CSYE 6200

Concepts of Object Oriented Design

Introduction to Eclipse

Daniel Peters

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Cross Platform Tools

- IntelliJ IDE (useful for installing JDK)
  https://www.jetbrains.com/idea/download/#section=mac
- Java JDK, NetBeans Bundle:
  http://www.oracle.com/technetwork/java/javase/downloads/jdk-netbeans-jsp-142931.html
- Eclipse: IDE for Java Developers
  https://www.eclipse.org/downloads/packages/
- NetBeans IDE
  https://netbeans.apache.org//

Resources (Cont'd)

- Java Standard Edition 8 Documentation
  http://docs.oracle.com/javase/8/docs/api/
- Java SE 8 Documentation Download
  http://www.oracle.com/technetwork/java/javase/documentation/jdk8-doc-downloads-2133158.html

Resources (Cont'd)

- Java Tutorial
  http://docs.oracle.com/javase/tutorial/tutorialLearningPaths.html
- Eclipse Documentation
  https://eclipse.org/users/

Additional Tools:

- jGRASP:
  https://www.jgrasp.org/
- Cygwin (for Unix commands on Windows):
  https://www.cygwin.com/

Using Eclipse

1. Set Eclipse Workspace directory
   - **workspace_2020_09_dan_peters_ex1**
2. Create Java Project
   - **project1**
3. Create Package
   - **edu.neu.csye6200**
4. Create ONLY class containing main
   - **Driver**
5. Create other classes as needed

Eclipse Start-up

- Set Eclipse Workspace directory
  - Will contain all Eclipse work
  - Can be changed anytime to restart or switch tasks
  - Use a meaningful name indicating version, language and task AND YOUR NAME
    - workspace_2020_09_dan_peters_ex1
- Click on Workbench Icon (upper right) to begin using IDE

New Project

- Keyboard Shortcut for File > New menu:
  - MacOSX: [COMMAND] [OPTION] N
  - Windows: [ALT] [SHIFT] N
  - Select Java Project from pop-up New menu
- Menu:
  - File > New > Java Project
  - OR
    - File > New > Project
    - Expand Java (click on arrow head left of Java)
      - Click Java Project

New Project

- Type Project name
  - Name project with all lowercase
    - project1
    - Click FINISH

New Package

- Classes are grouped and organized in packages
- Alternatively, Packages can be created with class
- Menu:
  - File > New > Package
  - Name package with all lower case
    - edu.neu.csye6200
    - Click FINISH

New Class

- Keyboard Shortcut for File > New > Class:
  – MacOSX: [COMMAND] [OPTION] N C
  – Windows: [ALT] [SHIFT] N C
- Menu:
  – File > New > Class

New Class

- Name class with initial Capital
  - Driver
- Package:
  - edu.neu.csye6200
- Click to Select
  - [x] public static void main(String[] args)
  - Use all other default selections unchanged
  - Click FINISH

Eclipse Package Explorer

- Window > Show View > Package
- Left Most Frame is Package Explorer:
  - Double-Click on **project1** to expand
  - Double-Click on **src** to expand
  - Double-Click on **edu.neu.csye6200** to expand
- Java source files (**.java**) are organized
  - Under package (**edu.neu.csye6200**)
  - Packages are under source file directory (**‘src’**)
  - Source directories are under project (**project1**)

Run Configuration

- Package Explorer:
  - Right Click on Driver.java
  - Select Run As > Run Configurations
  - Double-Click Java Application
  - Click Run
    - Keyboard Shortcut:
      - MacOSX: [COMMAND][SHIFT] F11
      - Windows: [CONTROL] F11
    - (the program is not doing anything… yet!)

Eclipse Console

- Menu:
  - Window > Show View > Console

Edit Driver.java

- Package Explorer:
  - Double-Click on Driver.java

```
package edu.neu.csye6200;

public class Driver {

   public static void main(String[] args) {
       // TODO Auto-generated method stub

   }
}
```

Edit Driver.java

- Editor Window:
  - Type to add “System.out.println …” code statement as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Driver {

   public static void main(String[] args) {
        // TODO Auto-generated method stub
        System.out.println("Driver executing main…");
   }
}
```

Run Program

- Menu:
  - Run > Run

- The output on the console should look like

```
Driver executing main…
```

New Class

- Keyboard Shortcut for File > New > Class:
  - MacOSX: [COMMAND] [OPTION] N C
  - Windows: [ALT] [SHIFT] N C
  - (OR, USE Menu to create new class):
    - File > New > Class

  - Name class with initial Capital
    - Shout
  - Click to Select
    - Click FINISH

Edit Shout.java

- Package Explorer:
  - Double-Click on Shout.java

```
package edu.neu.csye6200;

public class Shout {

}
```

Edit Shout.java

- Editor Window:
  - Type to add code as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Shout {
   private int age = 0;
   private String fname = "John";
   private char mi = 'C';
   private String lname = "Doe";

}
```

Edit Shout.java

- Editor Window
  - Right-Click
    - Source > Generate Constructor using Fields
    - Click Deselect All
    - Select Insertion Point: After lname
    - Click OK
- Save changes to Shout.java
  - CONTROL-S

Edit Shout.java

- Editor Window
  - Right-Click
    - Source > Generate Constructor using Fields
    - Click Select All
    - Select Insertion Point: After ‘Shout()’
    - Click OK
- Save changes to Shout.java
  - CONTROL-S

Edit Shout.java

- Editor Window
  - Right-Click
    - Source > Generate Setters and Getters
    - Click Select All
    - Select Insertion Point: After Shout(int, String, …
    - Click OK
  - Save changes to Shout.java
    - CONTROL-S

Edit Driver.java

- Package Explorer:
  - Double-Click on Driver.java
  - Type to add the following code (just before the TWO closing curly braces '}') and save changes (CONTROL-S):

```
   Shout s = new Shout();
   System.out.println("Are you: "
              + s.getFname()
              + " " + s.getMi()
              +". " + s.getLname()
              + ", " + s.getAge()
              +" years of age?");
   }
}
```

Run Program

- Menu:
  - Run > Run

- The output on the console should look like

```
Driver executing main…
Are you: John C. Doe, 0 years of age?
```

CSYE 6200

Concepts of Object Oriented Design

Introduction to Git

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Resources on the Web

- Git

  https://git-scm.com/

  •GitHub

  https://github.com/

  •Tutorials

  https://www.atlassian.com/git/tutorials/setting-up-a-repository/git-init

  http://www.vogella.com/tutorials/EclipseGit/article.html

Resources on the Web

- Command Summary

  https://confluence.atlassian.com/bitbucketserver/basic-git-commands-776639767.html

  https://www.atlassian.com/git/tutorials/atlassian-git-cheatsheet

Installation

- Git included with Mac OS X
  - Use Terminal app
    - Unix command line in terminal window
- Git included with Cygwin for Windows:
  - Use Cygwin Window
    - Unix command line in Cygwin window
- Portable Git
  - Install on USB thumb drive
    - https://sourceforge.net/projects/gitportable/

Eclipse and eGit

- Eclipse eGit project
  - JGit library
    - Java implementation of Git functionality
  - eGit plug-in
    - Usually already installed
    - Eclipse menu: Help > Eclipse MarketPlace
      - Find: egit
        - » EGIT – Git Integration for Eclipse 4.6.0
  - eGit documentation
    - Eclipse menu: Help > Help Contents
    - Egit Documentation

Eclipse and eGit: .gitconfig

- Eclipse eGit configuration (.gitconfig)
  - Eclipse menu: Preferences > Team Git > Configuration: User Settings
    - Key: name
      - Value: Daniel Peters
    - Key: email
      - Value: d.peters@neu.edu

Eclipse and eGit: Create Repo

- Alternatively
  - RIGHT-CLICK on project
    - Team > **Share Project**

- NOTE: Do NOT create repositories in Eclipse workspace.

Eclipse and eGit: Create Repo

- Git Repositories view
  - Eclipse menu: Window > Show View >> Other
    - Git: **Git Repositories**
      - To Create repositories
      - To Check-out Branch
      - To Create and Delete branches
- NOTE: Do NOT create repositories in Eclipse workspace.

Eclipse and eGit: Create Git Repo

- Configure Git Repository
  - CLICK **Create** (repository location)
  - Create a New Git Repository
    - /Users/danielgmp/git/**FirstGitRepo**
    - CLICK **FINISH**
- CLICK **FINISH**

Eclipse and eGit: Commit

- Git Staging view
  - Eclipse menu: Window > Show View >> Other
    - Git:
      - **Git Staging**
        - » Shows changed files
        - » Shows Staged changed files (ready for next commit)
        - » Supports Dragging files (staged, unstaged)
        - » Commit Staged changes

Eclipse and eGit: Commit

- Alternatively
  - RIGHT-CLICK on file in project
    - Team > **Add**
      - **REQUIRED:** ***stage*** current uncommitted changes in file.
        - » NOTE: THIS IS A **SNAPSHOT**: Edits to this file made subsequent to this ***stage*** would again have to be added.
    - Team > **Remove from index** (OPTIONAL UNDO)
      - ***Un-stage*** snapshot of changes in file.
    - Team > **Commit**
      - Add comment describing snapshot to be committed.
      - CLICK COMMIT
        - » Commits all stage changes to Git repository.

Eclipse and eGit: Revert

- RIGHT-CLICK on file in project
  - "Replace With..." -> "HEAD Revision”
  - "Replace With..." -> ”Local History"

Eclipse and eGit: Compare

- RIGHT-CLICK on file in project
  - ”Compare With..." -> "HEAD Revision”
  - ”Compare With..." -> ”Local History"

Git

- Fast
- Commits snapshots of your changes (edits) as complete files (not diffs like svn)
- Everybody has their own git repository
- Repository creation (git init) places a single .git file in top of source directory tree (remainder of tree untouched by git)
- **Optional** Central repository
  - Repository to Repository collaboration

Create Git Local Repository

- Repository creation (git init) places a single .git file in top of existing source directory tree (remainder of tree untouched by git)
- Example (MacOsX Terminal):

```
% mkdir myLocalRepo
% cd myLocalRepo
% git init
```

Create Git Local Repository

- Repository creation (git clone) internally performs a git init then clones (i.e. copies) data from an existing repository (specified by it's URL)
- Example (MacOsX Terminal):

  % git init remoteGitRepoURL

Git Configuration

- Configuration (git config) information for git
  git config configKey configValue
- Example (MacOsX Terminal):
  % git config – global user.email EmailAddress
  % git config –global user.name UserName
  % git config -l

Using Git Locally

- Create your local Git Repository
  - Make any changes to your files then your files (with any changes) go into your repository
    - **Files go into repository in TWO STEPS**:
      1. Add file(s)
      2. Commit file(s)

      Add -> Commit

      OR

      Add, Add … -> Commit

Using Git Locally

Create Local Repository

Add -> Commit

- Create your own local Git Repository
- Your files (with any edits) go into your repository
  1. Add (stage) edits (changes) in file(s) to git repository
  2. Commit ALL staged edits (changes) in file(s) to git repository

Using Git Locally

- Create Git Repository

1. Add (stage) edits (changes) in file(s) to git repository
2. Commit ALL staged edits (changes) in file(s) to git repository

Using Git Locally

- Create Git Repository
  git clone existingRepositoryURL

1. Add (stage) edits (changes) in file(s) to git
2. Commit ALL staged edits (changes) in file(s) to git repository

Using Git Locally

- Create Git Repository
  git init src_directory

1. Add (stage) edits (changes) in file(s) to git
2. Commit ALL staged edits (changes) in file(s) to git repository

Using Git Locally

- Create Git Repository
  git init src_directory

1. Add (stage) edits (changes) in file(s) to git
   git add someFileName
2. Commit ALL staged edits (changes) in file(s) to git repository

Using Git Locally

- Create Git Repository
  git init src_directory

1. Add (stage) edits (changes) in file(s) to git
   git add someFileName
2. Commit ALL staged edits (changes) in file(s) to git repository
   git commit someFileName –m “description”

Using Git

- Create Git Repository
  git init src_directory
  git clone
  git init --bare repo_directory

1. Add (stage) edits (changes) in file(s) to git
2. Commit ALL staged edits (changes) in file(s) to git repository
3. Push latest edits from local repo to remote repo

Creating Git Repository

- Create a Shared Git Central Repository
  - Create a BARE (empty) central (shared) remote repository
    - git init --bare myproject1.git

Creating Git Repository

- Create your personal Git Local Repository
  - Create a local (in current directory) developer repository
    - git init
  - OR Clone an existing git repository
    - git clone /someDir/myproject1.git

Create .gitignore

- Create .gitignore file in top directory of repository
  - Ignore C++ object files

    *.o
  - Ignore Java .class files

    *.class

Adding edits to Git

- Add (stage) the changes (edits) currently contained in specified files
  - Add (stage) current edits in **ALL files** to your personal Git repository
    - git add .
  - Add (stage) current edits in **one file** to your personal Git repository
    - git add oneFilename
- If files are edited again, *they must be added again* for the new changes to be staged.

Committing edits to Git repository

- Commit **ALL staged changes** (edits) to your personal Git repository
  git commit –m “log message.”
- ONLY Committed changes (edits) are safely in your personal Git repository and available for recall, if you want to revert changes (go back to an older version) in your files.

Using Git Collaboratively

- Allows for team SW development
  - Everyone making changes to files
    - Everyone creates their own local Git repository
    - Everyone's file edits go into their local repository
  - Everyone uploading their changes to one common central repository
    - Create one remote central Git repository
    - Periodically, Everyone uploads their edits from their local repository to the remote central repository

Create Central Git Repository

- A Central repository is optional
- Allows for Repository-to-Repository multi-developer collaboration
  - Everyone push their changes to central repository from time to time (periodically) to sync up all edits from all developers
- Allows for Off-line Central Repository support
  - Can push changes later when back on-line

Using Git Collaboratively

Create one common Central Repository

Also Create Local Repository

Add -> Commit -> Push

- Create a Central Git Repository
  - Also Create your own local Git Repository
- Your files (with any edits) go into your local repository
- Push (your latest changes) from your local repository to common Central Repository

Using Git Collaboratively

- Create Git Repository: Central and Local

1. Your files (with any edits) go into your local repository
   - Add (stage) edits (changes) in file(s) to git repository
   - Commit ALL staged edits (changes) in file(s) to git repository
2. Push your latest edits from your local repository to remote central repository
   - Can happen anytime, when back on-line

Using Git Collaboratively

- Create Git Repository: Central and Local

1. Add (stage) edits (changes) in file(s) to local git repository as usual
2. Commit ALL staged edits (changes) in file(s) to local git repository as usual
3. Push latest edits from local git repository to remote central repository

Using Git Collaboratively

- Create one Git Central Repository
  git init --bare repo_directory
- Create yout Git Local Repository
  git init src_directory

1. Add (stage) edits (changes) in file(s)
2. Commit ALL staged edits (changes) in file(s) to git local repository
3. Push latest edits from local repository to remote central repository

Create Central Git repository

- Create a bare remote central repository
  git init --bare   ../../Repo/Demo1.git
- Set-up access to remote central repository from local repository as ***origin***
  git remote add **origin** ../../Repo/Demo1.git
- Push ***initial*** edits from local repository to the remote central repository
  git push –set-upstream **origin** master

Push edits to central Git repository

- Periodically push the latest edits (since the last push) to central repository to allow all developer repositories to sync up with all the latest edits

  git push origin master

CSYE 6200

Concepts of Object Oriented Design

Introduction

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- Course Objectives
  1. Understand pragmatic design and implementation of OO Design.
  2. Gain a working knowledge of Encapsulation, Data Abstraction, Inheritance and Polymorphism.
  3. Learn design decomposition for distributed and managed software development.

- Course Objectives
    1. Understand GUI programing with Swing components.
    2. Learn Network Programming with Sockets.
    3. Develop familiarity with Eclipse IDE and NetBeans RCP Framework.

- Course Grading
- Attendance and Participation: 10%
  - Zoom Video Camera On
- Individual Assignments: 40%
- Mid-term Exam: 25%
- Final Exam: 25%

- NOTE department attendance policy in Syllabus

Java Standard Edition (SE)

- Java SE Development Kit 8
  - Java SE JDK 8
- Eclipse IDE 2019-09 R
  - Eclipse IDE for **Java Developers**
  - **(NOT** Enterprise Java Developers**)**
- Java Standard Edition Documentation
  - Java SE 8 API

Uniform Class Conventions

1. Eclipse IDE workspace for all submissions
   workspace-201909-dan-peters-assign1.zip
2. Java Project Name:
   project
3. Java NEU Package:
   edu.neu.csye6200
4. Java program entry point:
   – Only Driver class has main method
     - Driver.java

CSYE 6200

Concepts of Object-Oriented Design

Object Oriented (OO) Concepts

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Fundamental Object Oriented

- Class
- Object

- Borrows from real life
  - Life has different things
    - Rock, Tree, Person, Car, School, Education, etc.
  - We use things in life
    - Throw Rock, Drive car, Obtain Education, etc.

Demonstrate OOP in Java

1. Create a file
   Driver.java
2. Create Driver class in file Driver.java

public class **Driver {**

} // useless do nothing class

3. Compile class Driver.java
   javac Driver.java
4. Execute class Driver (???)
   java Driver

Javac Java Compiler

- Java Compiler: **javac**
  - Java is a compiled language
    - Can't execute source code
  - Source file Driver.java contains source code
    - **Driver.java** is a text file containing java code
  - Compilation creates class file from source file
    - **Driver.class** is a binary file containing java bytecode

Java: Java Execute Command

- Java command: **java**
  - Used to set up Java run-time environment to execute java class files
  - Java Class files contain ***Bytecodes***
  - Bytecodes are interpreted by the ***Just In Time* (JIT)** compiler in the ***Java Virtual Machine* (JVM)**

Complete Driver.java

- Create a *complete* Driver class with a class member method main (in file Driver.java)
  - *Note: **Driver** class is using **System** class*

```
public class Driver {
    public static void main(String[] args) {
        System.out.println("Hello World!");
    }
}
```

- Compile class Driver.java: **javac** Driver
- Execute class Driver: **java** Driver

CONSOLE OUTPUT

Hello World!

Class System

- Part of Java Class Library
- Used to interact with user through system console device
  - Output text data to console (standard output) device (**stdout**)
  - Output error text data to console (standard error) device (**stderr**)
  - Input text data from console (standard input) device (**stdin**)

4 Object Oriented Principles

- Abstraction
- Encapsulation
- Inheritance
- Polymorphism

Class

- Specification used to instantiate object
  - EXCEPTIONS
    - Interface
    - Abstract (pre Java 8)
- Both data and methods ENCAPSULATED together in same class
- Everything required to instantiate one or more object

Class

- Data: state
  - Class (global) data
    - **static**
    - Single copy associated only with class
    - Program Scope:
      - Does not require instantiation: available entire program
  - Instance object data
    - Non-static
    - Unique copy associated with each object
    - Object instance Scope:
      - Requires object instantiation

Class

- Methods operate on member data
  - **static**
    - Associated with the class
    - Does not require object instantiation
  - Non-static
    - Associated with each object
    - Object must be instantiated
- Abstract
  - Function signature only (pre Java 8)
  - Must be implemented for instantiation

Object Oriented Design (OOD)

- Object Oriented Design
  - Objects Model Real Life
  - Think Block Diagram

Object Oriented Design (OOD)

- Object Oriented Design
  - Abstraction
    - Black Box
  - Encapsulation
    - Data and Method Co-located together in same class
  - Inheritance
  - Polymorphism
    - Many forms
- Objects Model Real Life
- Think Block Diagram

Object Oriented Design (OOD)

- Abstraction (Black Box)
  - Data Hiding
    - Access Modifiers
      - public
      - private
      - Protected (package private)
      - (default)
  - Functionality Hiding
    - Java Concrete class
    - Java Interface
    - Java Abstract class
    - Used for Application Programming Interface (API)

Object Oriented Design (OOD)

- Encapsulation
  - Data and Method Co-located together in same class
    - Private data members
      - NOT accessible by any other classes
    - Public API methods
      - API defines how class is usable by other classes

Object Oriented Design (OOD)

- Inheritance
  - Super (Parent) class
    - API
      - Java Interface or abstract class
        - » Specify “What” without “How”
    - A *general* implementation
      - Default implementations
        - » Java concrete or abstract class
  - Derived (child or sub) class
    - A more specific implementation of parent class

Object Oriented Design (OOD)

- Polymorphism (many forms)
  - Inheritance
    - Super class (Parent base class)
    - Sub-class (Derived child class)
    - At run-time, super class variable is used as API and subclass method is called.

