a* relationship to the parent.
  - Child modify the arguments or names of methods
  -
- An example might be subclassing the idea of a *Set* from an existing *List* class.
  - Child class is not a more specialized form of parent class; no substitutability

# Forms of Inheritance

## (- *Inheritance for Extension* -)

Subclassification for extension occurs when a child class only adds new behavior to the parent class and does not modify or alter any of the inherited attributes.

Such subclasses are always subtypes, and substitutability can be used.

Example of this type of inheritance is done in the definition of the class Properties which is an extension of the class HashTable.

# Generalization or Extension

- The child class generalizes or extends the parent class by providing more functionality
  - In some sense, opposite of subclassing for specialization
- The child doesn't change anything inherited from the parent, it simply adds new features
  - Often used when we cannot modify existing base parent class
- Example, ColoredWindow inheriting from Window
  - Add additional data fields
  - Override window display methods

# Forms of Inheritance

## (- *Inheritance for Limitation* -)

Subclassification for limitation occurs when the behavior of the subclass is smaller or more restrictive than the behavior of its parent class.

Like subclassification for extension, this form of inheritance occurs most frequently when a programmer is building on a base of existing classes.

Is not a subtype, and substitutability is not proper.

# Limitation

- The child class limits some of the behavior of the parent class.
- Example, you have an existing List data type, and you want a Stack
- Inherit from List, but override the methods that allow access to elements other than top so as to produce errors.

# Forms of Inheritance

## (- ***Inheritance for Combination*** -)

This types of inheritance is known as *multiple inheritance* in Object Oriented Programming.

Although the Java does not permit a subclass to be formed be inheritance from more than one parent class, several approximations to the concept are possible.

Example of this type is Hole class defined as;

```
class Hole extends Ball implements PinBallTarget{  
  
// body of class  
  
}
```

# Combination

- Two or more classes that seem to be related, but it's not clear who should be the parent and who should be the child.
- Example: Mouse and TouchPad and JoyStick
- Better solution, abstract out common parts to new parent class, and use subclassing for specialization.

## Summary of Forms of Inheritance

- Specialization. The child class is a special case of the parent class; in other words, the child class is a subtype of the parent class.
- Specification. The parent class defines behavior that is implemented in the child class but not in the parent class.
- Construction. The child class makes use of the behavior provided by the parent class, but is not a subtype of the parent class.
- Generalization. The child class modifies or overrides some of the methods of the parent class.
- Extension. The child class adds new functionality to the parent class, but does not change any inherited behavior.
- Limitation. The child class restricts the use of some of the behavior inherited from the parent class.
- Variance. The child class and parent class are variants of each other, and the class-subclass relationship is arbitrary.
- Combination. The child class inherits features from more than one parent class. This is multiple inheritance and will be the subject of a later chapter.



# The Benefits of Inheritance

- Software Reusability (among projects)
- Increased Reliability (resulting from reuse and sharing of well-tested code)
- Code Sharing (within a project)
- Consistency of Interface (among related objects)
- Software Components
- Rapid Prototyping (quickly assemble from pre-existing components)
- Polymorphism and Frameworks (high-level reusable components)
- Information Hiding

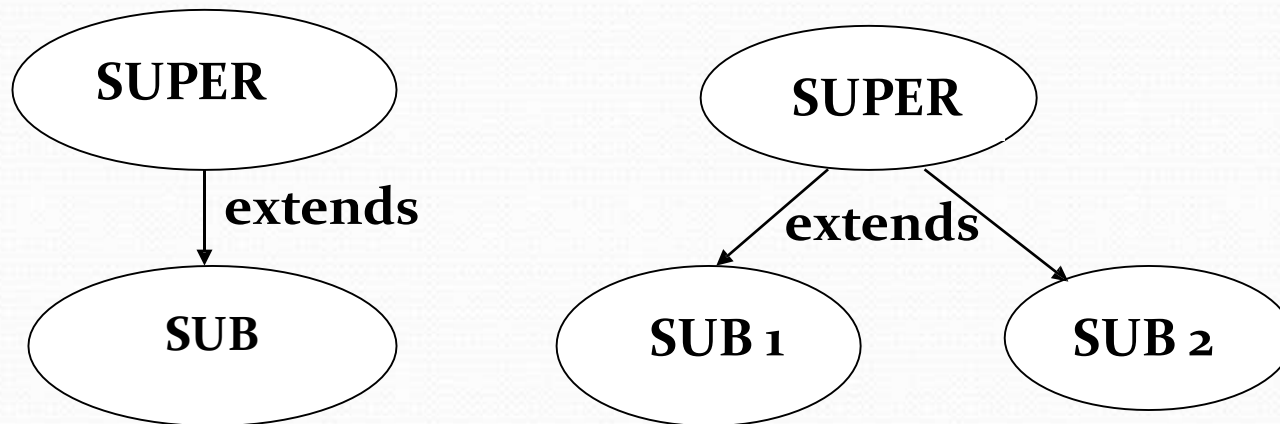
# The Costs of Inheritance

- Execution Speed
- Program Size
- Message-Passing Overhead
- Program Complexity (in overuse of inheritance)

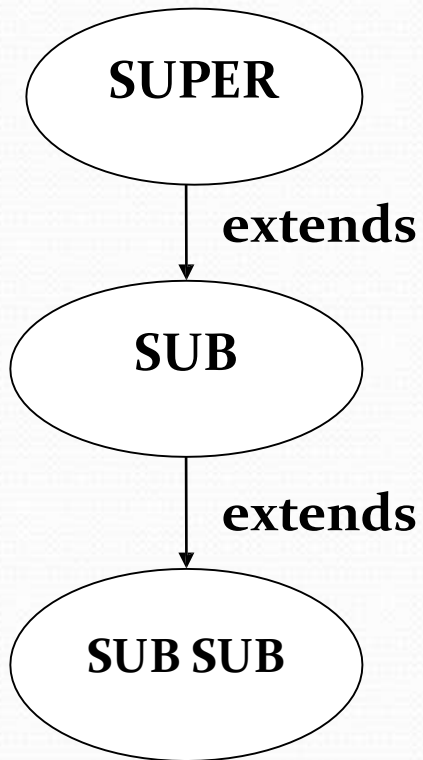
# Types of inheritance

- Acquiring the properties of an existing Object into newly creating Object to overcome the re-declaration of properties in deferent classes.
- These are 3 types:

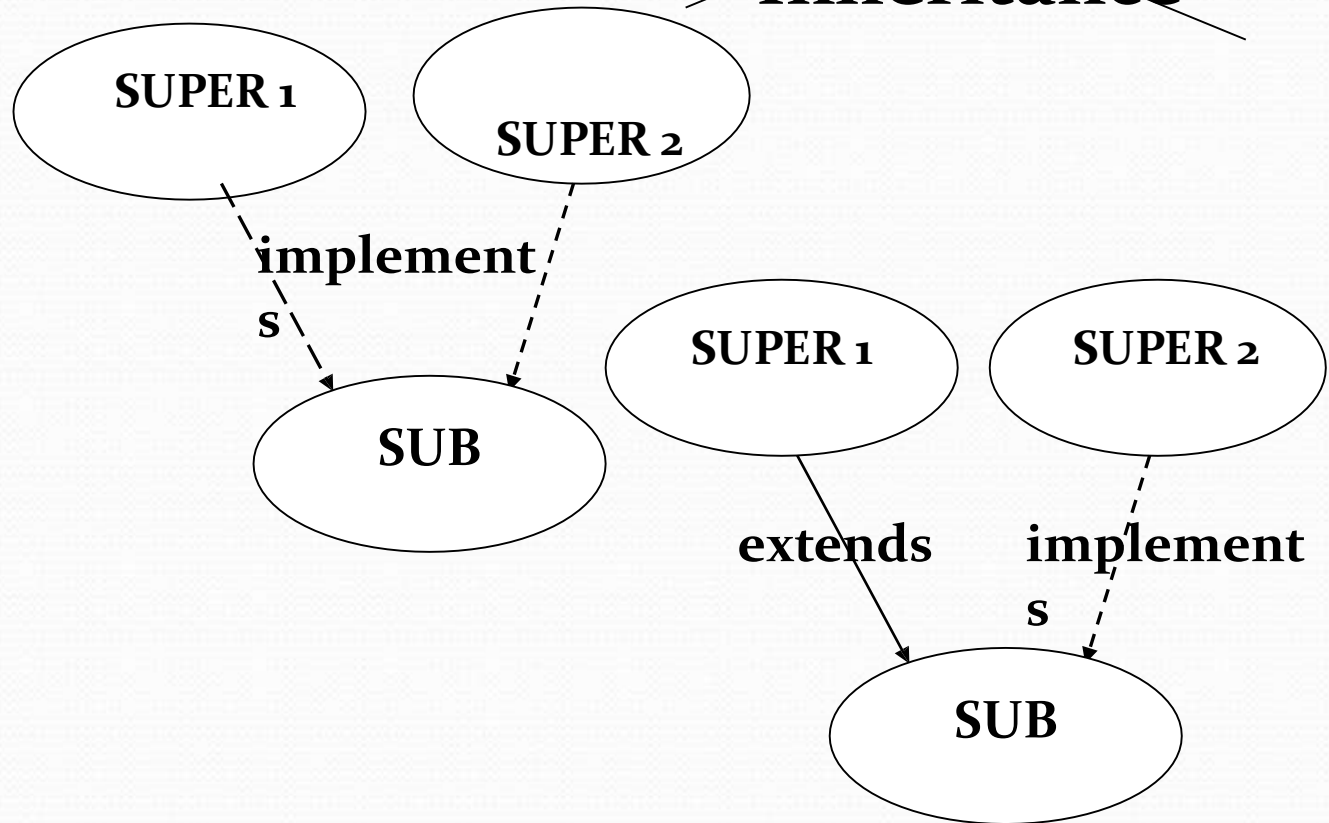
## 1.Simple Inheritance



## 2. Multi Level Inheritance



## ~~3. Multiple Inheritance~~



# Member access rules

- Visibility modifiers determine which class members are accessible and which do not
- Members (variables and methods) declared with public visibility are accessible, and those with private visibility are not
- Problem: How to make class/instance variables visible only to its subclasses?
- Solution: Java provides a third visibility modifier that helps in inheritance situations: protected

# Modifiers and Inheritance (cont.)

Visibility Modifiers for class/interface:

`public` : can be accessed from outside the class definition.

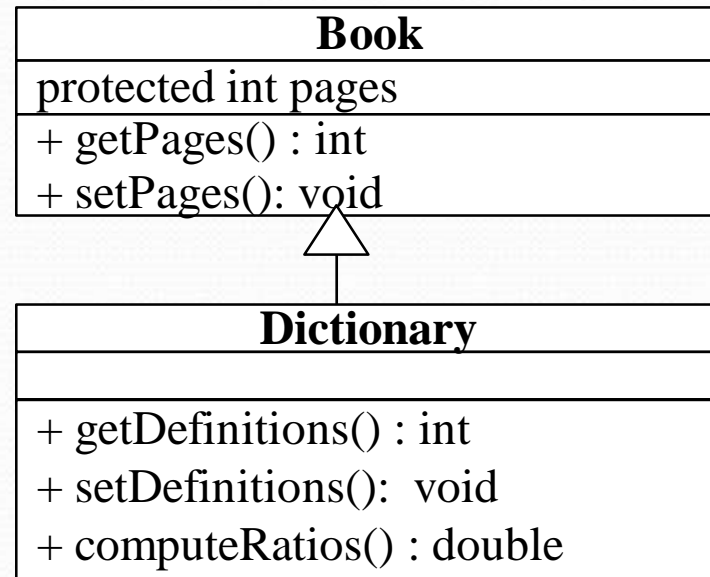
`protected` : can be accessed only within the class definition in which it appears, within other classes in the same package, or within the definition of subclasses.

`private` : can be accessed only within the class definition in which it appears.

*default-access (if omitted)* features accessible from inside the current Java package

# The protected Modifier

- The protected visibility modifier allows a member of a base class to be accessed in the child
  - protected visibility provides more encapsulation than public does
  - protected visibility is not as tightly encapsulated as private visibility



# “super” uses

- ‘super’ is a keyword used to refer to hidden variables of super class from sub class.
  - `super.a=a;`
- It is used to call a constructor of super class from constructor of sub class which should be first statement.
  - `super(a,b);`
- It is used to call a super class method from sub class method to avoid redundancy of code
  - `super.addNumbers(a, b);`



# Super and Hiding

- Why is super needed to access super-class members?
- When a sub-class declares the variables or methods with the same names and types as its super-class:

```
class A {  
    int i = 1;  
}  
class B extends A {  
    int i = 2;  
    System.out.println("i is " + i);  
}
```

- The re-declared variables/methods hide those of the super-class.

# Example: Super and Hiding

```
class A {  
    int i;  
}  
class B extends A {  
    int i;  
    B(int a, int b) {  
        super.i = a; i = b;  
    }  
    void show() {  
        System.out.println("i in superclass: " + super.i);  
        System.out.println("i in subclass: " + i);  
    }  
}
```

# Example: Super and Hiding

- Although the `i` variable in `B` hides the `i` variable in `A`, `super` allows access to the hidden variable of the super-class:

```
class UseSuper {  
    public static void main(String args[]) {  
        B subOb = new B(1, 2);  
        subOb.show();  
    }  
}
```

# Using final with inheritance

- final keyword is used declare constants which can not change its value of definition.
- final Variables can not change its value.
- final Methods can not be Overridden or Over Loaded
- final Classes can not be extended or inherited

# Preventing Overriding with final

- A method declared final cannot be overridden in any sub-class:

```
class A {  
    final void meth() {  
        System.out.println("This is a final method.");  
    }  
}
```

This class declaration is illegal:

```
class B extends A { void  
    meth() {  
        System.out.println("Illegal!");  
    }  
}
```

# Preventing Inheritance with final

- A class declared final cannot be inherited – has no sub-classes.

```
final class A { ... }
```

- This class declaration is considered illegal:

```
class B extends A { ... }
```

- Declaring a class final implicitly declares all its methods final.
- It is illegal to declare a class as both abstract and final.

# Polymorphism

- Polymorphism is one of three pillars of object-orientation.
- Polymorphism: many different (poly) forms of objects that share a common interface respond differently when a method of that interface is invoked.
  - 1) a super-class defines the common interface
  - 2) sub-classes have to follow this interface (inheritance), but are also permitted to provide their own implementations (overriding)
- A sub-class provides a specialized behaviors relying on the common elements defined by its super-class.

# Polymorphism

- A polymorphic reference can refer to different types of objects at different times
  - In java every reference can be polymorphic except of references to base types and final classes.
- It is the type of the object being referenced, not the reference type, that determines which method is invoked
  - Polymorphic references are therefore resolved at run-time, not during compilation; this is called *dynamic binding*
- Careful use of polymorphic references can lead to elegant, robust software designs



# Method Overriding

- When a method of a sub-class has the same name and type as a method of the super-class, we say that this method is overridden.
- When an overridden method is called from within the sub-class:
  - 1) it will always refer to the sub-class method
  - 2) super-class method is hidden

## Example: Hiding with Overriding 1

```
class A {  
    int i, j;  
    A(int a, int b) {  
        i = a; j = b;  
    }  
    void show() {  
        System.out.println("i and j: " + i + " " + j);  
    }  
}
```

## Example: Hiding with Overriding 2

```
class B extends A {  
    int k;  
    B(int a, int b, int c) {  
        super(a, b);  
        k = c;  
    }  
    void show() {  
        System.out.println("k: " + k);  
    }  
}
```

## Example: Hiding with Overriding 3

- When `show()` is invoked on an object of type B, the version of `show()` defined in B is used:

```
class Override {  
    public static void main(String args[]) {  
        B subOb = new B(1, 2, 3);  
        subOb.show();  
    }  
}
```

- The version of `show()` in A is hidden through overriding.

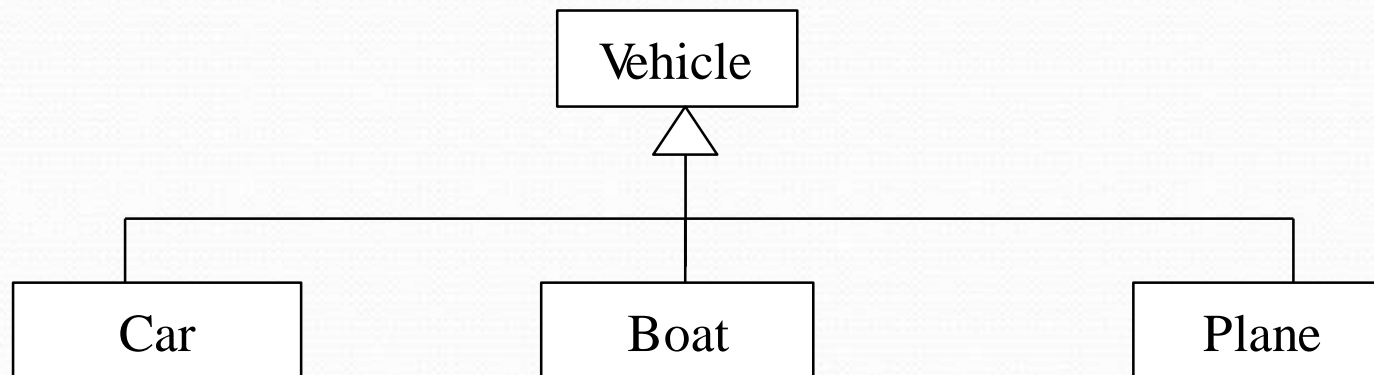
# Overloading vs. Overriding

- |                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Overloading deals with multiple methods in the same class with the same name but different signatures</li><li>• Overloading lets you define a similar operation in different ways for different data</li></ul> | <ul style="list-style-type: none"><li>• Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature</li><li>• Overriding lets you define a similar operation in different ways for different object types</li></ul> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

# Abstract Classes

- Java allows abstract classes
  - use the modifier `abstract` on a class header to declare an abstract class

```
abstract class Vehicle
{ ... }
```
- An abstract class is a placeholder in a class hierarchy that represents a generic concept



# Abstract Class: Example

- An abstract class often contains *abstract methods*, though it doesn't have to
  - Abstract methods consist of only methods *declarations*, without any method body

```
public abstract class Vehicle
{
    String name;
    public String getName()
        { return name; } \\ method body

    abstract public void move();
                                \\ no body!
}
```

# Abstract Classes

- An abstract class often contains *abstract methods*, though it doesn't have to
  - Abstract methods consist of only methods *declarations*, without any method body
- The non-abstract child of an abstract class must override the abstract methods of the parent
- An abstract class cannot be instantiated
- The use of abstract classes is a design decision; it helps us establish common elements in a class that is too general to instantiate



# Abstract Method

- Inheritance allows a sub-class to override the methods of its super-class.
- A super-class may altogether leave the implementation details of a method and declare such a method abstract:
- `abstract type name(parameter-list);`
- Two kinds of methods:
  - 1) concrete – may be overridden by sub-classes
  - 2) abstract – must be overridden by sub-classes
- It is illegal to define abstract constructors or static methods.



# UNIT-III



## UNIT III

**Exception Handling:** Benefits of exception handling, the classification of exceptions, usage of try, catch, throw, throws and finally.

**Multithreading:** Differences between multiple processes and multiple threads, thread states, creating threads, interrupting threads.

# Exceptions

- Exception is an abnormal condition that arises when executing a program.
- In the languages that do not support exception handling, errors must be checked and handled manually, usually
- through the use of error codes.

In contrast, Java:

- 1) provides syntactic mechanisms to signal, detect and handle errors

- 2) ensures a clean separation between the code executed in the

absence of errors and the code to handle various kinds of errors

- 3) brings run-time error management into object-oriented programming

# Exception Handling

- An exception is an object that describes an exceptional condition (error) that has occurred when executing a program.
- Exception handling involves the following:
  - 1) when an error occurs, an object (exception) representing this error is created and thrown in the method that caused it
  - 2) that method may choose to handle the exception itself or pass it on
  - 3) either way, at some point, the exception is caught and processed

# Exception Sources

- Exceptions can be:
  - 1) generated by the Java run-time system Fundamental errors that violate the rules of the Java language or the constraints of the Java execution environment.
  - 2) manually generated by programmer's code Such exceptions are typically used to report some error conditions to the caller of a method.