Object Oriented Design (OOD)

- Polymorphism (many forms)
  1. Overloaded methods
     - Same name
     - Different signatures
       - Number of parameters
       - Types of parameters
  2. Overridden methods (@Override)
     - Run-time polymorphism
     - Derived child class overrides method in parent base class (super class) to provide customized method

OOD Benefits

- Benefits of Object-Oriented Design
  - Simplicity: readable code
  - Flexibility: easy to refactor and change
  - Scalability: adaptable
  - Testability: unit test
  - Maintainability: easy to fix bugs
  - Design Decomposition
    - From complex problem to basic components
    - Phased development effort
    - Distributed Team development

CSYE 6200

Concepts of Object-Oriented Design

Introduction

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- Digest
    1. Resources
    2. Tutorials
    3. Reference
    4. Object-Oriented Design

Resources on the Web

- Java Development Kit (JDK)

https://www.oracle.com/java/technologies/jdk8-downloads.html

- Eclipse IDE for Java Developers

https://www.eclipse.org/downloads/packages/

- jGrasp IDE

https://www.jgrasp.org/

- Apache NetBeans

https://netbeans.apache.org/download/index.html

Resources on the Web (Cont'd)

- TutorialsPoint Online Java IDE

https://www.tutorialspoint.com/compile_java_online.php

- Online GDB Java Compiler

https://www.onlinegdb.com/online_java_compiler

Resources on the Web (Cont'd)

- Java Standard Edition 8 Documentation

  http://docs.oracle.com/javase/8/docs/api/
- Eclipse Documentation

  https://eclipse.org/users/

Java Tutorials on the Web

- TutorialsPoint:

https://www.tutorialspoint.com/java/index.htm

- W3schools.com

https://www.w3schools.com/java/

Java Tutorials on the Web (Cont’d)

- Oracle Tutorials:

https://docs.oracle.com/javase/tutorial/

https://docs.oracle.com/javase/tutorial/tutorialLearningPaths.html

Reference

- Books
  - *Java: A Beginner's Guide* by Herbert Schildt, 6th Edition, Osborne/Mcgraw Hill, ISBN-13: 978-0071809252, ISBN-10: 0071809252
  - *Java: A Completer Reference* by Herbert Schildt, 10th Edition, Osborne/ Mcgraw Hill, ISBN-13: 978-0071808552, ISBN-10: 0071808558
  - *Head First Java* by Bert Bates, Kathy Sierra, 2nd Edition, O'REILLY, ISBN-13: 978-0-596-00920-5, ISBN-10: 0-596-00920-8

Reference (Cont'd)

- Books
  - *Head First Design Patterns* by Eric Freeman, Bert Bates, Kathy Sierra, Elisabeth Robson, 1st Edition, O'REILLY, ISBN-13: 000-0-596-00712-4, ISBN-10: 0-596-00712-4
  - *Java: How to Program* by Deitel, 7-10th Edition, Prentice Hall, ISBN-13: 978-0132575669, ISBN-10: 0132575663

Reference (Cont'd)

- Books
  - *Thinking in Java* by Bruce Eckel, 4th Edition, Prentice Hall, ISBN-13: 978-0131872486, ISBN-10: 0131872486
  - *Effective Java* by Joshua Bloch, 2nd Edition, Addison-Wesley, ISBN-13: 860-1300201986, ISBN-10: 0321356683

Object Oriented Design

- Object-Oriented Design
  - Encapsulation
    - Data and Method Co-located together
  - Abstraction
    - Black Box hiding details
  - Inheritance
  - Polymorphism
    - Many forms
- Think Block Diagram

Benefits

- Benefits of Object-Oriented Design
  - Simplicity
  - Flexibility
  - Scalability
  - Testability
  - Maintainability
  - Design Decomposition

Eclipse Start-up

- Set Workspace
  - **workspace-202006_Dan_Peters_Assign1**
- Click on Workbench Icon (upper right)

New Project

- Keyboard Shortcut for File > New menu:
  - MacOSX: [COMMAND] [OPTION] N
  - Windows: [ALT] [SHIFT] N
  - Select Java Project from pop-up New menu
- Menu:
  - File > New > Java Project
  - OR
    - File > New > Project
    - Expand Java (click on arrow head left of Java)
      - Click Java Project

New Project

- Type Project name
  - Name project with ALL LOWERCASE letters
    - **project**
    - Click FINISH

New Package

- Classes are grouped and organized in packages
- Alternatively, Packages can be created with class
- Menu:
  - File > New > Package
  - Name package with all lower case
    - **edu.neu.csye6200**
    - Click FINISH

New Class

- Keyboard Shortcut for File > New > Class:
- MacOSX: [COMMAND] [OPTION] N C
- Windows: [ALT] [SHIFT] N C
- Menu:
- File > New > Class

New Class

- Name class with initial Capital
  - **Driver**
- Package:
  - **edu.neu.csye6200**
- Click to Select
  - [**X**] public static void main(String[] args)
  - Use all other default selections unchanged
  - Click FINISH

Eclipse Package Explorer

- Window > Show View > Package
- Left Most Frame is Package Explorer:
  - Double-Click on **project** to expand
  - Double-Click on **src** to expand
  - Double-Click on **edu.neu.csye6200** to expand
- Java source files (**.java**) are organized
  - Under package (**edu.neu.csye6200**)
  - Packages are under source file directory (**‘src’**)
  - Source directories are under project (**Project**)

Run Configuration

- Package Explorer:
  - Right Click on Driver.java
  - Select Run As > Run Configurations
  - Double-Click Java Application
  - Click Run
    - Keyboard Shortcut:
      - MacOSX: [COMMAND][SHIFT] F11
      - Windows: [CONTROL] F11
    - (the program is not doing anything… yet!)

Eclipse Console

- Menu:
  - Window > Show View > Console

Edit Driver.java

- Package Explorer:
  - Double-Click on Driver.java
  - Eclipse generated class code shown below

```
package edu.neu.csye6200;

public class Driver {

 public static void main(String[] args) {
     // TODO Auto-generated method stub

  }
}
```

Edit Driver.java

- Editor Window:
  - Type to add “System.out.println …” code as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Driver {

 public static void main(String[] args) {
     // TODO Auto-generated method stub
     System.out.println("This is a Java Program Console Output String!");
 }
}
```

Run Program

- Menu:
  - Run > Run
  - Keyboard Shortcut for Run > Run:
  - MacOSX: [COMMAND] [SHIFT] [F11]
  - Windows: [CONTROL] [F11]
- The output on the console should look like:

```
This is a Java Program Console Output
 String!
```

Edit Driver.java

- Editor Window:
  - Type to add “System.out.println …” code as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Driver {
 public static void main(String[] args) {
     // TODO Auto-generated method stub
     System.out.println("This is a Java Program Console
 Output String!");

JOptionPane.showMessageDialog(null, "My first Java Swing program!");
  }
}
```

Edit Driver.java

- Editor Window:
  - Type to add “System.out.println …” code as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Driver {
 public static void main(String[] args) {
     // TODO Auto-generated method stub
     System.out.println("This is a Java Program Console
 Output String!");

//JOptionPane.showMessageDialog(null, "My first Java Swing program!");
  }
}
```

New Class

- Menu:
  - File > New > Class
  - Name class with initial Capital
    - Person
  - Click to Select
    - Click FINISH

Edit Person.java

- Package Explorer:
  - Double-Click on Person.java
  - Eclipse generated initial java class code, shown in Eclipse center Editor frame

```
package edu.neu.csye6200;

public class Person {

}
```

Edit Person.java

- Editor Window:
  - Type to add code as below and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Person {
 public int age = 0;
 public String firstName = "John";
 public char mi = 'C';
 public String lastName = "Doe";

}
```

Edit Person.java

- Editor Window
  - Right-Click
    - Source > Generate Constructor using Fields
    - Click Select All
    - Select Insertion Point: First member
    - Click OK
- Save changes to Person.java
  - CONTROL-S

Edit Person.java

- Editor Window
  - Right-Click
    - Source > Generate Constructors from Superclass…
    - Click Select All
    - Select Insertion Point: First member
    - Click OK
- Save changes to Person.java
  - CONTROL-S

Edit Person.java

- Editor Window
  - Right-Click
    - Source > Generate Setters and Getters
    - Click Select All
    - Select Insertion Point: After Person(int, String, …
    - Click OK
  - Save changes to Person.java
    - CONTROL-S

Edit Driver.java

- Package Explorer:
  - Double-Click on Driver.java
  - Type to add the following code (just before the TWO closing curly braces ‘}’) and save changes (CONTROL-S):

```
 Person s = new Person();
 System.out.println("I am: "
          + s.getFirstName()
          + " " + s.getMi()
          +". " + s.getLastName()
          + ", " + s.getAge()
          +" years of age!");
 }
}
```

Java Import

- Package Import:
  - Package java.lang imported by default
  - All other packages must be imported
    - import java.util.ArrayList;
    - import java.util.*;
- Menu:
  - Source > Add Import
    - MacOSX: [COMMAND] [SHIFT] M
  - Source > Organize Imports
    - MacOSX: [COMMAND] [SHIFT] O

Run Program

- Menu:
  - Run > Run

- The output on the console should look like

```
This is a Java Program Console Output
 String!
I am: John C. Doe, 0 years of age!
```

Edit Person.java

- Editor Window:
  - Type to add code for a static demo method as below AND FILL IT IN so it does all that Driver did (and can be called from Driver to perform the same console output) and save changes (CONTROL-S):

```
package edu.neu.csye6200;

public class Person {
 public int age = 0;
 . . . .
 public static void demo() {
   . . . .
  }

}
```

Edit Driver.java

- Package Explorer:
  - Double-Click on Driver.java
  - Type to add the following code (just before the TWO closing curly braces '}') and save changes (CONTROL-S):

```
 Person s = new Person();
 System.out.println("I am: "
          + s.getFirstName()
          + " " + s.getMi()
          +". " + s.getLastName()
          + ", " + s.getAge()
          +" years of age!");
   Person.demo();     // static demo method to do same
 }
}
```

Run Program

- Menu:
  - Run > Run

- The output on the console should look like

```
This is a Java Program Console Output
 String!
I am: John C. Doe, 0 years of age!
This is a Java Program Console Output
 String!
I am: John C. Doe, 0 years of age!
```

CSYE 6200

Concepts of Object Oriented Design

Introduction References

Daniel Peters

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Resources on the Web

- IntelliJ (useful for installing JDK)
- Eclipse IDE for Java Developers
  https://www.eclipse.org/downloads/packages/
- Apache NetBeans
  https://netbeans.apache.org//

Old Resources on the Web

- Java Development Kit (JDK)
  https://www.oracle.com/java/technologies/jdk8-downloads.html
- NetBeans IDE
  https://netbeans.org/downloads/8.2/

Resources on the Web

- jGRASP
  https://www.jgrasp.org/

Resources on the Web

- Online IDE
  https://www.tutorialspoint.com/compile_java_online.php
- Online Compiler
  https://www.onlinegdb.com/online_java_compiler
-

Resources (Cont'd)

- Java Standard Edition 8 Documentation
  http://docs.oracle.com/javase/8/docs/api/
- Java SE 8 Documentation Download
  http://www.oracle.com/technetwork/java/javase/documentation/jdk8-doc-downloads-2133158.html
- Java Tutorial
  http://docs.oracle.com/javase/tutorial/tutorialLearningPaths.html

Resources (Cont'd)

- Oracle: Java A Beginners Guide (chapter 1)
  http://www.oracle.com/events/global/en/java-outreach/resources/java-a-beginners-guide-1720064.pdf
- Eclipse Documentation
  https://eclipse.org/users/

References

- Reference Books
  - *Java: A Beginner's Guide* by Schildt, 6th Edition, Oracle Press, ISBN-13: 978-0-07-180925-2, ISBN-10: 0-07-180925-2
  - *Java: How to Program* by Deitel, 7-10th Edition, Prentice Hall, ISBN-13: 978-0132575669, ISBN-10: 0132575663
  - *The Complete Reference* by Schildt, 8th Edition, Oracle Press, ISBN-13: 978-0-07-160631-8, MHID: 0-07-160631-9

References (cont'd)

- Reference Books
  - *Thinking in Java* by Bruce Eckel, 4th Edition, Prentice Hall, ISBN-13: 978-0131872486, ISBN-10: 0131872486
  - *Effective Java* by Joshua Bloch, 2nd Edition, Addison-Wesley, ISBN-13: 860-1300201986, ISBN-10: 0321356683
  - *Head First Design Patterns* by Eric Freeman, Bert Bates, Kathy Sierra, Elisabeth Robson, 1st Edition, O'REILLY, ISBN-13: 000-0-596-00712-4, ISBN-10: 0-596-00712-4

References (cont'd)

- Reference Books
  - *Head First Java* by Kathy Sierra, Bert Bates, 2nd Edition, O'REILLY, ISBN-13: 978-0-596-00920-5, ISBN-10: 0-596-00920-8

CSYE 6200

Concepts of Object Oriented Design

V4 9/16/2015

Java Classes and Objects

Daniel Peters
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- Lecture
  1. Java Classes and Objects
     1. Java Object Oriented Programming
     2. Package organization of java classes
     3. Java Class Details

Java Object Oriented Programming

- Object Oriented Programming (OOP)
  1. Classes are specified
  2. Classes are instantiated into useable objects
  3. Objects are used as the functional building blocks of the executing java program

Person Class

```
public class Person {
        public int age = 0;
        public String name = null;
        // class default constructor
        public Person() {
                this.age = 3;
                this.name = "Joe";
        }
    }
```

NOTE: ‘**public**’ class data for trivial example

Driver Class specification

```
public class Driver {
  // main() method
  public static void main(String [] args) {
      Person object1 = new Person();
      System.out.println(object1.name
      + “ is “ + object1.age);
  }
}
```

Java OOP: Class Specification

- Class specification
  - Each Java class is written (coded in java) in a single '***.java***' text file
  - Java code (classes) **MUST** be compiled using the java compiler:

javac *Driver***.java** *Person***.java**

Java OOP: Object Instantiation

- Object Instantiation
  - A compiled Java program is executed (begins running) using the **'java'** command:

    java *Driver*

    •program execution ALWAYS begins in **main()** method
  - A running java program executes java statements one after another beginning with the first java statement in (the designated) **main()** method

Java OOP: Object Instantiation

- Classes are instantiated into useable objects
  - Program execution begins in **main()** method in the Driver class
    - Java program executes **java statements** one after another beginning in the **main()** method.
    - ALL java statements **end with a semicolon ';'**
  - Java code in **main()** method will:
    - Instantiate objects from class specifications
    - Use objects for ALL program execution
  - Program execution ends when **main()** method exits

Java OOP: Object Instantiation

- Program execution uses program variables
- Program variables are named memory locations used to contain data for program execution
- All program variables MUST BE DECLARED (both type and name announced to java compiler) before they can used by java program

Java OOP: Object Instantiation

- The **main()** method in class **Driver**:

public class **Driver** {

public static void **main**(String [] args) {

Person object1 = *new* **Person();**

. . .

}

}

Java OOP: Object Instantiation

1. Declare program reference variable **‘object1’**:

   Person object1;

   – Type: class **Person**
   – Name: **object1**

2. Instantiate **Person** object from class using keyword ‘***new***’ AND **Person** class constructor

   new **Person()**;

3. Assign (write/save) Instantiated **Person** object to (memory location named) **‘object1’**

– ALL DONE IN A SINGLE Java STATEMENT

Person object1 = *new* **Person();**

Java OOP: Object Usage

- The **main()** method in class Driver:

```
public class Driver {
   public static void main(String [] args) {
         . . .
         System.out.println(object1.name
         + " is " + object1.age);
   }
}
```

Java OOP: Object Usage

- Objects are used as building blocks for a java program
- With one exception, we must instantiate java class as an object to use its members.
  – A class' **static** members may be used without instantiation as an object.
- Use the '.' (dot) to access public data and methods in static classes and instantiated objects

Java OOP: Object Instantiation

System.**out**.*println*(**object1**.*name*
+ " is " + **object1**.*age*);

- The **main()** method uses various objects to access member data, *e.g. out, name, age,* and methods, *e.g. println()*
- Java code use the '**.**' (dot) syntax to access (static or object instantiated) members defined in a class

Java OOP: Object Instantiation

System.**out**.*println*(**object1**.*name*
+ “ is “ + **object1**.*age*);

- Use the Dot **“.”** to :
  1. Access the class **System** static ‘**out**’ object
  2. Call the ‘**out**’ object’s ‘**println()**’ method
  3. Use the (instantiated class **Person**) **‘object1’** to access its **‘age’** and **‘name’** data members
  – ALL IN A SINGLE JAVA STATEMENT

Person Class usage

public class Driver{

public static void **main**(String[] args) {

// instantiate object from class using '*new*' and a class **Person** constructor

Person obj = *new* **Person()**;

System.out.println(**obj**.*name* + " is " + **obj**.*age* + " years old.");

}

}

Person Class usage

OUTPUT

Joe is 3 years old.