## Exception Constructs

- Five constructs are used in exception handling:
  - 1) try – a block surrounding program statements to monitor for exceptions
  - 2) catch – together with try, catches specific kinds of exceptions and handles them in some way
  - 3) finally – specifies any code that absolutely must be executed whether or not an exception occurs
  - 4) throw – used to throw a specific exception from the program
  - 5) throws – specifies which exceptions a given method can throw

# Exception-Handling Block

General form:

```
try { ... }  
catch(Exception1 ex1) { ... }  
catch(Exception2 ex2) { ... }  
...  
finally { ... }
```

where:

- 1) try { ... } is the block of code to monitor for exceptions
- 2) catch(Exception ex) { ... } is exception handler for the exception Exception
- 3) finally { ... } is the block of code to execute before the try block ends

# Benefits of exception handling

- Separating Error-Handling code from “regular” business logic code
- Propagating errors up the call stack
- Grouping and differentiating error types



# Using Java Exception Handling

```
method1 {  
  try {  
    call method2;  
  } catch (exception e) {  
    doErrorProcessing;  
  }  
}  
method2 throws exception {  
  call method3;  
}  
method3 throws exception {  
  call readfile;  
}
```

❖ Any checked exceptions that can be thrown within a method must be specified in its throws clause.

# Grouping and Differentiating Error Types

- ❖ Because all exceptions thrown within a program are objects, the grouping or categorizing of exceptions is a natural outcome of the class hierarchy.
- ❖ An example of a group of related exception classes in the Java platform are those defined in `java.io.IOException` and its descendants.
- ❖ `IOException` is the most general and represents any type of error that can occur when performing I/O.
- ❖ Its descendants represent more specific errors. For example, `FileNotFoundException` means that a file could not be located on disk.

- ❖ A method can write specific handlers that can handle a very specific exception.

- ❖ The FileNotFoundException class has no descendants, so the following handler can handle only one type of exception.

```
catch (FileNotFoundException e) {  
    ...  
}
```

- ❖ A method can catch an exception based on its group or general type by specifying any of the exception's super classes in the catch statement.

- ❖ For example, to catch all I/O exceptions, regardless of their specific type, an exception handler specifies an IOException argument.

```
// Catch all I/O exceptions, including  
// FileNotFoundException, EOFException, and so on.  
catch (IOException e) {  
    ...  
}
```

# Termination vs. Resumption

- There are two basic models in exception-handling theory.
- In *termination* the error is so critical there's no way to get back to where the exception occurred. Whoever threw the exception decided that there was no way to salvage the situation, and they don't *want* to come back.
- The alternative is called *resumption*. It means that the exception handler is expected to do something to rectify the situation, and then the faulting method is retried, presuming success the second time. If you want resumption, it means you still hope to continue execution after the exception is handled.

In resumption a method call that want resumption-like behavior (i.e don't throw an exception all a method that fixes the problem.)

- Alternatively, place your **try** block inside a **while** loop that keeps reentering the **try** block until the result is satisfactory.
- Operating systems that supported resumptive exception handling eventually ended up using termination-like code and skipping resumption.

# Exception Hierarchy

- All exceptions are sub-classes of the build-in class Throwable.
- Throwable contains two immediate sub-classes:
  - 1) Exception – exceptional conditions that programs should catch  
The class includes:
    - a) RuntimeException – defined automatically for user programs to include: division by zero, invalid array indexing, etc.
    - b) use-defined exception classes
  - 2) Error – exceptions used by Java to indicate errors with the runtime environment; user programs are not supposed to catch them



# Usage of *try-catch* Statements

- Syntax:

```
try {  
    <code to be monitored for exceptions>  
} catch (<ExceptionType1> <ObjName>) {  
    <handler if ExceptionType1 occurs>  
} ...  
} catch (<ExceptionTypeN> <ObjName>) {  
    <handler if ExceptionTypeN occurs>  
}
```



# Catching Exceptions: The *try-catch* Statements

```
class DivByZero {  
    public static void main(String args[]) {  
        try {  
            System.out.println(3/0);  
            System.out.println("Please print me.");  
        } catch (ArithmeticException exc) {  
            //Division by zero is an ArithmeticException  
            System.out.println(exc);  
        }  
        System.out.println("After exception.");  
    }  
}
```

# Catching Exceptions:

## Multiple catch

```
class MultipleCatch {
    public static void main(String args[]) {
        try {
            int den = Integer.parseInt(args[0]);
            System.out.println(3/den);
        } catch (ArithmeticException exc) {
            System.out.println("Divisor was 0.");
        } catch (ArrayIndexOutOfBoundsException exc2) {
            System.out.println("Missing argument.");
        }
        System.out.println("After exception.");
    }
}
```

# Catching Exceptions:

## Nested try's

```
class NestedTryDemo {
    public static void main(String args[]){
        try {
            int a = Integer.parseInt(args[0]);
            try {
                int b = Integer.parseInt(args[1]);
                System.out.println(a/b);
            } catch (ArithmeticException e) {
                System.out.println("Div by zero error!");
            } } catch (ArrayIndexOutOfBoundsException) {
                System.out.println("Need 2 parameters!");
            } } }
```

# Catching Exceptions: Nested try's with methods

```
class NestedTryDemo2 {
    static void nestedTry(String args[]) {
        try {
            int a = Integer.parseInt(args[0]);
            int b = Integer.parseInt(args[1]);
            System.out.println(a/b);
        } catch (ArithmeticException e) {
            System.out.println("Div by zero error!");
        }
    }
    public static void main(String args[]){
        try {
            nestedTry(args);
        } catch (ArrayIndexOutOfBoundsException e) {
            System.out.println("Need 2 parameters!");
        } } }
}
```

# Throwing Exceptions(throw)

- So far, we were only catching the exceptions thrown by the Java system.
- In fact, a user program may throw an exception explicitly:  
    `throw ThrowableInstance;`
- ThrowableInstance must be an object of type Throwable or its subclass.

Once an exception is thrown by:

`throw ThrowableInstance;`

- 1) the flow of control stops immediately.
- 2) the nearest enclosing try statement is inspected if it has a catch statement that matches the type of exception:
  - 1) if one exists, control is transferred to that statement
  - 2) otherwise, the next enclosing try statement is examined
  - 3) if no enclosing try statement has a corresponding catch clause, the default exception handler halts the program and prints the stack

# Creating Exceptions

Two ways to obtain a Throwable instance:

1) creating one with the new operator

All Java built-in exceptions have at least two Constructors:

One without parameters and another with one String parameter:

```
throw new NullPointerException("demo");
```

2) using a parameter of the catch clause

```
try { ... } catch(Throwable e) { ... e ... }
```

# Example: throw 1

```
class ThrowDemo {  
    //The method demoproc throws a NullPointerException  
    exception which is immediately caught in the try block and  
    re-thrown:  
    static void demoproc() {  
        try {  
            throw new NullPointerException("demo");  
        } catch(NullPointerException e) {  
            System.out.println("Caught inside demoproc.");  
            throw e;  
        }  
    }  
}
```

# Example: throw 2

The main method calls demoproc within the try block which catches and handles the NullPointerException exception:

```
public static void main(String args[]) {  
    try {  
        demoproc();  
    } catch(NullPointerException e) {  
        System.out.println("Recaught: " + e);  
    }  
}  
}
```



# throws Declaration

- If a method is capable of causing an exception that it does not handle, it must specify this behavior by the throws clause in its declaration:

```
type name(parameter-list) throws exception-list {  
    ...  
}
```

- where exception-list is a comma-separated list of all types of exceptions that a method might throw.
- All exceptions must be listed except Error and RuntimeException or any of their subclasses, otherwise a compile-time error occurs.

# Example: throws 1

- The throwOne method throws an exception that it does not catch, nor declares it within the throws clause.

```
class ThrowsDemo { static void throwOne() {  
    System.out.println("Inside throwOne.");  
    throw new IllegalAccessException("demo");  
}  
public static void main(String args[]) {  
    throwOne();  
}  
}
```

- Therefore this program does not compile.

# Example: throws 2

- Corrected program: throwOne lists exception, main catches it:

```
class ThrowsDemo {
    static void throwOne() throws IllegalAccessException {
        System.out.println("Inside throwOne.");
        throw new IllegalAccessException("demo");
    }
    public static void main(String args[]) {
        try {
            throwOne();
        } catch (IllegalAccessException e) {
            System.out.println("Caught " + e);
        } } }
```

# finally

- When an exception is thrown:
  - 1) the execution of a method is changed
  - 2) the method may even return prematurely.
- This may be a problem in many situations.
- For instance, if a method opens a file on entry and closes on exit; exception handling should not bypass the proper closure of the file.
- The finally block is used to address this problem.

# finally Clause

- The try/catch statement requires at least one catch or finally clause, although both are optional:

```
try { ... }  
catch(Exception1 ex1) { ... } ...  
finally { ... }
```

- Executed after try/catch whether or not the exception is thrown.
- Any time a method is to return to a caller from inside the try/catch block via:
  - 1) uncaught exception or
  - 2) explicit returnthe finally clause is executed just before the method returns.

# Example: finally 1

- Three methods to exit in various ways.

```
class FinallyDemo {  
    //procA prematurely breaks out of the try by throwing an  
    //exception, the finally clause is executed on the way out:  
    static void procA() {  
        try {  
            System.out.println("inside procA");  
            throw new RuntimeException("demo");  
        } finally {  
            System.out.println("procA's finally");  
        }  
    }  
}
```

## Example: finally 2

// procB's try statement is exited via a return statement, the finally clause is executed before procB returns:

```
static void procB() {  
    try {  
        System.out.println("inside procB");  
        return;  
    } finally {  
        System.out.println("procB's finally");  
    }  
}
```

## Example: finally 3

- In procC, the try statement executes normally without error, however the finally clause is still executed:

```
static void procC() {  
    try {  
        System.out.println("inside procC");  
    } finally {  
        System.out.println("procC's finally");  
    }  
}
```



# Example: finally 4

- Demonstration of the three methods:

```
public static void main(String args[]) {  
    try {  
        procA();  
    } catch (Exception e) {  
        System.out.println("Exception caught");  
    }  
    procB();  
    procC();  
}
```

# Java Built-In Exceptions

- The default java.lang package provides several exception classes, all sub-classing the RuntimeException class.
- Two sets of build-in exception classes:
  - 1) unchecked exceptions – the compiler does not check if a method handles or throws these exceptions
  - 2) checked exceptions – must be included in the method's throws clause if the method generates but does not handle them

# Unchecked Built-In Exceptions

Methods that generate but do not handle those exceptions need not declare them in the throws clause:

- 1) ArithmeticException
- 2) ArrayIndexOutOfBoundsException
- 3) ArrayStoreException
- 4) ClassCastException
- 5) IllegalStateException
- 6) IllegalMonitorStateException
- 7) IllegalArgumentException
8. StringIndexOutOfBoundsException
9. UnsupportedOperationException
10. SecurityException
11. NumberFormatException
12. NullPointerException
13. NegativeArraySizeException
14. IndexOutOfBoundsException
15. InterruptedException

# Checked Built-In Exceptions

Methods that generate but do not handle those exceptions must declare them in the throws clause:

1. `NoSuchMethodException` `NoSuchFieldException`
2. `InterruptedException`
3. `InstantiationException`
4. `IllegalAccessException`
5. `CloneNotSupportedException`
6. `ClassNotFoundException`

# Creating Own Exception Classes

- Build-in exception classes handle some generic errors.
- For application-specific errors define your own exception classes.  
How? Define a subclass of Exception:  

```
class MyException extends Exception { ... }
```
- MyException need not implement anything – its mere existence in the type system allows to use its objects as exceptions.

# Example: Own Exceptions 1

- A new exception class is defined, with a private detail variable, a one parameter constructor and an overridden toString method:

```
class MyException extends Exception {  
    private int detail;  
    MyException(int a) {  
        detail = a;  
    }  
    public String toString() {  
        return "MyException[" + detail + "];"  
    }  
}
```

# Example: Own Exceptions 2

```
class ExceptionDemo {
```

The static compute method throws the MyException exception whenever its a argument is greater than 10:

```
static void compute(int a) throws MyException {  
    System.out.println("Called compute(" + a + ")");  
    if (a > 10) throw new MyException(a);  
    System.out.println("Normal exit");  
}
```

# Example: Own Exceptions 3

The main method calls compute with two arguments within a try block that catches the MyException exception:

```
public static void main(String args[]) {  
    try {  
        compute(1);  
        compute(20);  
    } catch (MyException e) {  
        System.out.println("Caught " + e);  
    }  
}
```



# Differences between multi threading and multitasking

## Multi-Tasking

- Two kinds of multi-tasking:
  - 1) process-based multi-tasking
  - 2) thread-based multi-tasking
- Process-based multi-tasking is about allowing several programs to execute concurrently, e.g. Java compiler and a text editor.
- Processes are heavyweight tasks:
  - 1) that require their own address space
  - 2) inter-process communication is expensive and limited
  - 3) context-switching from one process to another is expensive and limited

# Thread-Based Multi-Tasking

- Thread-based multi-tasking is about a single program executing concurrently
- several tasks e.g. a text editor printing and spell-checking text.
- Threads are lightweight tasks:
  - 1) they share the same address space
  - 2) they cooperatively share the same process
  - 3) inter-thread communication is inexpensive
  - 4) context-switching from one thread to another is low-cost
- Java multi-tasking is thread-based.

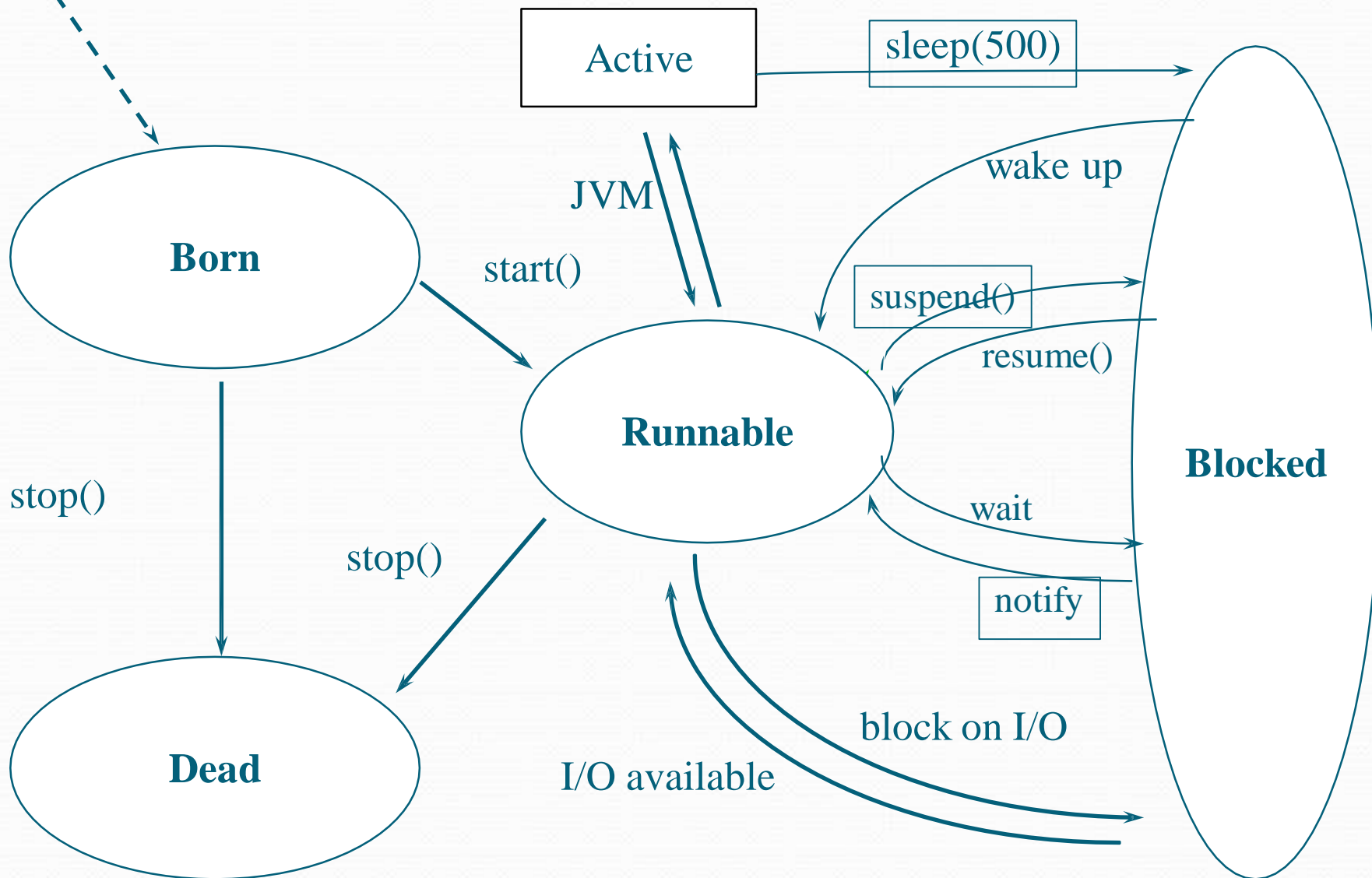
# Reasons for Multi-Threading

- Multi-threading enables to write efficient programs that make the maximum use of the CPU, keeping the idle time to a minimum.
- There is plenty of idle time for interactive, networked applications:
  - 1) the transmission rate of data over a network is much slower than the rate at which the computer can process it
  - 2) local file system resources can be read and written at a much slower rate than can be processed by the CPU
  - 3) of course, user input is much slower than the computer

# Thread Lifecycle

- Thread exist in several states:
  - 1) ready to run
  - 2) running
  - 3) a running thread can be suspended
  - 4) a suspended thread can be resumed
  - 5) a thread can be blocked when waiting for a resource
  - 6) a thread can be terminated
- Once terminated, a thread cannot be resumed.

# Thread Lifecycle



- **New state** – After the creation of Thread instance the thread is in this state but before the start() method invocation. At this point, the thread is considered not alive.

- **Runnable (Ready-to-run) state** – A thread starts its life from Runnable state. A thread first enters runnable state after the invocation of start() method but a thread can return to this state after either running, waiting, sleeping or coming back from blocked state also. On this state a thread is waiting for a turn on the processor.

- **Running state** – A thread is in running state that means the thread is currently executing. There are several ways to enter in Runnable state but there is only one way to enter in Running state: the scheduler selects a thread from the runnable pool.

- **Dead state** – A thread can be considered dead when its run() method completes. If any thread comes on this state that means it cannot ever run again.

- **Blocked** - A thread can enter in this state because of waiting for the resources that are held by another thread.

# Creating Threads

- To create a new thread a program will:
  - 1) extend the Thread class, or
  - 2) implement the Runnable interface
- Thread class encapsulates a thread of execution.
- The whole Java multithreading environment is based on the Thread class.

# Thread Methods

- Start: a thread by calling start its run method
- Sleep: suspend a thread for a period of time
- Run: entry-point for a thread
- Join: wait for a thread to terminate
- isAlive: determine if a thread is still running
- getPriority: obtain a thread's priority
- getName: obtain a thread's name



# New Thread: Runnable

- To create a new thread by implementing the Runnable interface:
  - 1) create a class that implements the run method (inside this method, we define the code that constitutes the new thread):

```
public void run()
```

- 2) instantiate a Thread object within that class, a possible constructor is:

```
Thread(Runnable threadOb, String threadName)
```

- 3) call the start method on this object (start calls run):

```
void start()
```

# Example: New Thread 1

- A class NewThread that implements Runnable:

```
class NewThread implements Runnable {
    Thread t;
    //Creating and starting a new thread. Passing this to the
    // Thread constructor – the new thread will call this
    // object's run method:
    NewThread() {
        t = new Thread(this, "Demo Thread");
        System.out.println("Child thread: " + t);
        t.start();
    }
}
```

# Example: New Thread 2

//This is the entry point for the newly created thread – a five-iterations loop  
//with a half-second pause between the iterations all within try/catch:

```
public void run() {  
    try {  
        for (int i = 5; i > 0; i--) {  
            System.out.println("Child Thread: " + i);  
            Thread.sleep(500);  
        }  
    } catch (InterruptedException e) {  
        System.out.println("Child interrupted.");  
    }  
    System.out.println("Exiting child thread.");  
}
```