Package

- Package
  - Organization of Java class libraries
  - Class libraries are related
  - Hierarchical dot'.' separated name

Package (cont'd)

- Package Name Convention
  - All lower-case package name begin with top level domain
    - edu, com, org, mil, ca, de, uk
  - Followed by organization name
    - ibm, neu, mit, microsoft
  - Followed by any groups, projects or sub-projects within the organization

Package (cont'd)

- Package name examples
  - java.lang
  - java.util
  - java.awt
  - java.swing
  - edu.neu.csye6200.lecture1.misc

Class

- Class
  - public class MyName [extends MySuperClass] [implements MyInterface] {
    - Data
    - Constructor
    - Method
    - }
- All outer class definitions MUST BE public
  - Inner class (defined in a class) may be private

Class (cont’d)

- Class
  - Concrete
    - Declared
    - Fully implemented methods
    - Can be instantiated to create objects

Class (cont'd)

- Class
  - Abstract
    - Declared: public, private or protected members
    - Partially implemented
    - Contains one or more abstract methods
    - Data
      - final or non final
      - static or non-static
    - Must be extended (keyword extends)
    - Cannot be instantiated (without completing implementation)

Class (cont'd)

- Class
  - Interface
    - Contains ONLY public methods
      - 'abstract' methods are unimplemented
      - Java 8 'default' Methods are implemented
      - Java 8 'static' Methods are implemented
    - Data
      - static (class variables) ONLY
      - final (immutable constant values) ONLY
    - Must be implemented (keyword implements)
    - Cannot be instantiated (without completing implementation)

Class (cont'd)

- Class
  - Data
    - Attribute
    - Field
  - Constructor
    - One ore more special Method to instantiate objects
  - Method
    - Function
    - Operation
    - Behavior

Class (cont'd)

- Class
  - Data declaration
    - [static] [final] [public | protected | private] type name
    - [= initializer] ;

Data Types

- Primitive types
  - byte, short, int, long, float, double, boolean, char
  - Passed by value
  - Stack memory allocation

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Data Types

- Reference types
  - Class
  - Passed by reference
  - Heap memory allocation
    - Automatic Garbage Collection (GC)
    - NEVER NEED TO FREE (C++ delete) heap allocation

Class (cont'd)

- Class
  - Static: class global data
    - Single instance of data
    - Associated with class
    - Object instantiation not required
    - Program scope

Class (cont'd)

- Class
  - Non-static: object instance data
    - Default
    - Independent instance with each object
    - Object instantiation required
      - Heap memory allocation
      - DOES NOT EXIST until object created with "new"
    - Object Reference assigned to variable
    - Reference points to Object in heap allocation

Class (cont'd)

- Class
  - final
    - Immutable data item: Constant data
      - Independent constant with each object
        - » final int JOB_ID = 347;
        - » Final String LABEL = "EMPLOYEE";
      - Single instance of data
        - » static final int ERROR_CODE = 147;
        - » static final String ERROR= "Invalid Input Parameter"
    - Immutable method
      - Cannot be overridden by inheritance (like C++ non-virtual method)

Class (cont'd)

- Class
  - Access Modifiers
    - Public
    - Protected
    - (Default)
    - Private
  - Provides Abstraction:
    - Provides Data Hiding

Class (cont'd)

- Class
  - Access Modifiers
    - Public
      - All access
        - » Accessible by classes within package
        - » Accessible by sub-class
        - » Accessible by classes outside package

Class (cont'd)

- Class
  - Access Modifiers
    - Protected
      - Class, Package and Sub-class access
        - » Accessible by classes within package
        - » Accessible by sub-class
        - » NOT Accessible by classes outside package

Class (cont'd)

- Class
  - Access Modifiers
    - Default: Neither Public, Protected nor Private
      - Package Private
        - » Accessible by classes within package
        - » NOT Accessible by sub-class
        - » NOT Accessible by classes outside package

Class (cont'd)

- Class
  - Access Modifiers
    - Private
      - Class private
        - » Class access ONLY
        - » NOT Accessible by classes within package
        - » NOT Accessible by sub-class
        - » NOT Accessible by classes outside package

Class (cont’d)

- Class
  - Constructor
    - Special Method used to instantiate objects
    - Constructor NAME is IDENTICAL to class name
    - MUST NOT specify a return value type OR void
    - Default Constructor
      - No arguments
      - Compiler provided IF NO CONSTRUCTORS
    - Multiple Constructors
      - Overloaded
        - » Different signatures (i.e. number and types of args)
      - Provides **Static Polymorphism**

Class (cont'd)

- Class
  - Method
    - Also called function, operations, behaviors
    - Abstract: declaration only: no implementation
    - Concrete: declaration and implementation
    - MUST specify a return value type OR void
    - Overloaded Methods
      - Same names
      - Different signatures (i.e. number and types of arguments)
      - Different return types DOES NOT distinguish methods
      - Provides **Static Polymorphism**
    - Override (@Override) **run-time Polymorphism**

Java Class Summary

- Class Summary
  - Concrete
    - Fully implemented methods
  - Abstract
    - Contains one or more abstract methods
    - *CANNOT be instantiated - MUST be extended
  - Interface
    - Contains public abstract, default and static methods
    - *CANNOT be instantiated - MUST be implemented
    - * NOTE: UNLESS implementation is completed

Benefits

- Java class Benefits
  - Encapsulation
    - Data and Method associated together in class
      - Private data with Public methods
  - Abstraction
    - Data hiding
      - Access Modifiers
        - » Public, Private, Protected
    - Functionality hiding
      - Abstract method as API
      - Interface as API

CSYE 6200

Concepts of Object Oriented Design

Java Data Types

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- Lecture
  1. Java Language Basics
  2. Java Data Types
  3. Java Primitive Types
  4. Java String class
  5. Java Reference Type
  6. Java Parameter Passing

Java Language

- Object Oriented Programming Language
  - Data
    - Memory used by the program
  - Program statements
    - Code instructing the actions of the processor
  - Class
    - Data
    - Methods (program code) operating on class data

Java Language

- Everything is a class
  - Definable aggregate containing data and methods
  - All data and code in Java exists only in context of a class
- Java Language Usage
  - Use class statically
  - Use object instantiated (created) from a class

Java Language

- Statically typed programming language

  "*The Java programming language is statically-typed, which means that all variables must first be declared before they can be used.*"

  –All data must be **declared** and made known to compiler before its first use

  DataType name;

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Java Language

- Statically typed Languages include:
  - Java
  - C
  - C++
- Dynamically typed languages include:
  - Python
  - Ruby

Java Language

- Strongly typed programming language
  - All data (variables and constants) must **ALWAYS** be **declared** along **with** its **type**.
    - Identify the memory location by symbol name
    - Identify the memory contents by data type
- Declaration Examples:

  DataType SymbolName

  1. int age;
  2. String name;
  3. class Person { }

Java Data Type Categories

- Only Two Data Type Categories

1. Pre-Defined Primitive data types:
2. Definable Reference data types:

Java Primitive Data Type

- Primitive data types:
  - Fundamental **predefined** data types
  - Passed by Value
    - Data value is **copied** and passed as a parameter therefore the **original data value cannot be changed when passed by value**

Java Reference Data Type

- Reference data types:
  - Classes and Objects are **definable aggregates**
  - Passed by Reference (like a pointer)
    - Reference is copied and passed as a parameter but always references the **same data object**

" The reference values (often just *references*) are pointers…"

https://docs.oracle.com/javase/specs/jls/se7/html/jls-4.html#jls-4.3.1

Java Primitive Data Types

1. **byte** *8-bit integer* (2^7 to 2^7 minus 1, i.e. -128 to 127)
2. **short** *16 bit integer* (2^15 to 2^15 minus 1, i.e. -32,768 to 32,767)
3. **int** *32 bit integer* (-2^31 to 2^31 minus 1)
4. **long** *64 bit integer* (-2^63 to 2^63 minus 1)
5. **float** *32-bit single precision floating point*
6. **double** *64-bit double precision floating point*
7. **boolean** *true or false*
8. **char** *16 bit Unicode character*

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Java Primitive Data Type Use

```
int n = 0;    // declare, create, init int value 0

n = 7;        // overwrite int value with 7;
n++;          // increment int value by 1
n = n + 1;    // increment int value by 1
```

Java Primitive Data Types

- "… **new** keyword isn't used when initializing a variable of a primitive type. Primitive types are special data types built into the language; they are not objects created from a class."

https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Java Primitive Data Types

- Literal values for primitive data types:
  1. byte b = 0;
  2. short s = 1000;
  3. int = 100000;
  4. long x = 0L;
  5. float y = 0.0f
  6. double z = 0.0d
  7. ‘\u0000’ for char
  8. false for boolean

Java Primitive Data Types

- Literal values for primitive data types:

```
int n1 = 13;            // 13 in decimal notation
int n2 = 0b1101;        // 13 in binary notation
int n3 = 0x0d;   // 13 in hexadecimal notation

double x1 = 123.4
double x2 = 1.234e2   // x1 in scientific notation
```

Java Primitive Data Types

- Literal values for primitive data types:

```
long creditCardNum = 1234_5678_9012_3456L;
long socialSecurityNumber = 999_99_9999L;
float pi = 3.14_15F;
```

Java Primitive Data Types

- Literal values for primitive data types:

```
long hexBytes = 0xFF_EC_DE_5E;
long hexWords = 0xCAFE_BABE;
long maxLong = 0x7fff_ffff_ffff_ffffL;
byte nybbles = 0b0010_0101;
long bytes =
0b11010010_01101001_10010100_10010010;
```

Java Primitive Data Types

- PLACE "_" ONLY BETWEEN DIGITS

  int x4 = 0_x52; // INVALID

  - NEVER At the beginning or end of a number

    int x2 = 52_; // INVALID

    int x5 = 0x_52; // INVALID

  - NEVER Adjacent to a decimal point in a floating point literal

    float pi1 = 3_.1415F; // INVALID

    float pi2 = 3._1415F; // INVALID

  - NEVER Prior to an F or L suffix, example:

    long socialSecurityNumber1 = 999_99_9999_L;

  - NEVER In positions where a string of digits is expected

Java Primitive Data Types

- Literal values for primitive data types:

```
char a1 = 'A';        // uppercase A character
char a2 = 'a';        // lowercase a character
char c1 = '\n';       // newline character
char c2 = '\t';       // tab character
```

Java Primitive Data Types

- Default values for primitive data types in class:
  1. 0 for byte
  2. 0 for short
  3. 0 for int
  4. 0L for long
  5. 0.0f for float
  6. 0.0d for double
  7. ‘\u0000’ for char
  8. false for boolean

Java Primitive Data Types

- Declaring variables of primitive data types without explicit initialization
  - Compiler set variables to reasonable default value

```
int age;                // initialized to 0
double gpa;             // initialized to 0.0d
char middleInitial;     // initialized to '\u0000'
```

Java Primitive Data Types

- Declaring and initializing variables of primitive data types

```
int age = 17;
double gpa = 4.0;
char middleInitial = ‘G’;
```

Java Reference Type

- A Class is a reference type
  - Definable custom data type
    - The fundamental Unit for Java Object Oriented Programming: Everything is a class
  - Wrapper for definable data and/or code
  - Aggregate data type
    - Including Primitive data types
    - Including Other reference types
    - Including Program code

Class Static members

- Use class statically
- Class members defined as ‘static’
  - ONE memory allocation
  - Program Scope
    - Always available for use
    - No need to create with “new”

Class Object Instance members

- Create and use objects from class
- Class members defined without '**static**'
  - New memory allocation with each object created
  - Object Instance scope
    - DOES NOT EXIST UNTIL object is created with "new"
    - Java Garbage Collection (GC) automatically deletes objects when no longer needed.

Simple Class Name

public class **Name {**

// state is one String

public **String n =** ”Dan”**;**

}

- Class **Name** is a container class for a String
  - See class **Java.Lang.String**
- Class **Name** is a Reference Type
- Object instance Member data is a String named ‘**n**’ holding a String value

Use Simple Class Name

```
// create object on heap and assign reference to obj
Name obj = new Name();
// use object on heap through reference in obj
System.out.println(obj.n);          // show #1 init state
obj.n = “Daniel”;                   // overwrite state
System.out.println(obj.n);          // #1 current state
Name obj2 = new Name();             // create object #2
System.out.println(obj2.n);         // show #2 init state
System.out.println(obj.n);          // #1 current state
```

Use Simple Class Name

CONSOLE OUTPUT

Dan

Daniel

Dan

Daniel

Simple Class Label

```
public class Label {
        // state is one String
        public static String n = "Dan";
}
```

- Class **Label** is a container class for a String
  - See class **Java.Lang.String**
- Class **Label** is a Reference Type
- Static class Member data is a String named ‘**n**’ holding a String value

Use Simple Class Label

```
// use class Label
System.out.println(Label.n);     // show init state
Label.n = "Daniel";              // overwrite state
System.out.println(Label.n);     // show current state
Label.n = "Danny";               // overwrite state
System.out.println(Label.n);     // show current state
System.out.println(Label.n);     // show current state
```

Use Simple Class Name

CONSOLE OUTPUT

Dan

Daniel

Danny

Danny

Java Reference Type

- A Class is a reference type
  - To instantiate an object from a class:
  1. Using keyword “**new**”
  2. Calling a class constructor

- Must Create ALL Objects with “**new**”
  - **EXCEPT** String objects

Java Reference Type

- To Create a Person object:

```
Person dan = null;
dan = new Person();
```

- Data Type is “**Person**” class
- Variable Name (Identifier) is “**dan**”
- Class constructor is “**Person()**”

Java Reference Type

- To Create a Student object:

Student sam = new Student();

- Data Type is “**Student**” class
- Variable Name (Identifier) is “**sam**”
- Class constructor is “**Student()**”

Java Reference Type

- To Create a container object:

```
List<String> names = null;
names = new ArrayList<>();
```

- Data Type is “**List<String>**” interface
- Variable Name (Identifier) is “**names**”
- Class constructor is “**ArrayList<>()**”, where <String> is compiler inferred

Java String: Java Reference Type

- Character String
  "This is a LITERAL character string."
- A String is a Reference Type
  java.lang.String class
- A String is immutable
- **NOT** an array of characters terminated by a null character (C Language).
  - A Java String object is **NOT** a C language string.

Java String

- Special String treatment:
  - Enclosing characters in double quotes **automatically** creates a String object:

String **name** = “**Dan**”;

  - Identifier ”**name**” contains a reference to a String object containing the immutable value of “**Dan**”.

Java String

- For String objects, Use of the ‘*new*’ keyword is optional (and **discouraged**)
  - Reference:
    - Java ***string pool*** and ***string interning***.
  - Both memory (and it’s allocation time) are conserved by saving immutable strings in a pool. When a new string is created, **if it is a repeated string**, a reference to an already preserved immutable string in the pool is established in lieu of a new created string.

Java String

- Use of the ‘new’ keyword is optional (and discouraged) for creating String objects.
- DO

```
String s = “abc”; // allows interning
```

- DO NOT

```
String s = new String(“abc”);  // forces new string
```

- String objects

Array: Java Reference Type

- To Create a fixed size array container object:

int [] myArray = new int[3];

- Data Type is “**int []**” int array
- Variable Name (Identifier) is “**myArray**”
- The array is created for ONLY three integers by using “**int[3]**”

Array: Java Reference Type

“In the Java programming language, *arrays* are objects…”

https://docs.oracle.com/javase/specs/jls/se8/html/jls-10.html

“An *object* is a *class instance* or an *array*. “

https://docs.oracle.com/javase/specs/jls/se8/html/jls-4.html#jls-4.3.1

Java Reference Type

- To Create a fixed size array container object:

int [] myArray = { 1, 2, 3 };

- Data Type is "**int []**" int array
- Variable Name (Identifier) is "**myArray**"
- The array is created for ONLY three integers by using the initializer "**{1,2,3}**"

Java Pass Primitives By Value

- Primitive data types are int, double, etc.
- Memory for Primitive data types are allocated on the stack
- Copies of Primitive data types are passed to methods
- Methods CAN NOT modify the Original primitive data type.

Java Pass Object Reference By Value

- Objects are Reference Types
- References point to Object allocation in heap memory
  - TWO memory allocations are needed to use an object.
    1. Object allocated on the heap
    2. Reference (pointer) allocated on stack, pointing to Object allocation on the heap
- References passed to methods are copies
- Copies STILL POINT TO SAME OBJECT

Simple Class N

```
public class N {
        public int n = 0; // state is one int
}
```

- Class N is a container class for an integer
  - See class **Java.Lang.Integer**
- Class **N** is a Reference Type
- Object instance Member data is an integer named ‘**n**’ holding an integer value

sillySwap method

```
public void sillySwap(N o1, N o2) {
        N temp = o1;        // save for later


        System.out.println("Swap object references:");
        o1 = o2;
        o2 = temp;          // original o1
        // COPIES of references have changed
}
```

showObjects method

```
// output the state of each object on console
public static void showObjects(N o1, N o2)
{
  System.out.println(”  " + o1.n + " " + o2.n);
}
```

Use SillySwap method

```
public void sillySwapObjects() {
   N o1 = new N();       // create object 1
   N o2 = new N();       // create object 2
   o1.n = 1;             // set value 1 in object 1
   o2.n = 2;             // set value 2 in object 2
   ValueN.showObjects(o1, o2);   // 1 2
   ValueN.sillySwap(o1, o2);  // useless swap
   ValueN.showObjects(o1, o2);   // 1 2
}
```

Use SillySwap method

Swap object references produces:

Console Output:

1 2

1 2

smartSwap method

```
public void smartSwap(N o1, N o2) {
        N temp = new N();
        temp.n = o1.n     // save for later


        System.out.println("Swap object state:");
        o1.n = o2.n;
        o2.n = temp.n;    // original o1 state
        // state of Objects have changed
}
```

Use smartSwap method

```
public void smartSwapObjects() {
   N o1 = new N();       // create object 1
   N o2 = new N();       // create object 2
   o1.n = 1;             // set value 1 in object 1
   o2.n = 2;             // set value 2 in object 2
   ValueN.showObjects(o1, o2);   // 1 2
   ValueN.smartSwap(o1, o2);  // swap state
   ValueN.showObjects(o1, o2);   // 2 1
}
```

Use SmartSwap method

Swap object state produces:

Console Output:

1 2

2 1

CSYE 6200

Concepts of Object Oriented Design

Java Enumerated Types

Daniel Peters

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- Lecture
    1. Enum

Enum

java.lang.Enum

public enum Color {*RED, WHITE, BLUE*};

- Trailing semicolon is OPTIONAL

  public enum Color {*RED,WHITE, BLUE*}

- Explicitly listed set of strongly typed constants
- Immutable: implicitly final static: Cannot be changed once initialized

Enum

java.lang.Enum

public enum Explosion {*GUNSHOT, GRENADE, ABOMB*};

- Explicitly listed set of strongly typed constants
- Immutable: ***implicitly final static***: Cannot be changed once initialized

Enum

- Declared enum “stockName” can only be assigned enum type from declared set of enum constant values, “EBAY”, “IBM”, “GOOGLE”, “YAHOO”, “ATT”

```
public enum Stock{
    EBAY, IBM, GOOGLE, YAHOO, ATT
}

Stock stockName = Stock.EBAY;
stockName = 1;   // Compilation Error
```

Enum

- Declared as class data member
- Prefer over integer or string codes to increase compile-time checking
- Can have constructors, methods and variables

Enum

- Constructors:
  - Private and never invoked directly in code
  - Called ***automatically*** when enum is initialized
- Declared inside a class but not in a method
- Declared public so ok to use outside a class
  - BUT Cannot be declared final
- Prefer over integer or string codes to increase compile-time checking

Enum Example

```
public enum Fruit{
  APPLE("A") , KIWI("K"), GRAPE("G"), PEAR("P");

        private String fruitLetter;

        private Fruit(String s) {
        fruitLetter = s;
        }
        public String getFruitLetter() {
                return fruitLetter;
        }
}
```

Enum Usage

```
public static void main(String[] args) {

System.out.println(”’kiwi’ enum constant is: "
+ Fruit.KIWI.getFruitLetter());
}
```

OUTPUT:

’kiwi’ enum constant is: Value: K

Example 2: Enum Planet

```
public enum Planet {
   MERCURY (3.303e+23, 2.4397e6), VENUS (4.869e+24, 6.0518e6), EARTH (5.976e+24, 6.37814e6), MARS (6.421e+23,
3.3972e6), JUPITER (1.9e+27, 7.1492e7), SATURN (5.688e+26, 6.0268e7), URANUS (8.686e+25, 2.5559e7), NEPTUNE
(1.024e+26, 2.4746e7);
   private final double mass; // in kilograms
   private final double radius; // in meters
   Planet(double mass, double radius) { this.mass = mass; this.radius = radius; }
   private double mass() { return mass; }
   private double radius() { return radius; }
   // universal gravitational constant (m3 kg-1 s-2)
   public static final double G = 6.67300E-11;
   double surfaceGravity() { return G * mass / (radius * radius); }
   double surfaceWeight(double otherMass) { return otherMass * surfaceGravity(); }
   public static void main(String[] args) {
      if (args.length != 1) {
         System.err.println("Usage: java Planet <earth_weight>");
         System.exit(-1);
      }  // end if
      double earthWeight = Double.parseDouble(args[0]);
      double mass = earthWeight/EARTH.surfaceGravity();
      for (Planet p : Planet.values()) System.out.printf("Your weight on %s is %f%n", p, p.surfaceWeight(mass));
    }  // end main
}  // end enum Planet
```

Enum Planet

```
public enum Planet {
        MERCURY (3.303e+23, 2.4397e6),
        VENUS (4.869e+24, 6.0518e6),
        EARTH (5.976e+24, 6.37814e6),
        MARS (6.421e+23, 3.3972e6),
        JUPITER (1.9e+27, 7.1492e7),
        SATURN (5.688e+26, 6.0268e7),
        URANUS (8.686e+25, 2.5559e7),
        NEPTUNE (1.024e+26, 2.4746e7);

…..
```

Enum Planet (cont'd)

```
…..
        private final double mass; // in kilograms
        private final double radius; // in meters

        Planet(double mass, double radius) {
                this.mass = mass; this.radius = radius;
        }
        private double mass() { return mass;  }
        private double radius() { return radius; }
…..
```

Enum Planet (cont'd)

```
…..
        // universal gravitational constant (m3 kg-1 s-2)
        public static final double G = 6.67300E-11;

        double surfaceGravity() {
                return G * mass / (radius * radius);
        }
        double surfaceWeight(double otherMass) {
                return otherMass * surfaceGravity();
        }
…..
```

Enum Planet (cont'd)

```
…..
        public static void main(String[] args) {
            if (args.length != 1) {
                System.err.println("Usage: java Planet <earth_weight>");
                System.exit(-1);
            }  // end if
            double earthWeight = Double.parseDouble(args[0]);
            double mass = earthWeight/EARTH.surfaceGravity();
…..
```

Enum Planet (cont'd)

```
…..
            for (Planet p : Planet.values())
                System.out.printf("Your weight on %s is
%f%n", p, p.surfaceWeight(mass));


        } // end main
}  // end enum Planet
```

CSYE 6200

Concepts of Object Oriented Design

Java Program

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- Lecture
  1. Constants
  2. Variables: NOT INITIALIZED BY DEFAULT
     1. Char
     2. integer
     3. float

  3. Scope

- Java is all about Classes
  - A Class is used to instantiate (i.e., create) one or more Objects

  Java program is made up of various classes
    - User created classes
    - Libraries: Pre-existing classes
- Java Class Libraries
  - Classes organized in packages
- We ALWAYS create OUR classes in packages

- Java Program
  - Create Java source (.java) file
    - editor or Integrated Design Environment (IDE)
    - javac Hello.java
  - Compile source file
    - Compiler (javac) creates .class file
  - Load classes (.class) into memory
    - Class loader loads class files from disk

- Java Program
  - Verify
    - Byte code verifier: checks byte codes in each class for security
  - JVM
    - Just-in-time (JIT) compiler translates bytecodes into machine specific language for execution

NOTE: Java Program execution begins in the main method

- Java Types
  - Primitive Types
    - boolean, char, short, int, float, long, double.
    - Stack memory allocation
  - Non-Primitive (Reference) Types
    - Used to reference and hold Objects, e.g. String
    - Heap memory allocation
- Java is
  - a STRONGLY TYPED LANGUAGE
  - a STATICALLY TYPED LANGUAGE

- Java is a STRONGLY TYPED LANGUAGE
  - All variables are required to have types

- Java is a STATICALLY TYPED LANGUAGE
  - Once assigned a type variables retain that type assignment for duration of program execution
    - EXCEPTION: type casting

- Classes are Reference types
  - Class variable holds reference (i.e. pointer) to actual object allocation on heap
- Class methods (like functions)
  - Each supplied argument must have a type
  - The return value must have types
  - Methods which do not return a value use void

- 8 Primitive Types
  - boolean: ONLY true or false
  - byte: 8-bits
  - char: 16-bits
  - short: 16-bits
  - int: 32-bits
  - float: 32-bits
  - long: 64-bits
  - double: 64-bits

- Online Information
  - Java 8
    - http://docs.oracle.com/javase/8/docs/api/index.html
  - Java 7
    - http://docs.oracle.com/javase/7/docs/api/index.html

CSYE 6200

Concepts of Object Oriented Design

String class

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- Lecture:
  1. Java String class
  2. Java StringBuilder class

Java String

- Character String
  "This is a LITERAL character string."
- A String is a Reference Type
  java.lang.String class
- A String is immutable
- **NOT** an array of characters terminated by a null character (C Language).
  – A Java String object is **NOT** a C language string.

Java String

- Special String class treatment:
  - Enclosing characters in double quotes **automatically** creates a String object:

String **name** = “**Dan**”;

  - Identifier ”**name**” contains a ***reference*** to a String object containing the immutable value of “**Dan**”.

Java String

- For String objects, Use of the ‘new’ keyword is optional (and discouraged)
  - Reference: Java **String pool** and **String interning**.
  - Both memory (and its allocation time) are conserved by saving immutable Strings in a pool. When a new String is created, **if it is a repeated String**, a reference to an already preserved immutable String in the pool is established in lieu of a new String created.

Java String

- Use of the ‘new’ keyword is optional (and discouraged) for creating String objects.
- DO

  String s = “abc”; // allows interning
- DO NOT

  String s = new String(“abs”); // forces new string

- String objects

String Operations

- String.**toUpperCase**()
  - Converts String to ALL CAPS
- String.**toLowerCase**()
  - Convert String to ALL LOWERCASE
- Compare: s1.**compareTo**(s2);
  - Returns 0 indicating lexagraphically equal strings

String Split

- String split

String s = **new String("Dan,16,4.0");**

String [] tokens = s.**split**(",");

System.*out.println("Student:"*

+ " NAME: " + tokens[0]

+ ", AGE: " + tokens[1]

+ ", GPA: " + tokens[2]);

- OUTPUT:

Student: NAME: Dan, AGE: 16, GPA: 4.0

Integer to String Conversion

- **Integer**.parseInt()
  - Convert String to int value

```
String s = “17”;            // String representation of int 17
int age = 0;
try {
    age = Integer.parseInt(s); // convert String to int
} catch (NumberFormatException e) {
    System.out.println(s + " is not a number!");
    e.printStackTrace();
}
System.out.println(s + “ is Age: “ + age);
```

Integer to String Conversion

- CONSOLE OUTPUT:

17 is Age: 17

Double to String Conversion

- **Double**.parseDouble()
  - Convert String to double value

```
String s = "4.0";          // String representation of 4.0
double gpa= 0;
try {
    gpa = Double.parseDouble(s); // String to double
} catch (NumberFormatException e) {
    System.out.println(s + " is not a  number!");
    e.printStackTrace();
}
System.out.println(s + " is GPA: " + gpa);
```

Double to String Conversion

- CONSOLE OUTPUT:

4.0 is GPA: 4.0

SubString

- SubString

  String s = **new String ("abcd");**

  int ix1 = 1;

  int ix2 = 3;

  sub = s.**substring**(ix1);   // bcd

  sub = s.**substring**(ix1,ix2); // bc

  int ix1 = 0;

  sub = s.**substring**(ix1,ix2); // abc

StringBuilder

StringBuilder sb = **new StringBuilder("Peter");**

sb.append(",");

sb.append("Paul");

sb.append(",");

sb.append("Mary");

sb.append(",");

System.out.println(sb.toString());

StringBuilder

- CONSOLE OUTPUT:

Peter, Paul, Mary,

CSYE 6200

Concepts of Object Oriented Design

Explosion Class

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- Lecture
  1. Inheritance
  2. Java Abstract Class
  3. Java Interface

Relationships

- Association
  - Aggregation
    - “Has-A”
- Generalization
  - Inheritance
    - “Is-A”

Relationships

- Association

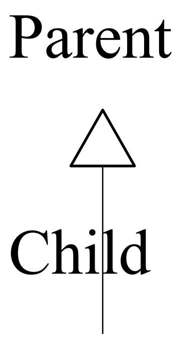
Teacher ⟷ Classroom (1 to 1)

Student ⟷ School (10..* to 1)

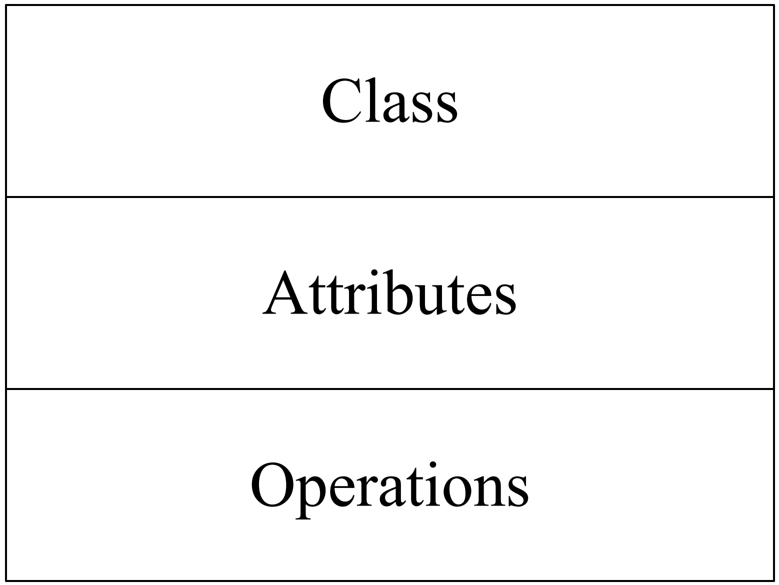
Employee ⟷ Corporation (1..* to 1)

Relationships

- Generalization



UML Class Diagram

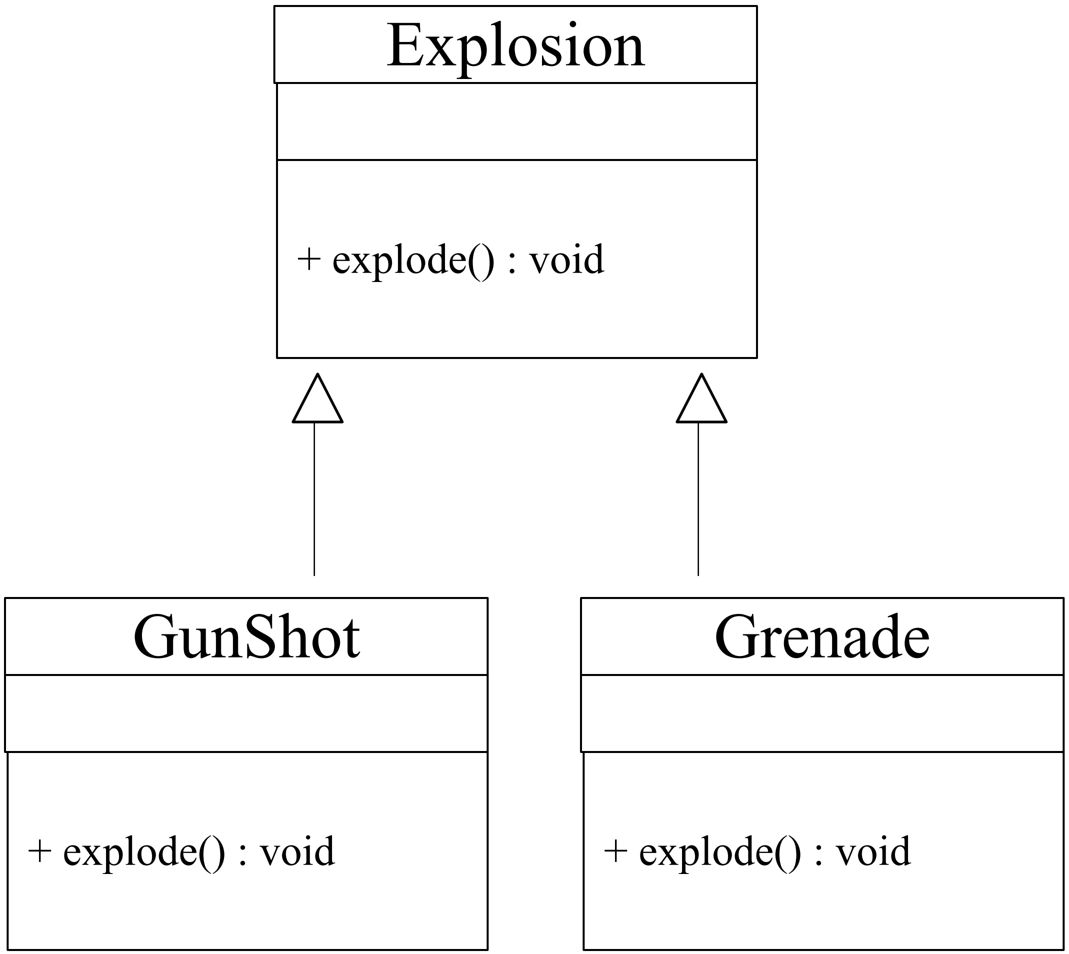


UML Class Diagram

- private
+ public

ClassName
- Attribute1 : int - Attribute2 : String
+ Operation1() : int + Operation2(int) : void

Explosion Class Diagram



Explosion Class

```
public class Explosion {
   public void explode() {
         System.out.println(
           "Explosion [** EXPLODE **] !!!”
         );
   }
}
```

GunShot Class

```
public class GunShot extends Explosion {
  @Override
  public void explode() {
      System.out.println(
       ”GunShot [** BANG **] !!!”
      );
  }
}
```

GunShot Class

```
public class GunShot extends Explosion {
}
```

- If **GunShot** class does not provide it's own *explode()* implementation
  - inherits default *explode()* implementation from **Explosion**

GunShot Class

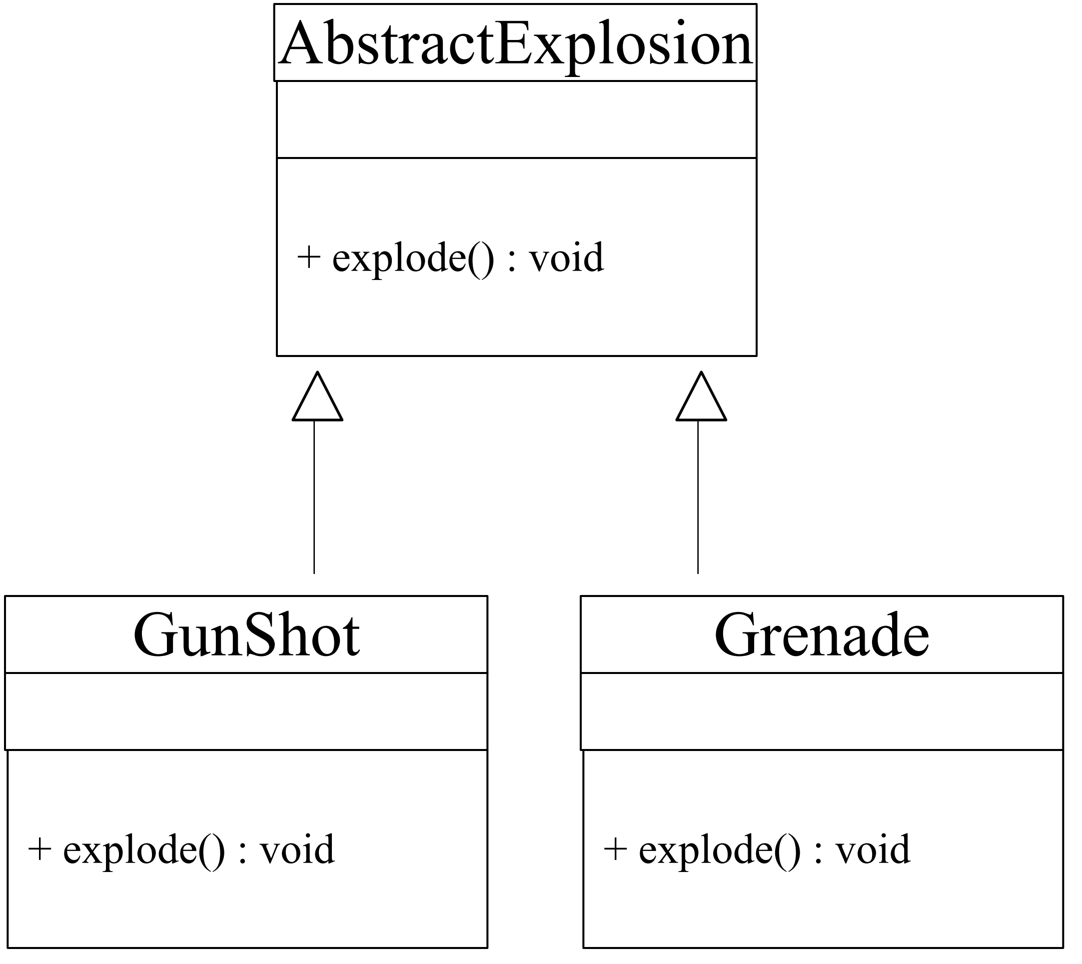
```
public class GunShot extends Explosion {
 public void explode() {
        System.out.println(
          "Explosion [** EXPLODE **] !!!”
        );
   }
}
```

- As if GunShot were written as above
  - **GunShot** can inherit **Explosion** *explode()*

Grenade Class

```
public class Grenade extends Explosion {
  @Override
  public void explode() {
      System.out.println(
        "Grenade [** SPLATTER **] !!!"
      );
  }
}
```

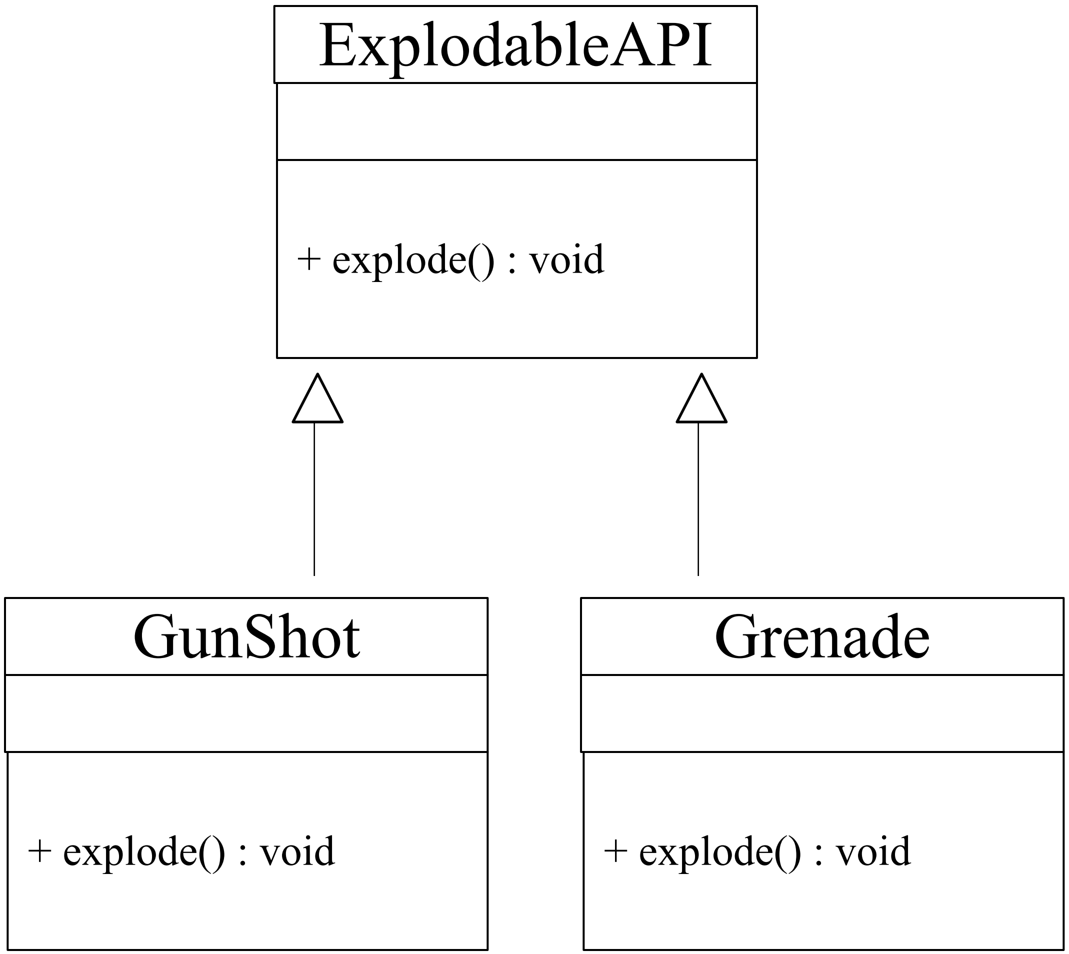
AbstractExplosion Class Diagram



AbstractExplosion Class

```
public abstract class AbstractExplosion {
   public abstract void explode();
}
```