# Example: New Thread 3

```
class ThreadDemo {  
    public static void main(String args[]) {  
        //A new thread is created as an object of  
        // NewThread:  
        new NewThread();  
        //After calling the NewThread start method,  
        // control returns here.  
    }  
}
```

# Example: New Thread 4

```
//Both threads (new and main) continue concurrently.  
//Here is the loop for the main thread:  
try {  
    for (int i = 5; i > 0; i--) {  
        System.out.println("Main Thread: " + i);  
        Thread.sleep(1000);  
    }  
} catch (InterruptedException e) {  
    System.out.println("Main thread interrupted.");  
}  
System.out.println("Main thread exiting.");  
}
```

# New Thread: Extend Thread

- The second way to create a new thread:
  - 1) create a new class that extends Thread
  - 2) create an instance of that class
- Thread provides both run and start methods:
  - 1) the extending class must override run
  - 2) it must also call the start method

# Example: New Thread 1

- The new thread class extends Thread:

```
class NewThread extends Thread {  
    //Create a new thread by calling the Thread's  
    // constructor and start method:  
    NewThread() {  
        super("Demo Thread");  
        System.out.println("Child thread: " + this);  
        start();  
    }  
}
```

# Example: New Thread 2

NewThread overrides the Thread's run method:

```
public void run() {  
    try {  
        for (int i = 5; i > 0; i--) {  
            System.out.println("Child Thread: " + i);  
            Thread.sleep(500);  
        }  
    } catch (InterruptedException e) {  
        System.out.println("Child interrupted.");  
    }  
    System.out.println("Exiting child thread.");  
}
```



# Example: New Thread 3

```
class ExtendThread {  
    public static void main(String args[]) {  
        //After a new thread is created:  
        new NewThread();  
        //the new and main threads continue  
        //concurrently...
```

# Example: New Thread 4

```
//This is the loop of the main thread:  
try {  
  for (int i = 5; i > 0; i--) {  
    System.out.println("Main Thread: " + i);  
    Thread.sleep(1000);  
  }  
} catch (InterruptedException e) {  
  System.out.println("Main thread interrupted.");  
}  
System.out.println("Main thread exiting.");  
}  
}
```

# Threads: Synchronization

- Multi-threading introduces asynchronous behavior to a program.
- How to ensure synchronous behavior when we need it?
- For instance, how to prevent two threads from simultaneously writing and reading the same object?
- Java implementation of monitors:
  - 1) classes can define so-called synchronized methods
  - 2) each object has its own implicit monitor that is automatically entered when one of the object's synchronized methods is called
  - 3) once a thread is inside a synchronized method, no other thread can call any other synchronized method on the same object

# Thread Synchronization

- Language keyword: synchronized
- Takes out a monitor lock on an object
  - Exclusive lock for that thread
- If lock is currently unavailable, thread will block

# Thread Synchronization

- Protects access to code, not to data
  - Make data members private
  - Synchronize accessor methods
- Puts a “force field” around the locked object so no other threads can enter
  - Actually, it only blocks access to other synchronizing threads

# Daemon Threads

- Any Java thread can be a *daemon* thread.
- Daemon threads are service providers for other threads running in the same process as the daemon thread.
- The run() method for a daemon thread is typically an infinite loop that waits for a service request. When the only remaining threads in a process are daemon threads, the interpreter exits. This makes sense because when only daemon threads remain, there is no other thread for which a daemon thread can provide a service.

To specify that a thread is a daemon thread, call the setDaemon method with the argument true. To determine if a thread is a daemon thread, use the accessor method isDaemon.

# Thread Groups

- Every Java thread is a member of a *thread group*.
- Thread groups provide a mechanism for collecting multiple threads into a single object and manipulating those threads all at once, rather than individually.
- For example, you can start or suspend all the threads within a group with a single method call.
- Java thread groups are implemented by the “ThreadGroup” class in the java.lang package.
- The runtime system puts a thread into a thread group during thread construction.
- When you create a thread, you can either allow the runtime system to put the new thread in some reasonable default group or you can explicitly set the new thread's
- group.  
The thread is a permanent member of whatever thread group it joins upon its creation--you cannot move a thread to a new group after the thread has been created

# The ThreadGroup Class

- The “ThreadGroup” class manages groups of threads for Java applications.
- A ThreadGroup can contain any number of threads.
- The threads in a group are generally related in some way, such as who created them, what function they perform, or when they should be started and stopped.
- ThreadGroups can contain not only threads but also other ThreadGroups.
- The top-most thread group in a Java application is the thread group named main.
- You can create threads and thread groups in the main group.
- You can also create threads and thread groups in subgroups of main.



# Creating a Thread Explicitly in a Group

- A thread is a permanent member of whatever thread group it joins when its created--you cannot move a thread to a new group after the thread has been created. Thus, if you wish to put your new thread in a thread group other than the default, you must specify the thread group explicitly when you create the thread.

- The Thread class has three constructors that let you set a new thread's group:


```
public Thread(ThreadGroup group, Runnable target) public  
Thread(ThreadGroup group, String name)
```

```
public Thread(ThreadGroup group, Runnable target, String name)
```

- Each of these constructors creates a new thread, initializes it based on the Runnable and String parameters, and makes the new thread a member of the specified group. For example:

```
ThreadGroup myThreadGroup = new ThreadGroup("My Group of Threads");
```

```
Thread myThread = new Thread(myThreadGroup, "a thread for my group");
```



# UNIT-IV



## UNIT IV

**Interface:** Interfaces vs Abstract classes, defining an interface, implement interfaces

**Packages:** Defining, creating and accessing a package, importing packages.

# Differences between classes and interfaces

- Interfaces are syntactically similar to classes, but they lack instance variables, and their methods are declared without any body.
- One class can implement any number of interfaces.
- Interfaces are designed to support dynamic method resolution at run time.
- Interface is little bit like a class... but interface is lack in instance variables....that's u can't create object for it.....
- Interfaces are developed to support multiple inheritance...
- The methods present in interfaces r pure abstract..
- The access specifiers public,private,protected are possible with classes, but the interface uses only one spcifier public.....
- interfaces contains only the method declarations.... no definitions.....
- A interface defines, which method a class has to implement. This is way - if you want to call a method defined by an interface - you don't need to know the exact class type of an object, you only need to know that it implements a specific interface.
- Another important point about interfaces is that a class can implement multiple interfaces.

# Defining an interface

- Using interface, we specify what a class must do, but not how it does this.
- An interface is syntactically similar to a class, but it lacks instance variables and its methods are declared without any body.
- An interface is defined with an interface keyword.
- ❖ An interface declaration consists of modifiers, the keyword `interface`, the interface name, a comma-separated list of parent interfaces (if any), and the interface body.  
For example:

```
GroupedInterface extends Interface1, Interface2, Interface3 {  
    public interface  
    // constant declarations double E = 2.718282;  
    // base of natural logarithms //  
    //method signatures  
    void doSomething (int i, double x);  
    int doSomethingElse(String s);  
}
```
- ❖ The public access specifier indicates that the interface can be used by any class in any package. If you do not specify that the interface is public, your interface will be accessible only to classes defined in the same package as the interface.
- ❖ An interface can extend other interfaces, just as a class can extend or subclass another class. However, whereas a class can extend only one other class, an interface can extend any number of interfaces. The interface declaration includes a comma-separated list of all the interfaces that it extends

# Implementing interface

General format:

```
access interface name {  
type method-name1(parameter-list);  
type method-name2(parameter-list);  
...  
type var-name1 = value1;  
type var-nameM = valueM;  
...  
}
```

- Two types of access:
  - 1) public – interface may be used anywhere in a program
  - 2) default – interface may be used in the current package only
- Interface methods have no bodies – they end with the semicolon after the parameter list.
- They are essentially abstract methods.
- An interface may include variables, but they must be final, static and initialized with a constant value.
- In a public interface, all members are implicitly public.

# Interface Implementation

- A class implements an interface if it provides a complete set of methods defined by this interface.
  - 1) any number of classes may implement an interface
  - 2) one class may implement any number of interfaces
- Each class is free to determine the details of its implementation.
- Implementation relation is written with the implements keyword.



# Implementation Format

- General format of a class that includes the implements clause:
- Syntax:  
access class name extends super-class implements  
interface1, interface2, ..., interfaceN {  
    ...  
}
- Access is public or default.

# Implementation Comments

- If a class implements several interfaces, they are separated with a comma.
- If a class implements two interfaces that declare the same method, the same method will be used by the clients of either interface.
- The methods that implement an interface must be declared public.
- The type signature of the implementing method must match exactly the type signature specified in the interface definition.

# Example: Interface

Declaration of the Callback interface:

```
interface Callback
{
void callback(int param);
}
```

Client class implements the Callback interface:

```
class Client implements Callback
{
public void callback(int p)
{
System.out.println("callback called with " + p);
}
}
```

# More Methods in Implementation

- An implementing class may also declare its own methods:

```
class Client implements Callback {
public void callback(int p) {
System.out.println("callback called with " + p);
}
void nonInterfaceMeth() {
System.out.println("Classes that implement " +
"interfaces may also define " +
"other members, too.");
}
}
```

# Applying interfaces

- ❖ A Java *interface* declares a set of method signatures i.e., says what behavior exists Does not say how the behavior is implemented i.e., does not give code for the methods
- ❖ Does not describe any state (but may include “final” constants)
- ❖ A concrete class that implements an interface Contains “implements *InterfaceName*” in the class declaration
- ❖ Must provide implementations (either directly or inherited from a superclass) of all methods declared in the interface
- ❖ An abstract class can also implement an interface
- ❖ Can optionally have implementations of some or all interface methods

- Interfaces and Extends both describe an “is- a” relation.
- If B *implements* interface A, then B inherits the (abstract) method signatures in A
- If B *extends* class A, then B inherits everything in A.
- which can include method code and instance variables as well as abstract method signatures.
- Inheritance” is sometimes used to talk about the superclass / subclass “extends” relation only

# Variables in interface

- Variables declared in an interface must be constants.
- A technique to import shared constants into multiple classes:
  - 1) declare an interface with variables initialized to the desired values
  - 2) include that interface in a class through implementation.
- As no methods are included in the interface, the class does not implement.
- anything except importing the variables as constants.