ExplodableAPI Class Diagram



ExplodableAPI Interface

public interface **ExplodableAPI** {
  void *explode*();
}

Class

- Class
  - class MyName [extends MySuperClass] [implements MyInterface] {
    - Data
    - Constructor
    - Method
    - }

Concrete Class

- Class
  - Concrete
    - Declared: public, private or protected members
    - Fully implemented methods
    - Data
      - final or non final
      - static or non-static
    - Can be instantiated to create objects

Abstract Class

- Class
  - Abstract
    - Declared: public, private or protected members
    - Partially implemented
    - Contains one or more abstract methods
    - Data
      - final or non final
      - static or non-static
    - Must be extended (keyword extends)
    - Cannot be instantiated (without completing implementation)

Interface

- Class
  - Interface
    - Contains ONLY public methods
      - ‘abstract’ methods are unimplemented
      - Java 8 ‘default’ Methods are implemented
      - Java 8 ‘static’ Methods are implemented
    - Data
      - static (class variables) ONLY
      - final (immutable constant values) ONLY
    - Must be implemented (keyword implements)
    - Cannot be instantiated (without completing implementation)

Class (cont'd)

- Class
  - Data
    - Attribute
    - Field
  - Constructor
    - One ore more special Method to instantiate objects
  - Method
    - Function
    - Operation
    - Behavior

Class (cont'd)

- Class
  - Data declaration
    - [static] [final] [public | protected | private] type name
    - [= initializer] ;

Class (cont'd)

- Class
  - Class Constructor declaration
    - [static] [final] [public | protected | private]
    - ClassName()
    - { constructor method body } ;

Class (cont'd)

- Class
  - Method declaration
    - [static] [final] [public | protected | private]
    - [returnType | void] methodName()
    - { method body } ;

Java Interface

- Java Interface
  - Reference type, similar to a class
  - Contains ONLY:
    - Data
      - Public Static Final (Constants)
    - Methods:
      - ALL METHODS IMPLICITLY PUBLIC
        - » Keyword public may be omitted from methods.
      - abstract methods (no body)
      - Static methods
      - Default methods (Java 8)

Java Interface

- Java Interface
  - Public:
    - Public interface is accessible to all classes
    - Otherwise, only accessible to classes in same package
  - Keyword interface
    - Must be implemented by a class
      - Class MUST implement all interface methods
    - Can be extended by other interfaces

Java Interface

- Java Interface Use
  - Must be implemented by a class
    - Class MUST implement all interface methods
  - Can be extended by another interface

Java Interface

- Java Interface as API
- “The robotic car example shows an interface being used as an industry standard *Application Programming Interface (API)*. **APIs are also common in commercial software products.** Typically, a company sells a software package that contains complex methods that another company wants to use in its own software product. An example would be a package of digital image processing methods that are sold to companies making end-user graphics programs. The image processing company writes its classes to implement an interface, which it makes public to its customers. The graphics company then invokes the image processing methods using the signatures and return types defined in the interface. While the image processing company's **API is made public (to its customers), its implementation of the API is kept as a closely guarded secret—**in fact, it **may revise the implementation at a later date as long as it continues to implement the original interface that its customers have relied on**.”

  https://docs.oracle.com/javase/tutorial/java/IandI/createinterface.html

Java Interface

- Java Interface Examples
  - Comparable
    - Implement to make your class sortable by default in natural order.
  - Comparator
    - Implement and use to specify a specific sort order.
  - Runnable
    - Implement to make your class executable on a new thread.
  - ExploadableAPI

CSYE 6200

Concepts of Object-Oriented Design

Inheritance

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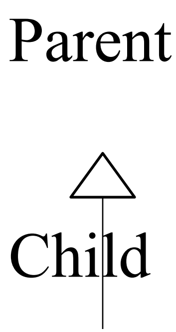
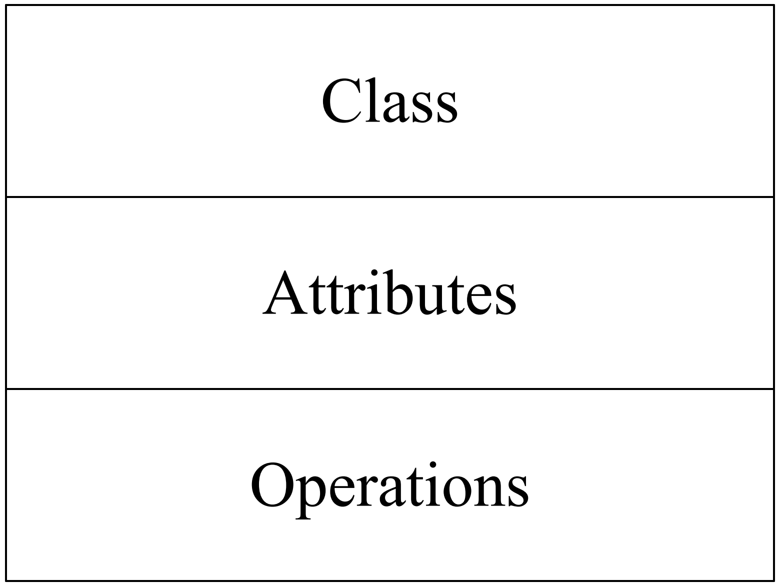
- Lecture
  1. Inheritance
  2. Java Concrete Class
  3. Java Abstract Class
  4. Java Interface

Relationships

- Generalization: Inheritance Is-A Relationship
  - Child Is-A Parent



UML Class Diagram

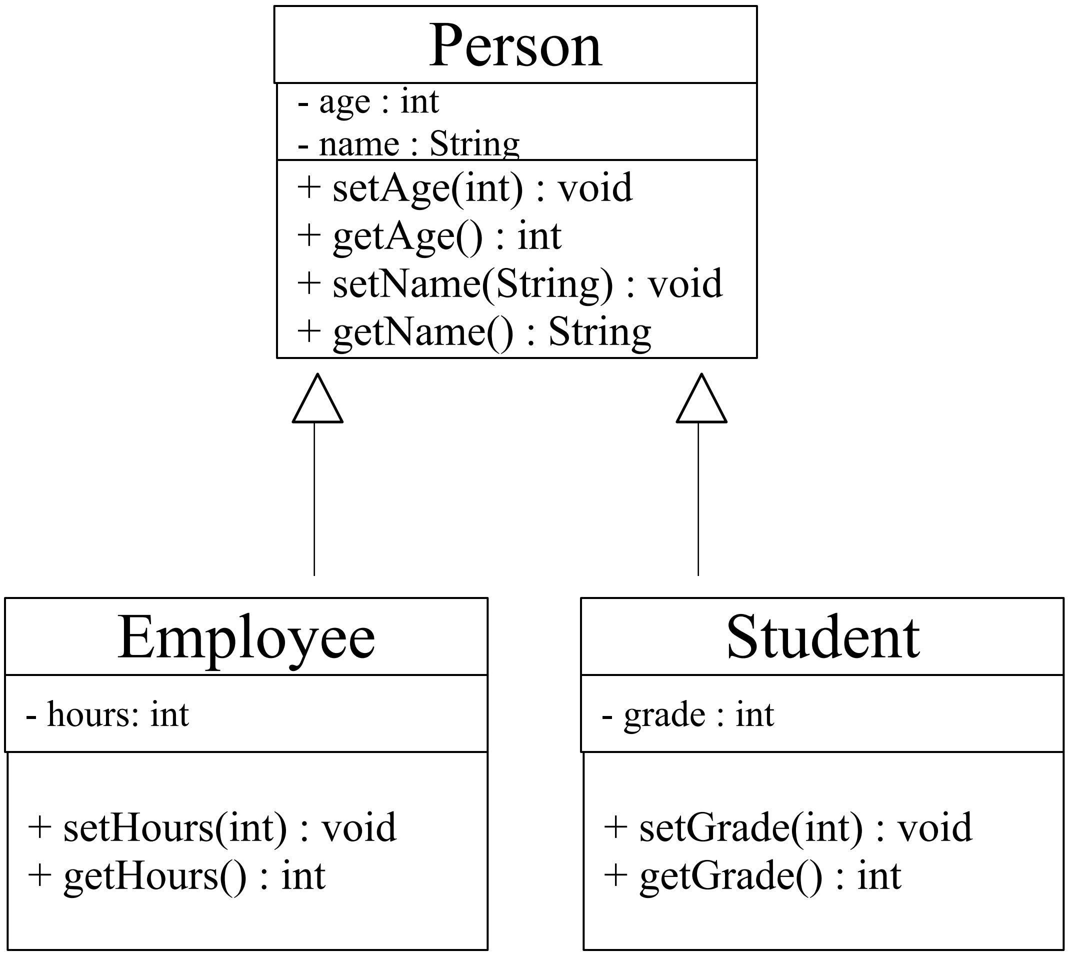


UML Class Diagram

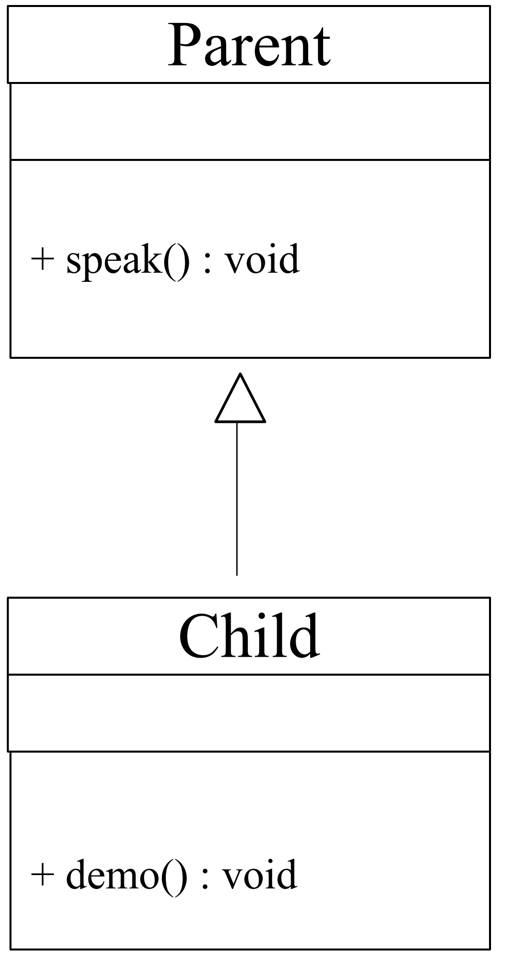
- private
+ public

ClassName
- Attribute1 : int - Attribute2 : String
+ Operation1() : int + Operation2(int) : void

Person Class Diagram



Inheritance Class Diagram



Class

- Class
  - class MyName [extends MySuperClass] [implements MyInterface1, MyInterface2] {
    - Data
    - Constructor
    - Method
    - }

Concrete Class

- Class
  - Concrete
    - Declared: public, private or protected members
    - Fully implemented methods
    - Data
      - final or non final
      - static or non-static
    - Can be instantiated to create objects

Abstract Class

- Class
  - Abstract
    - Declared: public, private or protected members
    - Partially implemented
    - Contains one or more abstract methods
    - Data
      - final or non final
      - static or non-static
    - Must be extended (keyword extends)
    - Cannot be instantiated (without completing implementation)

Interface

- Interface
  - Contains ONLY public methods
    - ‘abstract’ methods are unimplemented
    - Java 8 ‘default’ Methods are implemented
    - Java 8 ‘static’ Methods are implemented
  - Data
    - static (class variables) ONLY
    - final (immutable constant values) ONLY
  - Must be implemented (keyword implements)
  - Cannot be instantiated (without completing implementation)

Class

- Class
  - Data
    - Attribute
    - Field
  - Constructor
    - One ore more special Method to instantiate objects
  - Method
    - Function
    - Operation
    - Behavior

Class (cont'd)

- Class
  - Data declaration
    - [static] [final] [public | protected | private] type name
    - [= initializer] ;

Class (cont'd)

- Class
  - Class Constructor declaration
    - [static] [final] [public | protected | private]
    - ClassName()
    - { constructor method body } ;

Class (cont'd)

- Class
  - Method declaration
    - [static] [final] [public | protected | private]
    - [returnType | void] methodName()
    - { method body } ;

CSYE 6200

Concepts of Object-Oriented Design

Java Interface

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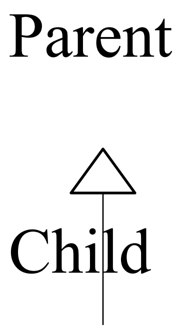
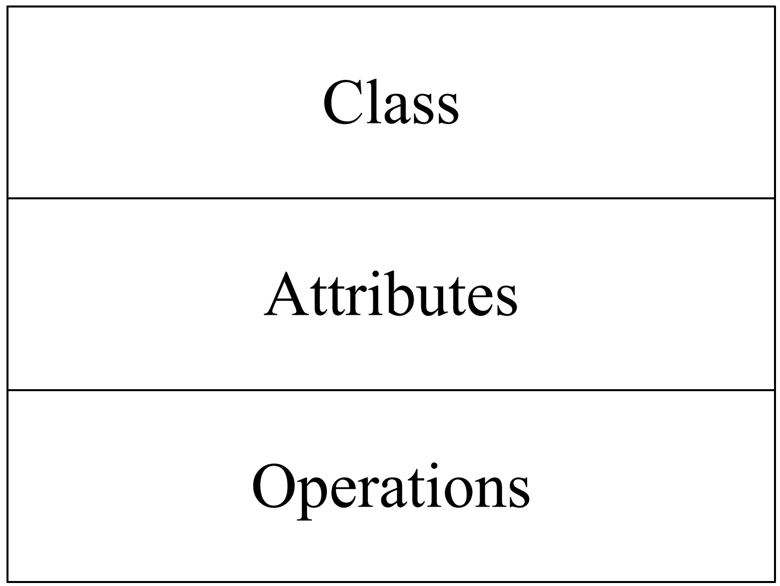
- Lecture
  1. Java Interface

Relationships

- Generalization: Inheritance Is-A Relationship
  - Child Is-A Parent



UML Class Diagram



UML Class Diagram

- private
+ public

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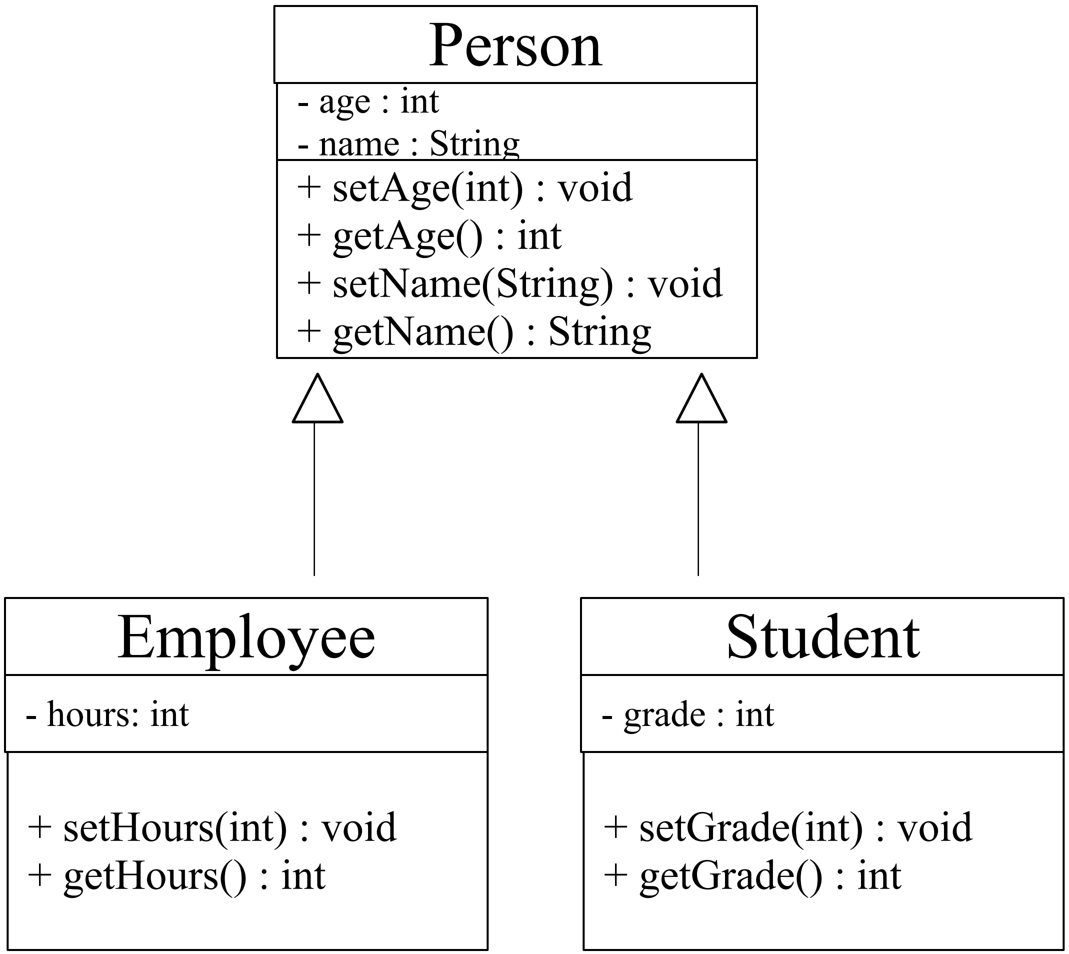
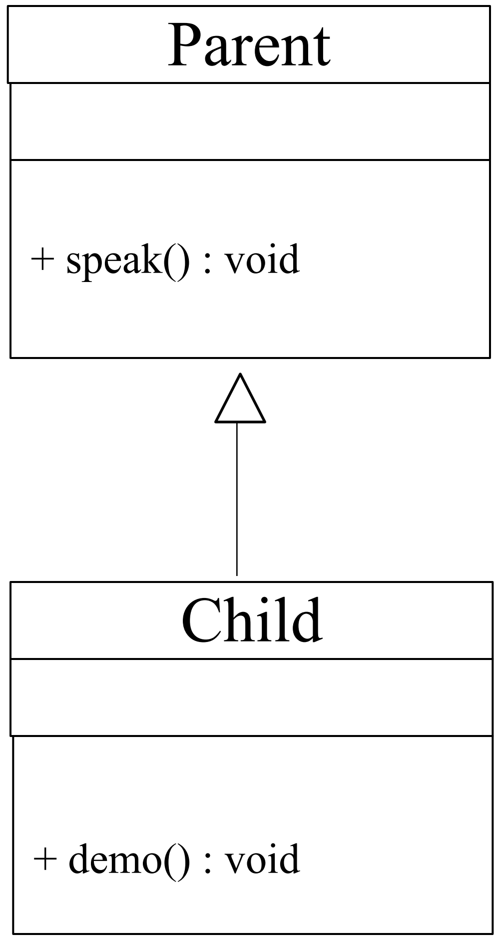
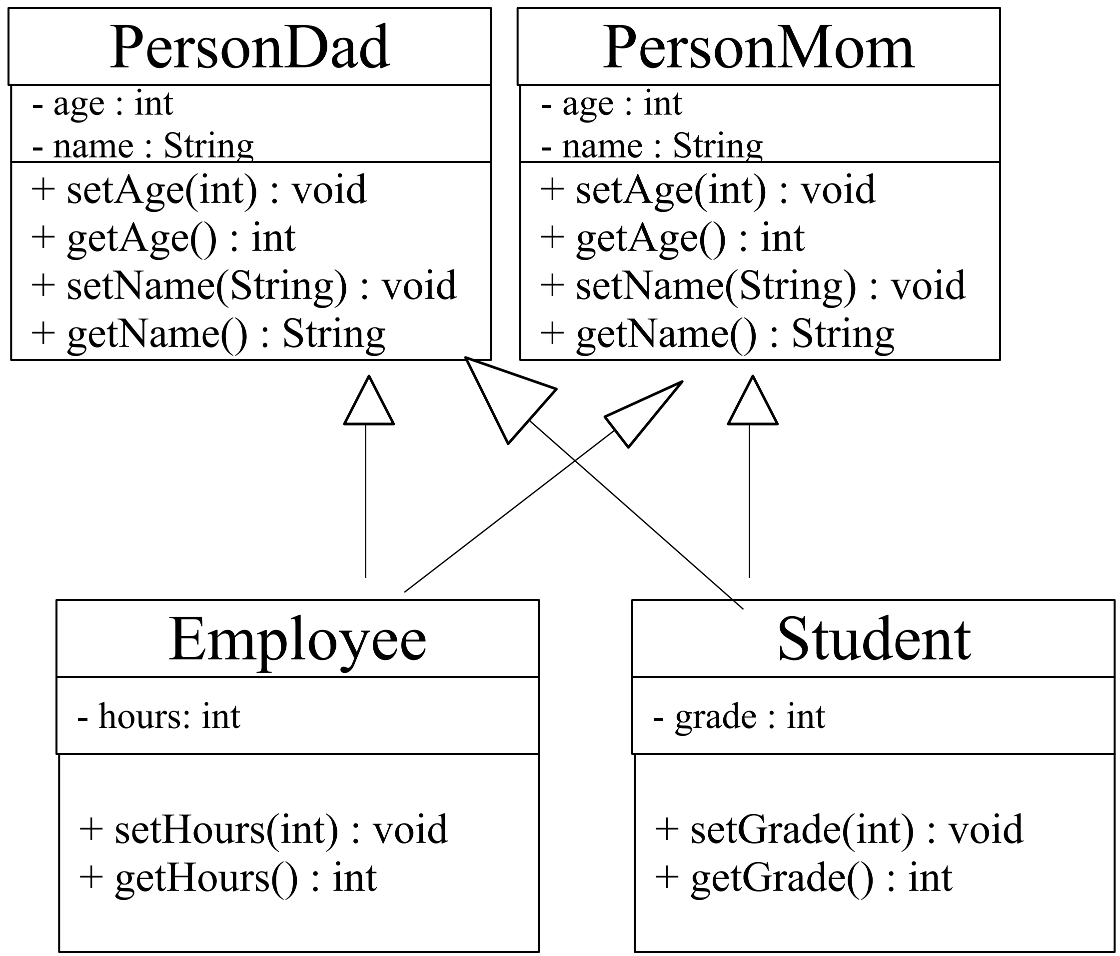
Person Class Diagram



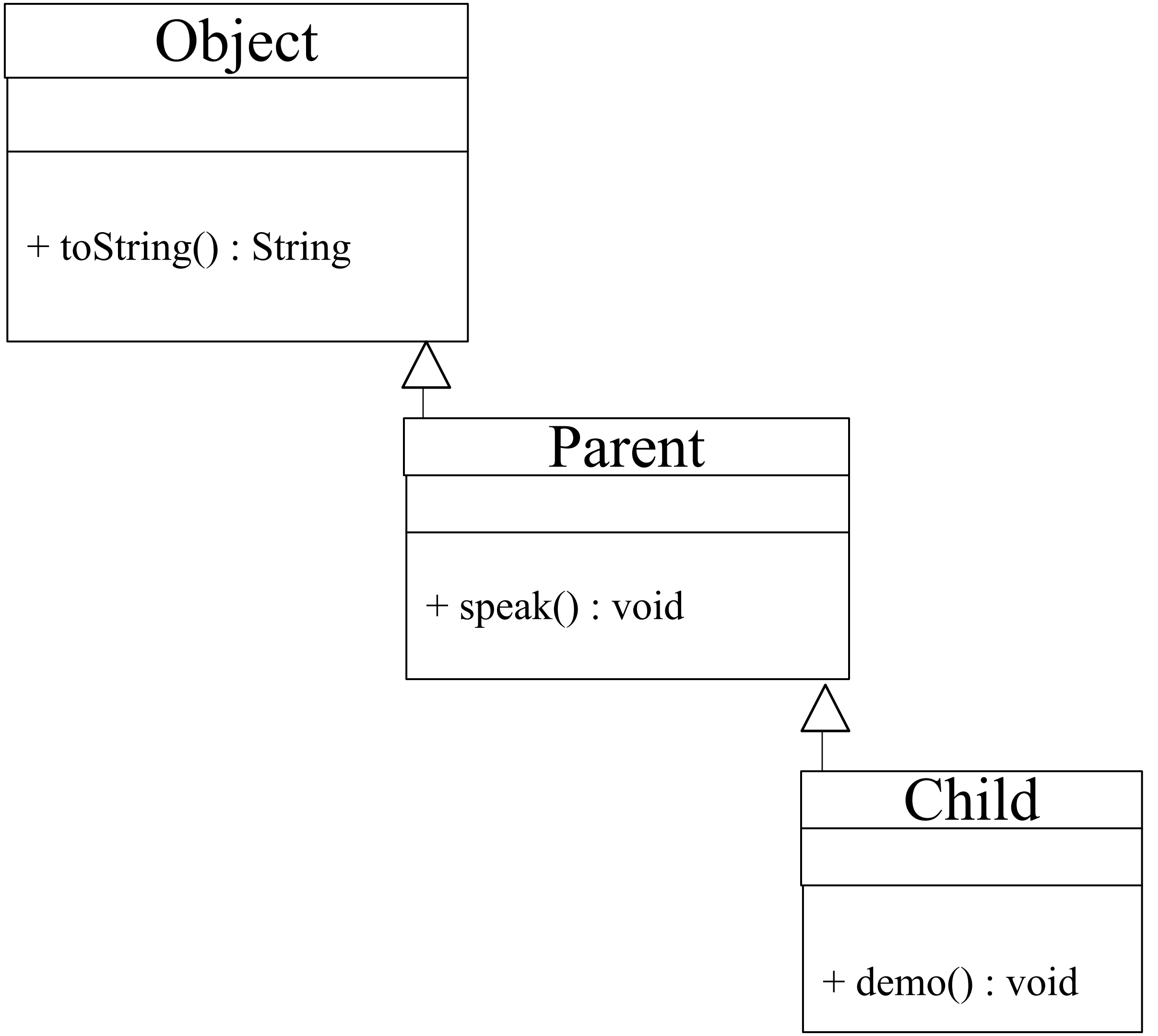
Inheritance Class Diagram



Multiple Inheritance Class Diagram



Single Inheritance Class Diagram



Class

- Class
  - class MyName [extends MySuperClass] [implements MyInterface1, MyInterface2] {
    - Data
    - Constructor
    - Method
    - }

Concrete Class

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  - Concrete
    - Declared: public, private or protected members
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    - Data
      - final or non final
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    - Can be instantiated to create objects

Abstract Class

- Class
  - Abstract
    - Declared: public, private or protected members
    - Partially implemented
    - Contains one or more abstract methods
    - Data
      - final or non final
      - static or non-static
    - Must be extended (keyword extends)
    - Cannot be instantiated (without completing implementation)

Interface

- Contains ONLY public methods
  – ‘abstract’ methods are unimplemented
  – Java 8 ‘default’ Methods are implemented
  – Java 8 ‘static’ Methods are implemented
- Data
  – static (class variables) ONLY
  – final (immutable constant values) ONLY
- Must be implemented (keyword implements)
- Cannot be instantiated (without completing implementation)

Java Interface

- Java Interface
  - Reference type, similar to a class
  - Contains ONLY:
    - Data
      - Public Static Final (Constants)
    - Methods:
      - ALL METHODS IMPLICITLY PUBLIC
        - » Keyword public may be omitted from methods.
      - abstract methods (no body)
      - Static methods
      - Default methods (Java 8)

Java Interface

- Java Interface
  - Public:
    - Public interface is accessible to all classes
    - Otherwise, only accessible to classes in same package
  - Keyword interface
    - Must be implemented by a class
      - Class MUST implement all interface methods
    - Can be extended by other interfaces

Java Interface

```
public interface GroupedInterface extends Interface1,
Interface2, Interface3 {
        // constant declarations
        // base of natural logarithms
        double E = 2.718282;
        // method signatures
        void doSomething (int i, double x);
        int doSomethingElse(String s);
}
```

https://docs.oracle.com/javase/tutorial/java/IandI/interfaceDef.html

Java Interface

public interface GroupedInterface

- Public: interface available to all classes
- Private: interface available to package ONLY
- Keyword interface required
- Keyword extends:
  - An interface can use multiple other interfaces
- ALL methods are public
  - Keyword ‘public’ optional for all methods
  - Abstract methods are signature only
  - Default and Static methods with implementations

Java Interface

- Java Interface Use
  - Must be ***implemented*** by a class
    - Class MUST implement all interface methods
    - Keyword: **implements**
  - Can be ***extended*** by another interface
    - Keyword: **extends**

Java Interface

- Java Interface as API
- "The robotic car example shows an interface being used as an industry standard *Application Programming Interface (API)*. **APIs are also common in commercial software products.** Typically, a company sells a software package that contains complex methods that another company wants to use in its own software product. An example would be a package of digital image processing methods that are sold to companies making end-user graphics programs. The image processing company writes its classes to implement an interface, which it makes public to its customers. The graphics company then invokes the image processing methods using the signatures and return types defined in the interface. While the image processing company's **API is made public (to its customers), its implementation of the API is kept as a closely guarded secret—**in fact, it **may revise the implementation at a later date as long as it continues to implement the original interface that its customers have relied on**."

  https://docs.oracle.com/javase/tutorial/java/IandI/createinterface.html

Java Interface

- Java Interface Examples
  - **Comparable**
    - Implement to make your class sortable by default in natural order.
  - **Comparator**
    - Implement and use to specify a specific sort order.
  - **Runnable**
    - Implement to make your class executable on a new thread.

Comparable Interface

- Sort Pizza objects by pizza price
  - Comparable Interface provides a natural order

```
public class Pizza implements Comparable < Pizza> {
 . . .
   public int compareTo (Pizza o) {
    return Double.compare(this.getPrice(), o.getPrice());
   }
}
List<Pizza> pizzaList = new ArrayList<>();
Collections.sort(pizzaList);    // Comparable (natural) order
```

Comparable Interface

```
public class Student extends Person implements Comparable
< Student > {
 . . .
   public int compareTo ( Student o) {
          return Double.compare(this.getGpa(), o.getGpa());
   }
}
List< Student > students = new ArrayList<>();
Collections.sort(students);     // Comparable (natural) order
```

Comparator Interface

```
public class CompareByPrice implements
Comparator<Price> {

   @Override
   public int compare(Pizza o1, Pizza o2) {
          return Double.compare(o.getPrice(), o.getPrice());
   }
}
List<Pizza> pizzaList = new ArrayList<>();
pizzaList.sort(new CompareByPrice());       // Comparator
(explicit) order
```

Comparator Interface

```
public class CGPA implements Comparator<Student> {

   @Override
   public int compare(Student o1, Student o2) {
          return Double.compare(o.getGpa(), o.getGpa());
   }
}
List< Student > students = new ArrayList<>();
students.sort(new CGPA());   // Comparator (explicit) order
```

Comparator Interface

```
public class Student extends Person implements Comparable < Student > {
 . . .
  private static class Ranking implements Comparator<Student> {
  @Override
        public int compare(Student o1, Student o2) {
          // sort by GPA High to Low
          return Double.compare(o2.getGpa(), o1.getGpa());
        }
  }
  public static void ranking(List<Student> students) {
          students.sort(new Ranking());
  }
}
 . . .
List< Student > students = new ArrayList<>();
Student.ranking(students); // Comparator (explicit) GPA order
```

Comparator Interface

```
public class Student extends Person implements Comparable < Student > {
 . . .
  private static class Ranking implements
Comparator<Student> {
  @Override
        public int compare(Student o1, Student o2) {
          // sort by GPA High to Low
          return Double.compare(o2.getGpa(), o1.getGpa());
        }
  }
 . . .
}
```

Comparator Interface

- Class implements a static sorting method

```
public class Student extends Person implements Comparable < Student > {
 . . .
   public static void ranking(List<Student> students) {
       students.sort(new Ranking());
   }
}
```

Comparator Interface

- Use the static class sorting method

```
List< Student > students = new ArrayList<>();
Student.ranking(students);      // Comparator GPA order
```

CSYE 6200

Concepts of Object-Oriented Design

Java Polymorphism

Daniel Peters

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Java Class

- Class implementation in java source file (.java)
- File name identical to class name

Java Class (Cont'd)

- Implementation for one class only
  - Data members
  - Class Constructors
  - Method members

Java Class (Cont'd)

- Implementation for one class only
  - Data members
    - Class Storage specifier

      static: Class global variable

      Object instance variable (default)
    - Access modifier (public, private, protected, none)
    - Type
    - Name
    - Optional initializer

      = 1;

      = "I am an animal.";

Java Class (Cont’d)

- Implementation for one class only
  - Class Constructors
    - Special Methods
      - Constructor name Identical to class name
      - No return type (not even ‘void’)
      - Otherwise, like methods
  - Method members
    - Methods
      - Return type (or void)
      - Method name
      - Parameters and Parameter types
      - Function body (curly braces)

OO Language comparison

- Polymorphism as implemented in Object Oriented Languages
- **Java** method override
  - Allowed by default
  - Disallowed explicitly with keyword **final**
- **C++ and C#** method override:
  - Disallowed by default
  - Allowed explicitly with keyword **virtual**

Polymorphism

- Polymorphism: Existing in many forms.
- Provides flexibility
- Multiple implementations
- Extensibility
- Polymorphism
  – Static Compile-Time Polymorphism
    - Function Overloading
  – Dynamic Run-Time Polymorphism
    - Function Overriding

Static Compile-Time Polymorphism

- Polymorphism: Existing in many forms.
- Implemented in Class Methods:
- Function Overloading:
  - Multiple methods:
    - In SAME CLASS
    - Share SAME NAME
    - DIFFERENT function signatures
      - Type and number of parameters
      - Return value type NOT part of signature

Dynamic Run-Time Polymorphism

- Polymorphism: Existing in many forms.
- Implemented in Class Methods:
- Function Overriding:
  - Inheritance Required
  - Overridable method NOT disabled by Parent superclass (i.e. NOT final)
  - Overriding method implemented in Deriving Child subclass with IDENTICAL SIGNATURE
  - MUST USE Derived Child subclass object through Parent superclass type (API).

Animal.java

```
package edu.neu.csye6200;

public class Animal {
        public Animal() {
        }
        public void speak() {
                System.out.println(“I am an animal.”);
        }
}
```

- Concrete class as Superclass and API
- Specifies What (signature) and How (implementation)

Animal.java

- Specifies WHAT and HOW
  - What: method signature
  - How: method implementation
- Default implementation provided
- Every derived class **can** provide its own implementation for API speak() method
  - Animal speak() implementation inherited if not provided (overriden) by derived class.

AnimalForced.java

```
package edu.neu.csye6200;

public class AnimalForced {
        public Animal() {
        }
        public void final speak() {
                System.out.println("I am an animal.");
        }
}
```

- Concrete class as Superclass and API
- Specifies What (signature) and How (implementation)

AnimalForced.java

- Specifies WHAT and HOW
  - What: method signature
  - How: method implementation
- ONLY Implementation for speak()
- Every derived class **can NOT** provide it's own implementation for API speak() method
  - AnimalForced speak() implementation is forced and can not be overriden by derived class.

AbstractAnimal.java

```
package edu.neu.csye6200;

public abstract class AbstractAnimal {
        public Animal() {
        }
        public abstract void speak(); // abstract method as API
}
```

- Abstract class as Superclass and API
- Specifies WHAT without HOW
  - What: method signature
  - How: method implementation

AbstractAnimal.java

- Specifies WHAT without HOW
  - What: method signature
  - How: method implementation
- No default implementation provided
- Every derived class must provide it's own implementation for API speak() method
  - Compiler error if not provided

Animal.java

```
public void speak() {
        System.out.println("I am an animal.");
}
```

- speak method in class Animal
  - speak()
- Provides implementation in function body (curly braces)

Animal.java

```
public void speak() {
        System.out.println("I am an animal.");
}
```

•Java allows a **non-final** method in the superclass to be overridden by a subclass that implements same identical method signature.

Dog.java

```
package edu.neu.csye6200;

public class Dog extends Animal {
	public Dog() {
	}
	@Override
	public void speak() {
		System.out.println(“I am a dog.”);
	}
}
```

Cat.java

```
package edu.neu.csye6200;

public class Cat extends Animal {
        public Cat() {
        }
        @Override
        public void speak() {
                System.out.println("I am a cat.");
        }
}
```

Fish.java

```
package edu.neu.csye6200;

public class Fish extends Animal {
        public Fish() {
        }
        @Override
        public void speak() {
                System.out.println("I am a Fish.");
        }
}
```

@Override

- @Override annotation
- NOT part of Java code
- NOT required
- VERY HELPFUL
- ALWAYS RECOMMENDED
  - Informs Java compiler of the intent of your code
    - To override Superclass method of same signature (name, arg types)
  - Allows java compiler to double-check your code
  - Compiler error if @Override method DOES NOT MATCH a Superclass method.

Driver.java

```
package edu.neu.csye6200;
import java.util.ArrayList;
import java.util.List;
public class Driver {
   public static void main(String[] args) {
         Animal animal = new Animal();
         Dog dog = new Dog();
         animal.speak();
         dog.speak();
         List<Animal> list = new ArrayList<Animal>();
         list.add(animal);
         list.add(dog);
         for (Animal obj : list) {  obj.speak();  }
   }
}
```

Driver.java

```
package edu.neu.csye6200;
import java.util.ArrayList;
import java.util.List;
public class Driver{
  public static void main(String[] args) {
        Animal animal= new Animal();
        Dog dog= new Dog();
        animal.speak();
        dog.speak();
        List<Animal> list = new ArrayList<Animal>();
        list.add(animal);
        list.add(dog);
        for (Animal obj : list) {  obj.speak(); }
  }
}
```

Driver.java

// Create **Animal** object

Animal animal = new **Animal**();

// Create **Dog** object: **Dog** *IS-A* **Animal**

Dog dog = new **Dog**(); // use as **Dog**

animal.speak(); // **Animal** speak

dog.speak(); // **Dog** speak

Driver.java

```
package edu.neu.csye6200;
import java.util.ArrayList;
import java.util.List;
public class Driver{
  public static void main(String[] args) {
          Animal animal= new Animal();
          Animal dog= new Dog(); // use as Animal ?
          animal.speak();
          dog.speak();
          List<Animal> list = new ArrayList<Animal>();
          list.add(animal);
          list.add(dog);
          for (Animal obj : list) {  obj.speak(); }
  }
}
```

Driver.java

// Create **Animal** object

Animal animal = new **Animal**();

// Create **Dog** object: **Dog** *IS-A* **Animal**

// Alternatively, use dog as type Animal

Animal dog = new **Dog**(); // use as **Animal**

animal.speak(); // **Animal** speak

dog.speak(); // **Dog** speak

Driver.java

```
package edu.neu.csye6200;
import java.util.ArrayList;
import java.util.List;
public class Driver{
  public static void main(String[] args) {
        Animal animal= new Animal();
        Animal dog= new Dog(); // use Dog as Animal
        animal.speak();          // I am an animal
        dog.speak();             // I am a dog
        List<Animal> list = new ArrayList<Animal>();
        list.add(animal);
        list.add(dog);
        for (Animal obj : list) {
                obj.speak(); // I am an animal, … I am a dog
        }
  }
}
```

Driver.java

```
List<Animal> list =
        new ArrayList<Animal>();
        list.add(animal); // add obj to container
        list.add(dog);     // add obj to container

// for each item in container, execute speak
        for (Animal obj : list) {
                obj.speak();        // speak
        }
```

DriverProject.cpp

- CONSOLE OUTPUT

DriverProject main() ...