# Example: Interface Variables 1

An interface with constant values:

```
import java.util.Random;
interface SharedConstants {
int NO = 0;
int YES = 1;
int MAYBE = 2;
int LATER = 3;
int SOON = 4;
int NEVER = 5;
}
```



- Question implements SharedConstants, including all its constants.
- Which constant is returned depends on the generated random number:

```
class Question implements SharedConstants {
    Random rand = new Random();
    int ask() {
        int prob = (int) (100 * rand.nextDouble());
        if (prob < 30) return NO;
        else if (prob < 60) return YES;
        else if (prob < 75) return LATER;
        else if (prob < 98) return SOON;
        else return NEVER;
    }
}
```

- AskMe includes all shared constants in the same way, using them to display the result, depending on the value received:

```
class AskMe implements SharedConstants {
    static void answer(int result) {
        switch(result) {
            case NO: System.out.println("No"); break;
            case YES: System.out.println("Yes"); break;
            case MAYBE: System.out.println("Maybe"); break;
            case LATER: System.out.println("Later"); break;
            case SOON: System.out.println("Soon"); break;
            case NEVER: System.out.println("Never"); break;
        }
    }
}
```

# Example: Interface Variables 4

- The testing function relies on the fact that both ask and answer methods.
- defined in different classes, rely on the same constants:

```
public static void main(String args[]) {  
    Question q = new Question();  
    answer(q.ask());  
    answer(q.ask());  
    answer(q.ask());  
    answer(q.ask());  
}  
}
```

# Extending interfaces

- One interface may inherit another interface.
- The inheritance syntax is the same for classes and interfaces.

```
interface MyInterface1 {  
    void myMethod1(...);  
}  
interface MyInterface2 extends MyInterface1 {  
    void myMethod2(...);  
}
```

- When a class implements an interface that inherits another interface, it must provide implementations for all methods defined within the interface inheritance chain.

- Consider interfaces A and B.

```
interface A {  
    void meth1();  
    void meth2();  
}
```

B extends A:

```
interface B extends A {  
    void meth3();  
}
```

# Example: Interface Inheritance 2

- MyClass must implement all of A and B methods:

```
class MyClass implements B {  
    public void meth1() {  
        System.out.println("Implement meth1().");  
    }  
    public void meth2() {  
        System.out.println("Implement meth2().");  
    }  
    public void meth3() {  
        System.out.println("Implement meth3().");  
    }  
}
```

# Example: Interface Inheritance 3

- Create a new MyClass object, then invoke all interface methods on it:

```
class IFExtend {  
    public static void main(String arg[]) {  
        MyClass ob = new MyClass();  
        ob.meth1();  
        ob.meth2();  
        ob.meth3();  
    }  
}
```

# Defining a Package

- ❖ A package is both a naming and a visibility control mechanism:
  - 1) divides the name space into disjoint subsets It is possible to define classes within a package that are not accessible by code outside the package.
  - 2) controls the visibility of classes and their members It is possible to define class members that are only exposed to other members of the same package.
- ❖ Same-package classes may have an intimate knowledge of each other, but not expose that knowledge to other packages



# Creating a Package

- A package statement inserted as the first line of the source file:

```
package myPackage;  
class MyClass1 { ... }  
class MyClass2 { ... }
```

- means that all classes in this file belong to the myPackage package.
- The package statement creates a name space where such classes are stored.
- When the package statement is omitted, class names are put into the default package which has no name.

# Multiple Source Files

- Other files may include the same package instruction:
  1. 

```
package myPackage;  
    class MyClass1 { ... }  
    class MyClass2 { ... }
```
  2. 

```
package myPackage;  
    class MyClass3{ ... }
```
- A package may be distributed through several source files

# Packages and Directories

- Java uses file system directories to store packages.
- Consider the Java source file:

```
package myPackage;  
class MyClass1 { ... }  
class MyClass2 { ... }
```
- The byte code files `MyClass1.class` and `MyClass2.class` must be stored in a directory `myPackage`.
- Case is significant! Directory names must match package names exactly.

# Package Hierarchy

- To create a package hierarchy, separate each package name with a dot:

```
package myPackage1.myPackage2.myPackage3;
```

- A package hierarchy must be stored accordingly in the file system:

- 1) Unix myPackage1/myPackage2/myPackage3

- 2) Windows myPackage1\myPackage2\myPackage3

- 3) Macintosh myPackage1:myPackage2:myPackage3

- You cannot rename a package without renaming its directory!

# Accessing a Package

- As packages are stored in directories, how does the Java run-time system know where to look for packages?
- Two ways:
  - 1) The current directory is the default start point - if packages are stored in the current directory or sub-directories, they will be found.
  - 2) Specify a directory path or paths by setting the CLASSPATH environment variable.

# CLASSPATH Variable

- CLASSPATH - environment variable that points to the root directory of the system's package hierarchy.
- Several root directories may be specified in CLASSPATH,
- e.g. the current directory and the C:\raju\myJava directory:  
.;C:\raju\myJava
- Java will search for the required packages by looking up subsequent directories described in the CLASSPATH variable.

# Finding Packages

- Consider this package statement:  
`package myPackage;`

In order for a program to find `myPackage`, one of the following must be true:

- 1) program is executed from the directory immediately above `myPackage` (the parent of `myPackage` directory)
- 2) `CLASSPATH` must be set to include the path to `myPackage`

# Example: Package

```
package MyPack;
```

```
class Balance {  
String name;  
double bal;  
Balance(String n, double b) {  
name = n; bal = b;  
}  
void show() {  
if (bal<0) System.out.print("-->> ");  
System.out.println(name + ": $" + bal);  
} }  
}
```



# Example: Package

```
class AccountBalance
{
public static void main(String args[])
{
Balance current[] = new Balance[3];
current[0] = new Balance("K. J. Fielding", 123.23);
current[1] = new Balance("Will Tell", 157.02);
current[2] = new Balance("Tom Jackson", -12.33);
for (int i=0; i<3; i++) current[i].show();
}
}
```

# Example: Package

- Save, compile and execute:
  - 1) call the file AccountBalance.java
  - 2) save the file in the directory MyPack
  - 3) compile; AccountBalance.class should be also in MyPack
  - 4) set access to MyPack in CLASSPATH variable, or make the parent of MyPack your current directory
  - 5) run: `java MyPack.AccountBalance`
- Make sure to use the package-qualified class name.

# Importing of Packages

- Since classes within packages must be fully-qualified with their package names, it would be tedious to always type long dot-separated names.
- The import statement allows to use classes or whole packages directly.
- Importing of a concrete class:  
`import myPackage1.myPackage2.myClass;`
- Importing of all classes within a package:  
`import myPackage1.myPackage2.*;`

# Import Statement

- The import statement occurs immediately after the package

statement and before the class statement:

```
package myPackage;
```

- ```
import otherPackage1;otherPackage2.otherClass;  
class myClass { ... }
```

- The Java system accepts this import statement by default:

```
import java.lang.*;
```

- This package includes the basic language functions. Without such functions, Java is of no much use.

# Example: Packages 1

- A package MyPack with one public class Balance.

The class has two same-package variables: public constructor and a public show method.

```
package MyPack;
public class Balance {
String name;
double bal;
public Balance(String n, double b) {
name = n; bal = b;
}
public void show() {
if (bal<0) System.out.print("-->> ");
System.out.println(name + ": $" + bal);
}
}
```

# Example: Packages 2

The importing code has access to the public class `Balance` of the

`MyPack` package and its two public members:


```
import MyPack.*;
class TestBalance {
public static void main(String args[]) {
Balance test = new Balance("J. J. Jaspers", 99.88);
test.show();
}
}
```

# Java Source File

Finally, a Java source file consists of:

- 1) a single package instruction (optional)
- 2) several import statements (optional)
- 3) a single public class declaration (required)
- 4) several classes private to the package (optional)

At the minimum, a file contains a single public class declaration.



# UNIT-V





## UNIT V

**Files:** streams – byte streams, character stream, text input/output, binary input/output, file management;

**Connecting to Database:** Connecting to a database, querying a database and processing the results, updating data with JDBC.

# I/O Overview

- I/O = Input/Output
- In this context it is input to and output from programs
- Input can be from keyboard or a file
- Output can be to display (screen) or a file
- Advantages of file I/O
  - permanent copy
  - output from one program can be input to another
  - input can be automated (rather than entered manually)

Note: Since the sections on text file I/O and binary file I/O have some similar information, some duplicate (or nearly duplicate) slides are included.

# Methods for `BufferedReader`

- `readLine`: read a line into a `String`
- no methods to read numbers directly, so read numbers as `Strings` and then convert them (`StringTokenizer` later)
- `read`: read a char at a time
- `close`: close `BufferedReader` stream

# BufferedReader vs Scanner (parsing primitive types)

- Scanner
  - `nextInt()`, `nextFloat()`, ... for parsing types
- BufferedReader
  - `read()`, `readLine()`, ... none for parsing types
  - **needs** `StringTokenizer` then wrapper class methods like `Integer.parseInt(token)`

# JDBC connectivity

# Introduction

- JDBC stands for **J**ava **D**atabase **C**onnectivity, which is a standard Java API for database-independent connectivity between the Java programming language and a wide range of databases.
- The JDBC library includes APIs for each of the tasks commonly associated with database usage:
  - Making a connection to a database
  - Creating SQL or MySQL statements
  - Executing that SQL or MySQL queries in the database
  - Viewing & Modifying the resulting records

## Required Steps:

There are following steps required to create a new Database using JDBC application:

- **Import the packages** . Requires that you include the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.\** will suffice.
- **Register the JDBC driver** . Requires that you initialize a driver so you can open a communications channel with the database.
- **Open a connection** . Requires using the *DriverManager.getConnection()* method to create a Connection object, which represents a physical connection with database server.
- To create a new database, you need not to give any database name while preparing database URL as mentioned in the below example.
- **Execute a query** . Requires using an object of type Statement for building and submitting an SQL statement to the database.
- **Clean up the environment** . Requires explicitly closing all database resources versus relying on the JVM's garbage collection.

- # Creating JDBC Application

There are six steps involved in building a JDBC application in this tutorial.

## 1. Import the packages:

which I'm going to brief

- To use the standard JDBC package, which allows you to select, insert, update, and delete data in SQL tables, add the following *imports* to your source code:
  - //STEP 1. Import required packages
  - Syntax `:import java.sql.*;`

## 2. Register the JDBC driver:

- This requires that you initialize a driver so you can open a communications channel with the database.
- Registering the driver is the process by which the Oracle driver's class file is loaded into memory so it can be utilized as an implementation of the JDBC interfaces.
- You need to do this registration only once in your program
- //STEP 2: Register JDBC driver
- Syntax: `Class.forName("com.mysql.jdbc.Driver");`



- **Open a connection:**

- After you've loaded the driver, you can establish a connection using the **DriverManager.getConnection()** method, which represents a physical connection with the database as follows:

- **//STEP 3: Open a connection // Database credentials**

- `static final String USER = "username"; static`
- `final String PASS = "password";`
- `System.out.println("Connecting to database...");`
- `conn = DriverManager.getConnection(DB_URL,USER,PASS);`

- **Execute a query:**

- This requires using an object of type Statement or PreparedStatement for building and submitting an SQL statement to the database as follows:

- **//STEP 4: Execute a query**

- `System.out.println("Creating statement...");`
- `stmt = conn.createStatement();`
- `String sql; sql = "SELECT id, first, last, age FROM Employees";`
- `ResultSet rs = stmt.executeQuery(sql);`

Following table lists down popular JDBC driver names and database URL.

RDBMS	JDBC driver name	URL format
MySQL	com.mysql.jdbc.Driver	<b>jdbc:mysql://</b> hostname/ databaseName
ORACLE	oracle.jdbc.driver.OracleDriver	<b><u><a href="#">jdbc:oracle:thin:@hostname:port</a></u></b> Number:databaseName
DB2	COM.ibm.db2.jdbc.net.DB2Driver	<b>jdbc:db2:</b> hostname:port Number/databaseName
Sybase	com.sybase.jdbc.SybDriver	<b>jdbc:sybase:Tds:</b> hostname: port Number/databaseName

All the highlighted part in URL format is static and you need to change only remaining part as per your database setup.

- If there is an SQL UPDATE, INSERT or DELETE statement required, then following code snippet would be required:

- //STEP 4: Execute a query

- System.out.println("Creating statement...");
- stmt = conn.createStatement();
- String sql;
- sql = "DELETE FROM Employees";
- ResultSet rs = stmt.executeUpdate(sql);

- **Extract data from result set:**

- This step is required in case you are fetching data from the database. You can use the appropriate `ResultSet.getXXX()` method to retrieve the data from the result set as follows:

- **//STEP 5: Extract data from result set**

- `while(rs.next())`

- `{`

- **//Retrieve by column name**

- `int id = rs.getInt("id");`

- `int age = rs.getInt("age");`

- `String first = rs.getString("first");`

- `String last = rs.getString("last");`

- **//Display values**

- `System.out.print("ID: " + id);`

- `System.out.print(", Age: " + age);`

- `System.out.print(", First: " + first);`

- `System.out.println(", Last: " + last); }`

- **Clean up the environment:**
- You should explicitly close all database resources versus relying on the JVM's garbage collection as follows:
- //STEP 6: Clean-up environment
  - `rs.close();`
  - `stmt.close();`
  - `conn.close();`

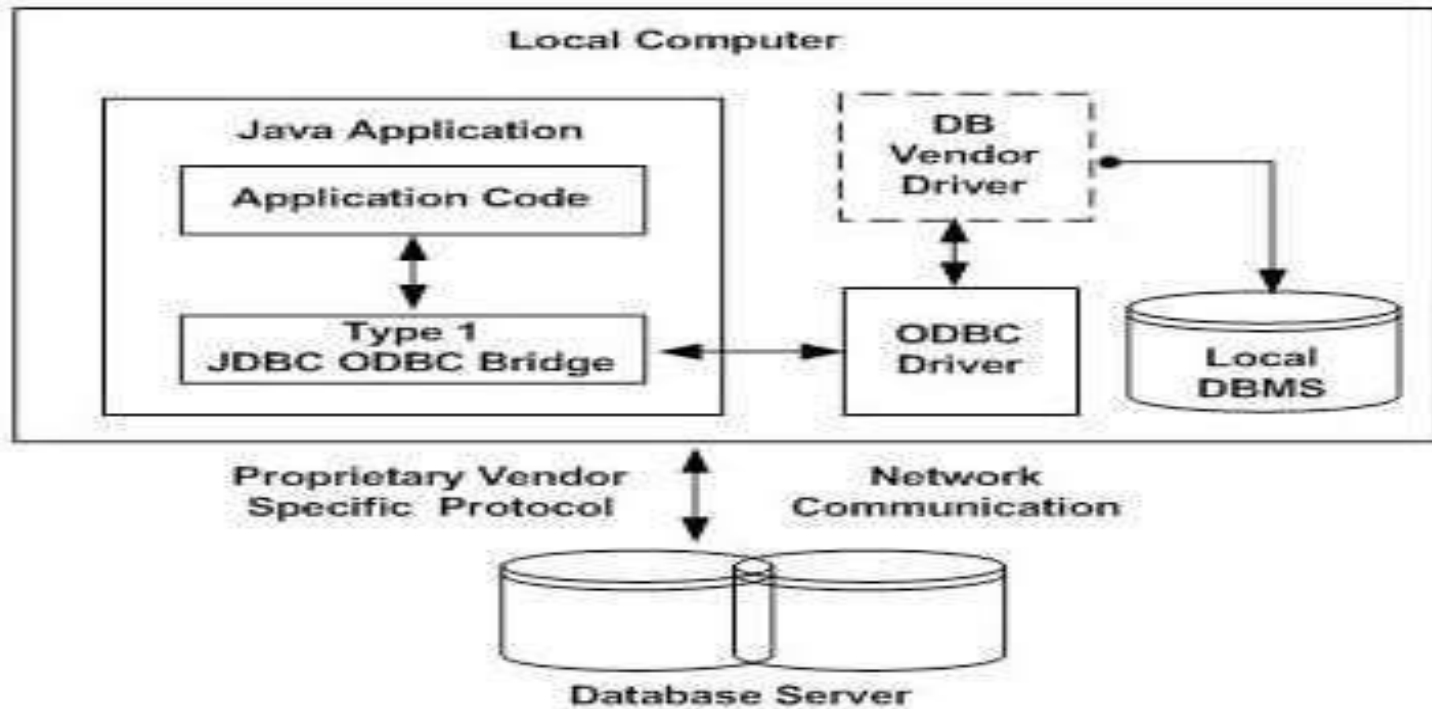
# JDBC Driver

- JDBC drivers implement the interfaces in the JDBC API for defined using JDBC drivers enable you to open database connections and to interact with it by sending SQL or database commands then receiving results with Java.
- The *Java.sql* package that ships with JDK contains various classes with their behaviours defined and their actual implementations are done in third-party drivers.
- Third party vendors implement the *java.sql.Driver* interface in their database driver.
- **JDBC Drivers Types:**
- JDBC driver implementations vary because of the wide variety of operating systems and hardware platforms in which Java operates. Sun has divided the implementation types into four categories, Types 1, 2, 3, and 4

# Type 1: JDBC-ODBC Bridge Driver

- In a Type 1 driver, a JDBC bridge is used to access ODBC drivers installed on each client machine.
- Using ODBC requires configuring on your system a Data Source Name (DSN) that represents the target database.
- When Java first came out, this was a useful driver because most databases only supported ODBC access but now this type of driver is recommended only for experimental use or when no other alternative is available.
- The JDBC-ODBC bridge that comes with JDK 1.2 is a good example of this kind of driver.

# Type 1: JDBC-ODBC Bridge Driver

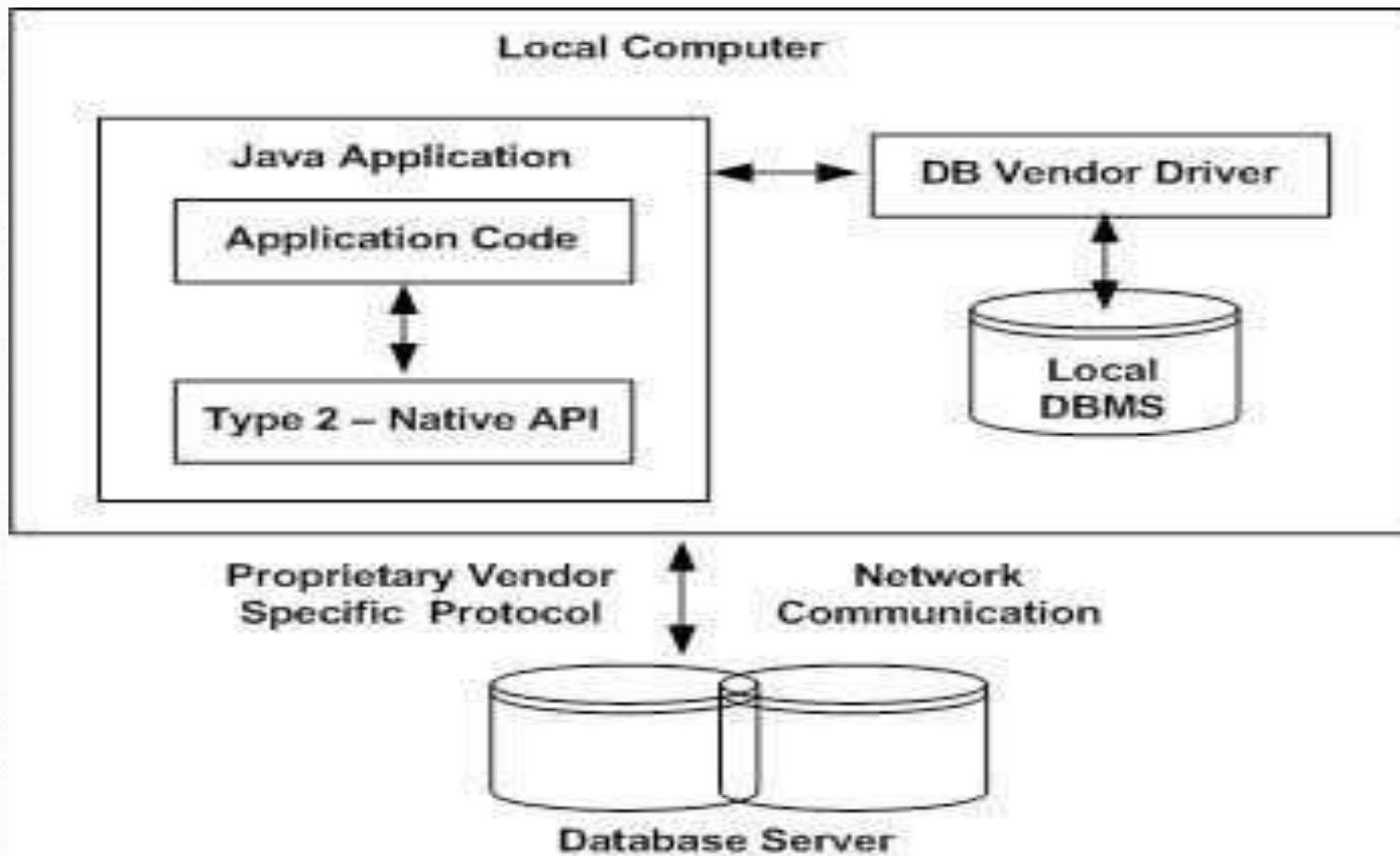




# Type 2: JDBC-Native API

- In a Type 2 driver, JDBC API calls are converted into native C/C++ API calls which are unique to the database.
- These drivers typically provided by the database vendors and used in the same manner as the JDBC-ODBC Bridge, the vendor-specific driver must be installed on each client machine.
- If we change the Database we have to change the native API as it is specific to a database and they are mostly obsolete now but you may realize some speed increase with a Type 2 driver, because it eliminates ODBC's overhead.
- The Oracle Call Interface (OCI) driver is an example of a Type 2 driver.