I am an animal.

I am a dog.

I am an animal.

I am a dog.

Using Polymorphism

- Driver instantiates both Animal and Dog objects:

  Animal animal = new **Animal**();

  Dog dog = new **Dog**();

- Dog class is derived from Animal class so any dog object *IS-A* Animal object and can be used as an Animal type without a java type mismatch error.

Using Polymorphism

- Driver uses the **Animal** object to speak:

  animal.speak();   // Animal speak

- Driver uses the **Dog** object to speak:

  dog.speak();   // Dog speak

- This is conventional use of an objects, no run-time polymorphism here.

Driver.java

```
List<Animal> list = new ArrayList<>();
        list.add(animal); // add obj to container
        list.add(dog);    // add obj to container
```

Using Polymorphism

- Driver declares an **Animal** container;

  List<**Animal**> list = new ArrayList<>();

  –Can contain **Animal** object

  –Can contain **Dog** object

    - Dog *IS-A* Animal

- Driver adds both Animal and Dog objects to **Animal** container:

  list.add(animal);

  list.add(dog);

Using Polymorphism

- Driver adds BOTH the Animal object AND the Dog object to the Animal container because Dog *IS-A* Animal:

  list.add(animal);

  list.add(dog);

Driver.java

```
// for each item in container, execute speak
        for (Animal obj : list) {
                obj.speak();        // speak
        }
```

- obj reference variable is type **Animal**
  - Range based For Loop uses variable obj
  - obj uses **Animal** API *speak()* method

Using Polymorphism

- Driver uses each object out of the Animal container as if it were an **Animal** object because Dog *IS-A* Animal:

  obj.speak();   // speak

Using Polymorphism

obj.speak(); // speak

- Java is a strongly typed language
  - Reference variable obj, is type **Animal**
- Therefore, variable obj:
  - uses ONLY **Animal** API
  - Calls *speak()* from superclass API **Animal**
    - Executes *speak()* from derived object **Dog**
    - **Dog** *speak()* implementation overrides **Animal** *speak()* implementation via polymorphism

Using Polymorphism

- Use of an **Animal** container is significant
  - Use **Animal** class as an *abstracting* **API**
    - Uses ALL objects as if an **Animal** object.
  - Using **API** provides *Functionality Hiding*

Using Polymorphism

- Using **API** provides *Functionality Hiding*
  - **API** to Specify **What** without specifying **How**
    - Use an Abstract class or Interface to specify an API for derived classes which **MUST** implement missing functionality
  - **API** to Specify **What** with specifying **How**
    - Concrete **Animal** class allows **API** to provide a DEFAULT implementation (**How**) IF derived class does not provide it's own implementation (**override**)

Using Polymorphism

- Using **API** provides *Functionality Hiding*
  – Hides specific implementation of derived classes implementing **Animal API**
- Using Animal API also provides **Loose Coupling**
    - Derived class details do not have to be used to Speak()

Using Polymorphism

- Use of an **Animal** container is significant
  - Allows Driver to be designed to use Animal objects ONLY and only by Animal container
  - Driver design is independent of any derived child classes of Animal (but Driver can use them all because of '*IS-A*' relationship)

Using Polymorphism

- Use of an **Animal** container is significant
  - Driver is compatible with any future design extensions as long as they are derived from the Animal class
  - Implementing and overriding info method provides the new functionality

Using Polymorphism

- Java keyword '**final**'
  - Java allows a subclass to override any superclass method *by default*.
    - The subclass must provide it's own implementation in one of it's methods that has an IDENTICAL signature to the superclass method to be overriden
  - Java allows a superclass to disable this feature and not allow a subclass to override it's method
    - The superclass must use the keyword '**final**' to disable function overriding

CSYE 6200

Concepts of Object Oriented Design

Java Collections: Containers and Algorithms

Daniel Peters

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- Lecture
  1. List
     - Vector, ArrayList, LinkedList
  2. Map
     - HashMap, HashTable, TreeMap
  3. Set
     - HashSet, TreeSet, LinkedHashSet
  4. Algorithms

Java Collections

- Java Collections Framework
  - Collections (a.k.a. Containers) contains a group of objects (i.e. one or more elements or items) of the same type

- Primitive types are NOT ALLOWED
  - Requires boxing (Auto-Boxing):
    - Wrap 'int' in Integer class
    - Wrap 'double' in Double class

Java Collections

- Java Collections Framework
  - Online Information
    - https://docs.oracle.com/javase/tutorial/collections/
    - https://docs.oracle.com/javase/8/docs/api/index.html?overview-summary.html
    - http://docs.oracle.com/javase/8/docs/technotes/guides/collections/overview.html
    - http://docs.oracle.com/javase/8/docs/technotes/guides/collections/reference.html

Java Collection Terms

- Unmodifiable
  - Do not support add, remove, clear methods
- Immutable
  - Guarantee no change to item will be visible
- Fixed-size
  - Guarantee size remains constant
- Random-access
  - Same time to access to any item
  - Opposite of Sequential access

Java List

- List
  - Interface: **ordered** collection (i.e. sequence)
    - Implemented by several collection classes
    - Best Practice: Use List API
      - names.add(“James”);
      - facilitates change to collection class if required (ArrayList => Vector => LinkedList)
    - Declare variables as List; instantiate Object of choice (ArrayList, Vector, LinkedList, etc.)
      - List<String> names = new ArrayList<String>();
      - List<String> names = new Vector<String>();

Java Collection classes

- Vector
  - Synchronized (thread safe)
  - Resizable random-access List implementation
  - Better than fixed-size array
- ArrayList
  - Unsynchronized Vector (essentially)
    - NOT Thread safe
    - Executes Faster than Vector

Java LinkedList class

- LinkedList
  - Unsynchronized
  - Faster than ArrayList
  - resizable List implementation
  - Queue implementation
    - LIFO
      - Last In First Out (i.e. for stack use)
  - Dequeue implementation
    - FIFO
      - First In First Out

Vector Container

- Implements the List interface
- Can be instantiated
- Can grow and shrink as needed
  - Growable array
  - Storage size increases in capacityIncrement chunks
- Ordered collection (i.e. sequence)
- Supports random access like an array
- Like ArrayList but is thread safe (synchronized)
- Slower than ArrayList

ArrayList Container

- Java Collections Framework
- Implements the List interface
- Can be instantiated
- Can grow and shrink as needed
- Ordered collection (i.e. sequence)
- Supports random access
- Like Vector but not thread safe (unsynchronized)
- Faster than Vector

LinkedList Container

- Implements the List interface
- Can be instantiated
- Can grow and shrink as needed
- Ordered collection (i.e. sequence)
- Does NOT support random access
- NOT thread safe (unsynchronized)
  - List list = Collections.synchronizedList(new LinkedList(...));
- Double Linked List implementation

Java Collection classes

- Queue
  - Interface: LIFO: add(), remove(), peek(), poll()
- Dequeue
  - Interface: FIFO
  - Double-ended Queue; extends Queue

Java Collection classes

- Map
  - Interface for Associative containers
  - Contains Key Value (K,V) pairs
  - Unique key mapped to each item

Java Collection classes

- HashMap
  - Implements Map interface
  - Unsynchronized: NOT Thread-safe
  - Allows NULL as key or value
  - Unordered
- HashTable
  - Implements Map interface
  - Synchronized: Thread-safe
    - Slower than HashMap

Java Collection classes

- TreeMap
  - Implements Map interface
  - Unsynchronized: NOT Thread-safe
    - SortedMap m = Collections.synchronizedSortedMap(new TreeMap(...));
  - Ordered (natural order or Comparator)

HashMap Container

- Java Collections Framework
- Implements the Map interface
- Can be instantiated
- Can grow and shrink as needed
- Unordered Associative collection (i.e. Key, Value pairs)
- Accepts null (key or value)
- NOT thread safe (unsynchronized)
  - Map m = Collections.synchronizedMap(new HashMap(...));

HashMap Container

```
Map<Integer, String>m = new HashMap<>();
m.put(1,"one");           // auto-boxing int into Integer object
m.put(3,"three");
m.put(5,"five");
m.put(null, "nullKey");          // hashMap accepts null key
m.put(7, null);           // HashMap accepts null value
System.out.println("5 is the integer index for the string " +
m.get(5));
System.out.println("Display map keys: ");
for (Integer key : m.keySet()) {
        System.out.print(key + ", ");
}
```

HashMap Container

```
Map<Integer, String>m = new HashMap<>();
 . . .
for (Integer key : m.keySet()) {
        System.out.print(key + ", ");
}
System.out.println("Display map values: ");
for (String value : m.values()) {
        System.out.print(value + ", ");
}
System.out.println(m.size() + " Elements in map: " + m);
```

HashTable Container

- Java Collections Framework
- Implements the Map interface
- Can be instantiated
- Can grow and shrink as needed
- Unordered Associative collection (i.e. Key, Value pairs)
- DOES NOT accept null (key or value)
- Synchronized: thread safe
  - Highly Concurrent, use ConcurrentHashMap

TreeMap Container

- Java Collections Framework
- Implements the Map interface
- Can be instantiated
- Can grow and shrink as needed
- Ordered Associative collection (i.e. Key, Value pairs)
- DOES NOT accept null (key or value)
- NOT thread safe (unsynchronized)
  - SortedMap m = Collections.synchronizedSortedMap(new TreeMap(...));

TreeMap Example

```
Map<Integer, String> m =
        new TreeMap<Integer,String>();

m.put(19,"Dan");
m.put(21,"James");
m.put(3, "Baby Sue");
System.out.println("3 is the correct age for " +
m.get(3));
```

TreeMap Example

```
Map<Integer, String> m =
        new TreeMap<Integer,String>();

m.put(19,"Dan");
m.put(21,"James");
m.put(3, "Baby Sue");
System.out.println("3 is the correct age for " +
m.get(3));
```

Java Set

- Set – NO Duplicate elements
  - Interface: unordered collection (i.e. sequence)
    - Implemented by several collection classes
    - Best Practice: Use Set API
      - names.add(“James”);
      - facilitates change to collection class if required (HashSet => TreeSet => LinkedHashSet)
    - Declare variables as Set; instantiate Object of choice (HashSet, TreeSet, LinkedHashSet)
      - Set<String> names = new HashSet<String>();
      - Set<String> names = new TreeSet<String>();
      - Set<String> names = new LinkedHashSet<String>();

Java Set

- Set https://docs.oracle.com/javase/tutorial/collections/interfaces/set.html

Java Collection classes

- HashSet
  - Unsynchronized (NOT thread safe)
  - Unordered
    - Faster than Ordered TreeSet
  - Backed by HashMap implementation of HashTable
  - No Duplicate entries
    - Null elements allowed

Java Collection classes

- TreeSet
  - Unsynchronized (NOT thread safe)
  - Ordered (natural order)
    - Slower than unordered HashSet
    - Slower than ordered LinkedHashSet
  - Backed by TreeMap
  - No Duplicate entries
    - Null entries NOT allowed (exception thrown)

Java Collection classes

- LinkedHashSet
  - Unsynchronized (NOT thread safe)
  - Double-Linked List implementation
    - "Iteration over a LinkedHashSet requires time proportional to the *size* of the set,"
  - Insertion Order (order inserted)
    - Faster than TreeSet
  - No Duplicate entries
    - Null elements allowed

Arrays.asList

- asList: array to list
  - Random Access list
    - Implements RandomAccess interface
  - Returns a Fixed List
    - Cannot grow or shrink
  - List is Backed by Array
    - Writes to list also writes to Array
    - List View of original array

Arrays.asList

String[] names = { "Jen", "Zac", "Dan" };

List<String> listOriginal = Arrays.*asList(names);*

- listOriginal.add("Mary");
  - Run-Time EXCEPTION:
    - cannot add to fixed size list

Arrays.asList

String[] names = { "Jen", "Zac", "Dan" };

List<String> listOriginal = Arrays.*asList(names);*

listOriginal.set(2, "Daniel");// writes through to array

- Both array names and List list contain identical data:
  - Jen, Zac, Daniel

Contains: To Search List

- java.util.List
- contains
  - Returns ***true*** if this list contains the specified element.

```
if ( list.contains(target) ) {
  // target found in list
  index = list.indexOf(target);
}
```

Find Dan

```
String[] names = { “Sam”,“Dan”,”Jim” };
List<String> list = new ArrayList<>(Arrays.asList(names));

if (list.contains(“Dan”)) {
   System.out.print("FOUND DAN! ");
   index = list.indexOf(target);
   System.out.println(" # " + ++index + " in the
list");
}
```

Console Output

FOUND DAN! # 2 in the list

Find Guitar Item

```
List<Item> list = new ArrayList<Item>();
Item car = new Item(2, “Car”);
Item home = new Item(1, “Home”);
Item guitar = new Item(3, “Guitar”);
list.add(car);
list.add(home);
list.add(guitar);
if (list.contains(guitar)) {
   index = list.indexOf(target);
   System.out.println(”FOUND GUITAR! # " + ++index + " in 
the list");
}
```

Console Output

FOUND GUITAR! # 3 in the list

FindItemInList

```
public Item findItemInList(List<Item> list, Item target) {
  Item foundItem = null;
  Iterator<Item> it = list.iterator();
  while (it.hasNext()) {
        foundItem = it.next();  // get next Item in list
        if (list.contains(target)) {
              break;  // found target Item in list
        } else {
              foundItem = null;
        }
  return foundItem;  // return Item found in list
}
```

Algorithms

- java.util
- Arrays class
  - asList
  - Sort
    - Comparable
    - Comparator

Sort Comparable Example

```
Integer[] numbers = { 9, 7, 23, 3, 5 };
java.util.Arrays.sort(numbers);
```

- Sorted array contains:
  - 3, 5, 7, 9, 23
- Comparable interface provides class with support for sort() natural order
- Integer class implements natural order (via Comparable interface)

Sort Comparable Example

String[] names = { “sam”,“dan”,”jim” };

List<String> ***list*** = **new ArrayList<>(Arrays.*asList(names));***

java.util.Collections.**sort**(***list***);

- Sorted List contains:
  - dan, jim, sam
- String implements natural order (Comparable interface)

Sort Algorithm

List<String> ***list*** =

new ArrayList<String>();

. . .

list**.sort***(null);*

- Sorted List contains:
  - dan, jim, sam
- String implements Comparable for natural order sort (comparator not required).

Algorithms

- java.util
- Collections class
  - Contains
  - Sort
    - Comparator
- class Student
  - Attributes: Id, name, GPA
  - Sort by class attributes

Comparator

- Package: java.util
- Interface
  - java class ‘implements’ Comparator

Comparator class

class **AlphabetizeStrings** implements **Comparator**<String> {

@Override

public int **compare**(String o1, String o2)
{ // sort in Natural order

return o1.compareTo(o2);

}

}

Comparator Example

String[] names = { "Jen", "Zac", "Dan" };

Arrays.*sort(names, new* ***AlphabetizeStrings****());*

- *Array names contains:*
  - Dan, Jen, Zac
- Comparator directs sort to ”Sort-this-way”.
- Class AlphabetizeStrings implements Comparator for “Sort-this-way” for Strings.

Anonymous Comparator Example 1

```
String[] names = { "Jen", "Zac", "Dan" };
Arrays.sort(names, new Comparator<String>() {
        @Override
        public int compare(String o1, String o2) {

        return o1.compareTo(o2);      // lexicographic order
        }
 });    // Dan, Jen, Zac
```

- *Array names contains:*
  - Dan, Jen, Zac

Anonymous Comparator Example 2

```
List<String> names = new ArrayList<String>();

// add elements to collection
names.add("Adam");
names.add("Eve");
names.add("Marilyn");
names.add("Robin");
names.add("William");
names.add("Devon");
names.add("Sylvester");
```

Anonymous Comparator Example 2

```
List<String> names =
new ArrayList<String>();
 . . .
Collections.sort(names, new
Comparator<String>() {
        // sort collection by element length
        public int compare(String o1, String o2) {
                return o1.compareTo(o2);
        }
});
```

Sort Student Example

List<Student> *students* =

new ArrayList<Student>();

Collections.*sort(students);*

•Student MUST implement Comparable for natural order sort (comparator not required)

Sort Student Example

```
public class Student extends Person implements
Comparable<Student> {
 . . .
  // Implement compareTo for Comparable
  @Override public int compareTo(Student obj) {
// Student natural order: sort by GPA
        return Double.compare(this.getGpa(),
                              obj.getGpa());
  }
}
```

Sort Student Example

List<Student> *students* =
new ArrayList<Student>();

Collections.*sort(students, Comparator);*

- Specific Comparator supplied to direct sort (Comparable implementation not required).
- Use Comparators to provide additional specific sort orders for your object.

Sort Student Example

List<Student> *students* =

new ArrayList<Student>();

students.*sort(Comparator);*

•Specific Comparator supplied to direct sort (Comparable implementation not required).

•Use Comparators to provide additional specific sort orders for your object.