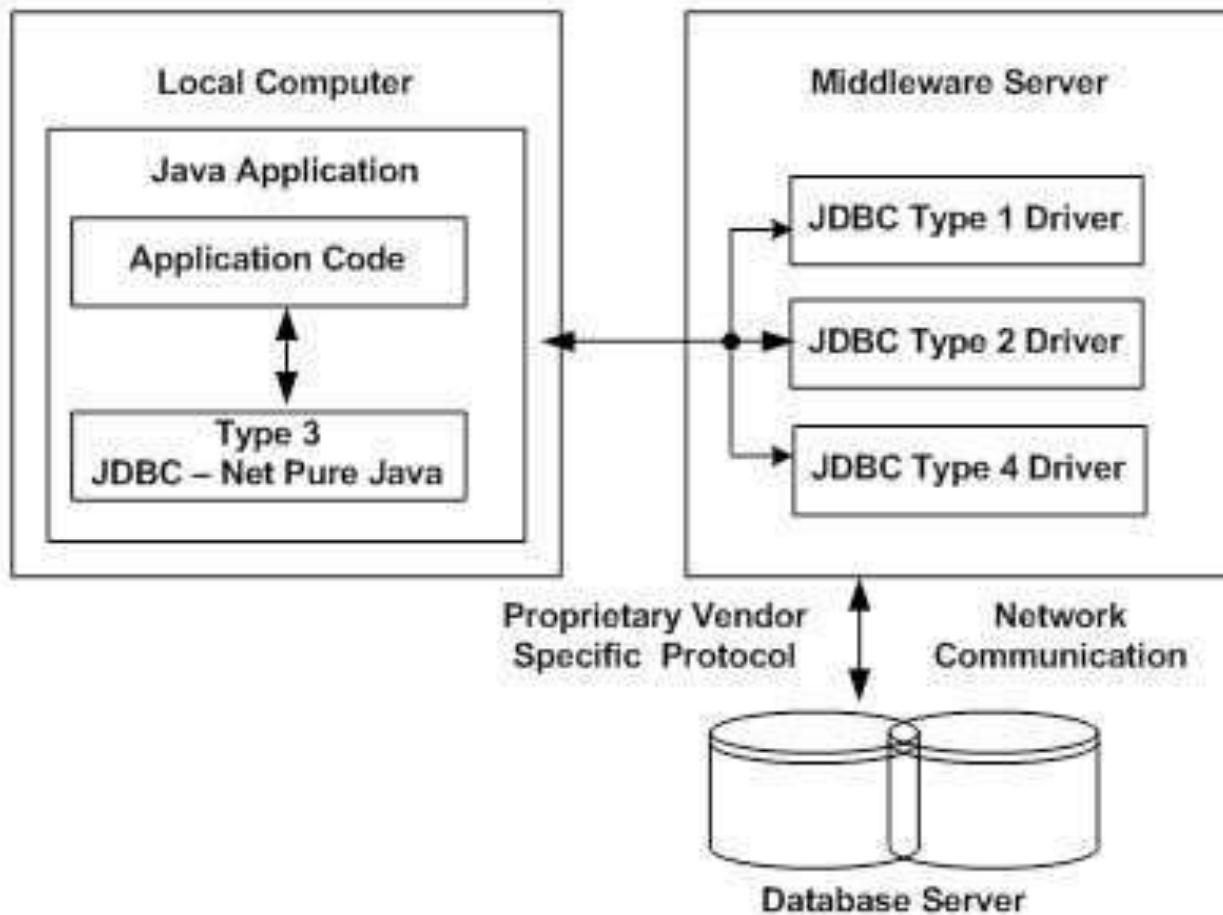
# Type 2: JDBC-Native API



# Type 3: JDBC-Net pure Java

- In a Type 3 driver, a three-tier approach is used to accessing databases.
- The JDBC clients use standard network sockets to communicate with an middleware application server. The socket information is then translated by the middleware application server into the call format required by the DBMS, and forwarded to the database server.
- This kind of driver is extremely flexible, since it requires no code installed on the client and a single driver can actually provide access to multiple databases

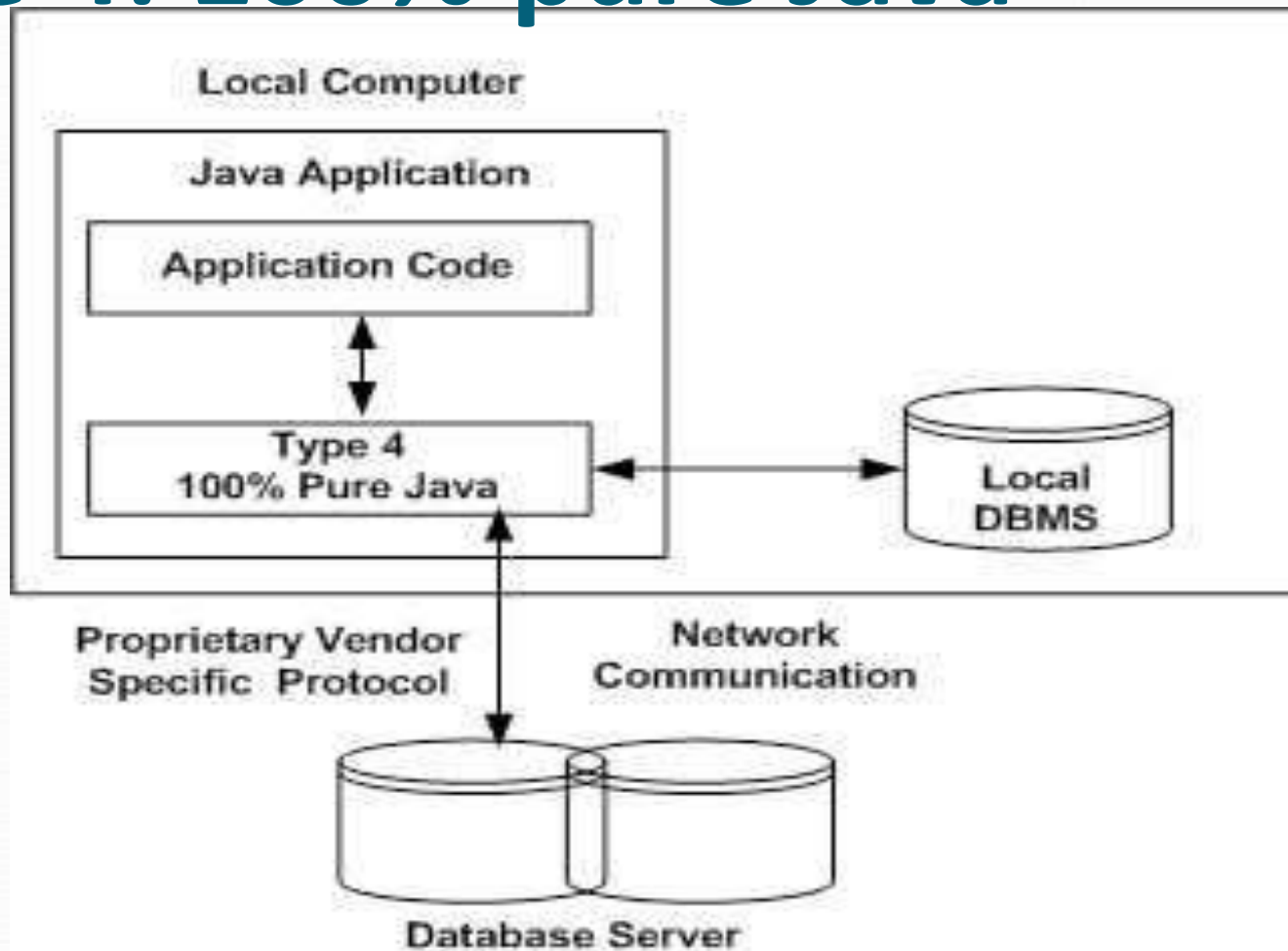
# Type 3: JDBC-Net pure Java



## Type 4: 100% pure Java

- In a Type 4 driver, a pure Java-based driver that communicates directly with vendor's database through socket connection.
- This is the highest performance driver available for the database and is usually provided by the vendor itself.
- This kind of driver is extremely flexible, you don't need to install special software on the client or server. Further, these drivers can be downloaded dynamically.
- MySQL's Connector/J driver is a Type 4 driver. Because of the proprietary nature of their network protocols, database vendors usually supply type 4 drivers.

# Type 4: 100% pure Java



## Which Driver should be used?

- If you are accessing one type of database, such as Oracle, Sybase, or IBM, the preferred **driver type is 4**.
- If your Java application is accessing multiple types of databases at the same time, **type 3** is the preferred driver.
- **Type 2** drivers are useful in situations where a type 3 or **type 4** driver is not available yet for your database.
- **The type 1** driver is not considered a deployment-level driver and is typically used for development and testing purposes only.