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  /**
   * Implement Comparable so Student can be sorted in Natural order (by GPA)
   */
  @Override
  public int compareTo(Student o) {
		// return o.gpa.compareTo(this.gpa); // hi to low
		return this.gpa.compareTo(o.gpa); // low to hi
  }
 . . .
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  /**
   * Student comparators for additional specific Student Sort ordering.
   * @param o1          Student object
   * @param o2          Student object
   * @return                          integer result of comparison
   */
    public static int compareByLastName(Student o1, Student o2) {
            return o1.getlName().compareToIgnoreCase(o2.getlName());
    }
    public static int compareByFirstName(Student o1, Student o2) {
            return o1.getfName().compareToIgnoreCase(o2.getfName());
    }
 . . .
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  /**
   * Student comparators for additional specific Student Sort ordering.
   * @param o1          Student object
   * @param o2          Student object
   * @return                        integer result of comparison
   */
 . . .
     public static int compareByAge(Student o1, Student o2) {
             return Integer.compare(o1.getAge(), o2.getAge());
     }
 . . .
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  public static void demo() {
        List<Student> students = new ArrayList<>();
        students.add(new Student(44, "barack", "obama", 56, 3.2));
        students.add(new Student(45, "donald", "trump", 71, 2.25));
        students.add(new Student(12, "zachary", "taylor", 65, 4.0));
        students.add(new Student(2, "john", "adams", 90, 3.0));
        students.add(new Student(1, "george", "washington", 67, 2.5));
 . . .
  }
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  public static void demo() {
. . .
            /*
             * Sort the collection of Student objects by Natural order
             * (Student class implements Comparable interface)
             */
            System.out.println(students.size()
            + " students in the following collection: 1. SORTED BY GPA.");
            Collections.sort(students);
            for (Student s : students) {
                        System.out.println(s);
            }
 . . .
  }
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  public static void demo() {
. . .
            /*
             * Sort the collection of Student objects by Natural order
             * (Student class implements Comparable interface)
             */
            System.out.println(students.size()
            + " students in the following collection: 2. SORTED BY GPA.");

            // no comparator, natural order: student implements Comparable
            students.sort(null);     students.forEach(System.out::println);
 . . .
  }
}
```

Sort Student Example

```
public class Student extends Person implements Comparable<Student> {
 . . .
  public static void demo() {
. . .
            // use a static comparator in class for different sort ordering
            System.out.println(students.size() \
            + " students in the following collection: 3. SORTED BY LAST NAME.");
            students.sort(Student::compareByLastName);
            students.forEach(System.out::println);

            System.out.println(students.size()
            + " students in the following collection: 4. SORTED BY FIRST NAME.");
            students.sort(Student::compareByFirstName);
            students.forEach(System.out::println);
 . . .
  }
}
```

Sort Student Example

```
public static void demo() {
. . .
        // use a static comparator in class for different sort ordering
. . .
        System.out.println(students.size()
        + " students in the following collection: 5. SORTED BY AGE.");
        students.sort(Student::compareByAge);
        students.forEach(System.out::println);

        System.out.println(students.size()
        + " students in the following collection: 6. SORTED BY LASTNAME.");
        Collections.sort(students, Student::compareByLastName);
        students.forEach(System.out::println);
. . .
    }
}
```

Sort Student Example

```
  public static void demo() {
. . .
        // use a static comparator in class for different sort ordering
 . . .
        System.out.println(students.size()
         + " students in the following collection: 7. SORTED BY FIRST NAME.");
        Collections.sort(students, Student::compareByFirstName);
        students.forEach(System.out::println);

        System.out.println(students.size()
        + " students in the following collection: 8. SORTED BY AGE.");
        Collections.sort(students, Student::compareByAge);
        students.forEach(System.out::println);
  }
}
```

Sort Student Example

- CONSOLE OUTPUT

5 students in the following collection: 1. SORTED BY GPA.
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
5 students in the following collection: 2. SORTED BY GPA.
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0

. . .

Sort Student Example

- CONSOLE OUTPUT (continued)

. . .

5 students in the following collection: 3. SORTED BY FIRST NAME.
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
5 students in the following collection: 4. SORTED BY LAST NAME.
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5

Sort Student Example

- CONSOLE OUTPUT (continued)

. . .

5 students in the following collection: 5. SORTED BY AGE.
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
5 students in the following collection: 6. SORTED BY FIRST NAME.
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0

Sort Student Example

- CONSOLE OUTPUT (continued)

. . .

5 students in the following collection: 7. SORTED BY LAST NAME.
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
5 students in the following collection: 8. SORTED BY AGE.
Person: barack obama, age: 56, id: 44, is a student having a GPA of: 3.2
Person: zachary taylor, age: 65, id: 12, is a student having a GPA of: 4.0
Person: george washington, age: 67, id: 1, is a student having a GPA of: 2.5
Person: donald trump, age: 71, id: 45, is a student having a GPA of: 2.25
Person: john adams, age: 90, id: 2, is a student having a GPA of: 3.0

CSYE 6200

Concepts of Object Oriented Design

Generics

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Generics

- Lecture
  1. List<Object>
  2. List<>
  3. List<T>
  4. List<?>
  5. List<? extends Person>

Parameterized Types

- Collections of elements of a specific type
  - Specify type of element in parameterized type

```
List<Student> students = new Vector<Student>();
```

- Type Inference:
  - Java SE 7 Compiler can infer or determine type:

```
List<Student> students = new Vector<>();
```

- “In general, if Foo is a subtype (subclass or subinterface) of Bar, and G is some generic type declaration, it is **not** the case that G<Foo> is a subtype of G<Bar>. This is probably the hardest thing you need to learn about generics, because it goes against our deeply held intuitions.”
- https://docs.oracle.com/javase/tutorial/extra/generics/subtype.html

- In general, if ***Child*** is a subtype (subclass or subinterface) of ***Parent***, and G is some generic type declaration, it is **not** the case that G<*Child*> is a subtype of G<*Parent*>. This is probably the hardest thing you need to learn about generics, because it goes against our deeply held intuitions.
- https://docs.oracle.com/javase/tutorial/extra/generics/subtype.html
- Danny paraphrase

1. If Class ***Child*** is a subtype (subclass or derived from) Class **Parent**,
2. AND G is some generic type (example **List**<> or Vector<>),
3. List< ***Child*** > is **NOT** a subtype of List< **Parent** >.

Generic Type

- Class name<T1, T2, … Tn> {/* ... */}
- Pithy (single char) naming convention
  - Formal Type
  - Single, **uppercase** character naming convention
    - E
    - K – Key
    - N – Number
    - T – Type
    - V – Value
    - S,U,V etc. 2nd, 3rd, 4th types

Generic Type Declaration

- Generic Class Declaration
  - Use T as a generic type parameter
    - It is used as a place holder to be replaced by Actual Specific Type when Generic Class is used
    - NOTE: Prior to JDK 5.0 legacy code used raw type UNTIL classes became generic, i.e. a concrete type (e.g. Integer) can be applied

```
class Box<T> {
      . . .
}
```

Generic Type Invocation

- Generic Class Invocation:
  - Replace formal type **T** by substituting ***Integer*** as generic type argument as a parameterized type
  - Substitute any **non-primitive** type
  - **Reference Types ONLY**

class Box<Integer> // Integer class wrapper
class Box<Double> // Double class wrapper
NOT class Box<double> // primitive double type

Generic Type Benefits

- Type Abstraction
- Promote Code Reuse
  - Test and Development efficiency
  - Consistency
  - Flexibility

Wildcard

"In generic code, the question mark (?), called the *wildcard*, represents an unknown type."

https://docs.oracle.com/javase/tutorial/java/generics/wildcards.html

Wildcard

"To declare an upper-bounded wildcard, use the wildcard character ('?'), followed by the extends keyword, followed by its *upper bound*."

https://docs.oracle.com/javase/tutorial/java/generics/upperBounded.html

Wildcard: List<? extends Foo>

- Upper bounded Type

<? **extends** Foo>

- – Foo is any type
- – Matches Foo
  - (and classes derived from Foo)
    - – IS-A relationship
- – Matches **ANY SUBTYPE** of Foo.

Wildcard: List<? extends Explosion>

- Upper bounded Type

<? **extends** Explosion>

  - Explosion is a explosion API concrete class
  - Matches Explosion super class
  - Matches **ANY SUBTYPE** of Explosion.
    - GunShot Is-A Explosion
    - Grenade Is-A Explosion

Wildcard: List<? extends Number>

- Example: **sumOfList**

```
public static double sumOfList(List<?
   extends Number> list) {
  double sum = 0.0;
  for (Number n : list)
 sum += n.doubleValue();
  return sum;
}
```

Wildcard: List<? extends Number>

- Example: **sumOfList**

public static double **sumOfList**(List<? **extends Number**> list) {

- Matches a list of any **subtype** of Number (Integer, Short, Double, Long, etc.).

Wildcard: List<? extends Number>

- Example: **sumOfList**

List<**Integer**> *ints* = Arrays.asList(1, 2, 3);
System.out.println("sum = ”
+ **sumOfList**(*ints*));

  - List of Integer objects:
    1, 2, 3
  - Prints sum = 6.0:

Wildcard: List<? extends Number>

- Example: **sumOfList**

List<**Double**> *d* = Arrays.asList(1.2, 2.3, 3.5);

System.out.println("sum = " + **sumOfList**(*d*));

  – List of Double objects:
    1.2, 2.3, 3.5
  – Prints sum = 7.0:

Wildcard: List<?>

- Unbounded Type: List<?>
- "Because for any concrete type A, List<A> is a subtype of List<?> …"
- Member of every type: null

Wildcard: List<?>

- Note List<Object> and List<?> are NOT THE SAME.
  - List<Object>
    - Can insert Object
    - Can insert (add to List) ANY subtype of Object
  - List<?>
    - Can ONLY insert (add to List) null
- Unbounded wildcard ? useful when NOT inserting (add to List)

Wildcard: List<?>

- Example: printList

```
public static void printList(List<?> list) {
    for (Object elem: list)
        System.out.print(elem + " ");
    System.out.println();
} // end printList
```

- Leverage Object.toString()

Wildcard: List<?>

- Unknown (Unbounded) Type
- Member of every type: null
- Useful:
  - If you are writing a method that can be implemented using functionality provided in the **Object** class.
  - When the code is using methods in the generic class that don't depend on the type parameter.
    - List.size
    - List.clear.

Wildcard: List<? super Foo>

- Lower bounded Type

<? **super** Foo>

  - Foo is any type
  - Matches Foo
  - Matches **ANY SUPER TYPE** of Foo.

- Name TWO classes? Foo and Object

Wildcard: List<? super Foo>

- Example: **addNumbers**

```
public static void addNumbers(List<? super Integer> list) {
    for (int i = 1; i <= 10; i++) {
        list.add(i);
    } // end for
} // end addNumbers
```

Wildcard: List<? super Foo>

- Example: **addNumbers**

public static void **addNumbers**(List<? super Integer> list) {

. . .

} // end addNumbers

- Matches a list of any **supertype** of Integer (Integer, Number and Object).

Generic Class Example

```
public class ShowState<E> {
private List<E> objects = new ArrayList<E>();
        public void addOBject(E obj) {
                this.objects.add(obj);
        }
        public void showObjects(String title) {
                System.out.println(title);
                this.objects.stream()
                .forEach(System.out::println); // call toString()
                System.out.println(objects.size() + " objects.");
        }
} // Why can you System.out::println an object from ANY class?  Ans. toString()
```

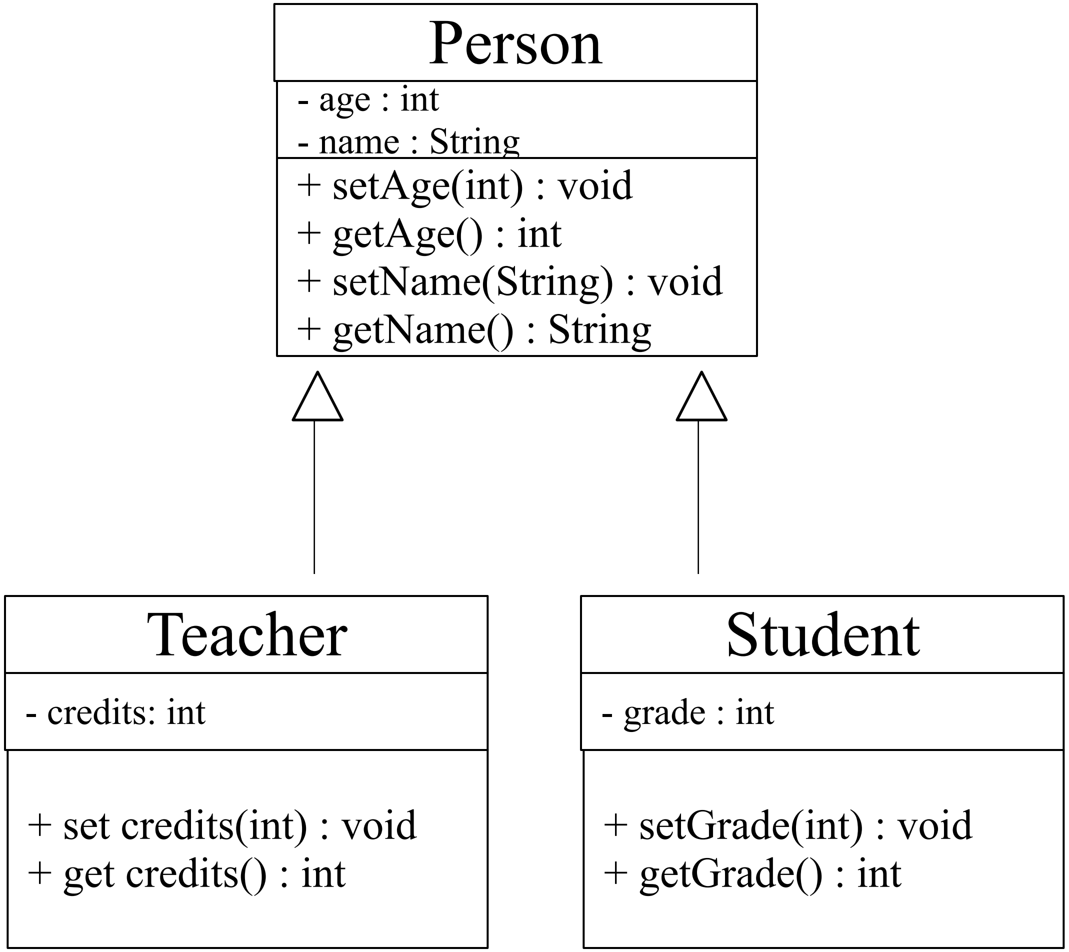
Generic Class Example

```
public class ShowState<E> {
private List<E> objects = new ArrayList<E>();
        public void addOBject(E obj) {
                this.objects.add(obj);
        }
        public void showObjects(String title) {
                System.out.println(title);
                this.objects.stream()
                .forEach(o ->System.out.println(o.toString()));
                System.out.println(objects.size() + " objects.");
        }
} What can implement Consumer Interface? Lambda, anon., concrete classes
```

Java type casting

- instanceof
- JavaClass class.cast
- (type)

Class Diagram



Type casting example

```
Student s = new Student(); // Student object
Student s2 = null;  // TYPE: ref to student obj
Person p = s;       // Student IS-A Person
// does p reference a Student object?

if (p instanceof Student ) {
        s2 = (Student) p;  // if true, downcast
}
```

- Example of downcasting (bad) with casting

Type casting example

```
Student s = new Student();
Student s2 = null;
Person p = s;       // ok, Student IS-A Person
if (p instanceof Student ) {
        s2 =  p;  // true, but illegal without cast
}
```

- Inheritance IS-A relationship
  - Child IS-A Parent
  - Parent is never a Child

Type casting example

SwingControlDemo **sw3** = new SwingControlDemo();

Person p = null;

// can't cast just any object

p = (Student) **sw3**; // NOT a Student object

GUI Updater Example

```
package edu.neu.csye6200.util;
import java.util.ArrayList;
import javax.swing.*;
import javax.swing.JComboBox;

public class TextAreaUpdaterTask<T extends JComponent>
implements Runnable {
 /**
    * construct a Runnable updater for the text of one GUI component
    * @param guiComponent targeted GUI component for text update
    */
 . . .
}
```

GUI Updater Example

```
public TextAreaUpdaterTask(T guiComponent) {
        this.guiComponent = guiComponent;
    }
    JButton b;
    JComboBox c;
    JLabel l;
    JTextArea t;
    JTextField f;
    String message;     // message to update gui component
    ArrayList list;     // list of messages to update gui component
    T guiComponent;     // gui components to update with message
```

GUI Updater Example

```
/**
  * provide text for updating GUI component
  *
  * @param message text for GUI component update
  */
 public void setMessage(String message) {
    this.message = message;
 }
```

GUI Updater Example

```
/**
 *
 * @param aList list of messages to update GUI component
 */
public void setMessage(ArrayList aList) {
    this.list = aList;
}

private <S> S convert(Class<S> cls, Object o) {
    return cls.cast(o);
}
```

GUI Updater Example

```
@Override
  public void run() {
    if (guiComponent instanceof JButton) {
      b = (JButton) guiComponent;
      b.setText(message); // update button text
    }

    if (guiComponent instanceof JComboBox) {
      c = convert(JComboBox.class, guiComponent) ;
      c.removeAllItems();
      for (Object item : list) {
        c.addItem(item);
      }
    }
```

GUI Updater Example

```
if (guiComponent instanceof JLabel) {
        l = (JLabel) guiComponent;
        l.setText(message); // update label text
    }
    if (guiComponent instanceof JTextArea) {
        t = (JTextArea) guiComponent;
        t.setText(message); // update text area contents
    }
    if (guiComponent instanceof JTextField) {
        f = (JTextField) guiComponent;
        f.setText(message); // update text field
    }
  }
}
```

Online Links

- Oracle:
  - Generics:
    https://docs.oracle.com/javase/tutorial/java/generics/index.html
  - Guidelines for Wildcard Use:
    https://docs.oracle.com/javase/tutorial/java/generics/wildcardGuidelines.html
  - Restrictions on Generics:
    https://docs.oracle.com/javase/tutorial/java/generics/restrictions.html

CSYE 6200

Concepts of Object Oriented Design

Java Exceptions

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- Lecture
  - Java Exceptions
  - Throw
  - Try, Catch, Finally
  - Try with Resources

Exception

"An exception is an event that occurs during the execution of a program that disrupts the normal flow of instructions."

https://docs.oracle.com/javase/tutorial/essential/exceptions/index.html

Exception

- An aberration or abnormal event
    1. Exceptional Event
    2. Error or Fault
    3. Disruptive
    4. Sometimes unrecoverable

Java Exception Types

1. **Checked Exception**
2. External **Error** or Fault
3. **Runtime Exception**

Java Checked Exception Type

- **ALL** Exceptions are Checked Exceptions
  - *EXCEPT*: **Error, RuntimeException** and their subclasses.
- Predictable Error Conditions
  - File I/O with user specified invalid file name
- Must EITHER be ***Caught*** or ***Specified***
- Compiler error if neglected
- **java.io.FileReader**
  - **java.io.FileNotFoundException**

Java Error Exception Type

- Errors ***External*** to application
  - Hardware Error
- Difficult to anticipate
- **Error** and its subclasses
- OPTIONAL: ***Caught*** or ***Specified***
- **java.io.IOError** Exception

Java Runtime Exception Type

- Errors ***Internal*** to application
  - Programming bug
- Difficult to anticipate
- **RuntimeException** and its subclasses
- OPTIONAL: ***Caught*** or ***Specified***
- **NullPointerException** Exception

Java Custom Exception Type

```
public class MyException extends Exception
{
        public MyException() {
                super();
        }
        public MyException(String message) {
                super(message);
        }
}
```

Throw

- “When an **error** occurs within a method, the method creates an object and hands it off to the runtime system. The object, called an ***exception object***, contains information about the error, including its type and the state of the program when the error occurred. Creating an exception object and handing it to the runtime system is called ***throwing an exception***.”

Throw

SYNTAX:

throw *someThrowableObject*

•Where *someThrowableObject* are instances of subclasses derived from the java.lang.**Throwable class**

Throw Example

public void
throwAnException() ***throws*** **Exception** {
    throw **new Exception**(”Boo!”);
}

•Exception which may be thrown by method *throwAnException*() is ***Specified*** by using ***throws Exception***

Try, Catch, Finally

SYNTAX:

try {
        . . .
} **catch** {
        . . .
} **finally** {
        . . .
}

https://docs.oracle.com/javase/tutorial/essential/exceptions/finally.html

Try, Catch, Finally

Where:

- Try block
  - Surrounds code which ***may*** throw exception
- Catch block
  - Exception Handler
  - Executed ***only when*** exception is thrown
- Finally block
  - ***OPTIONAL***
  - ***Always*** executed **IF** present

Try, Catch Example

```
try {
        this.throwAnException();
} catch (Exception e) {
        System.out.println(“Caught!");
        System.out.println(e.getMessage());
        e.printStackTrace();
}
```

- Exception thrown by *throwAnException*() is ***Caught***

Try, Catch, Finally Example

```
try {
        this.throwAnException();
} catch (Exception e) {
        System.out.println(“Caught!");
        System.out.println(e.getMessage());
        e.printStackTrace();
} finally {
        System.out.println(“Finally done!");
}
```

Try with Resources

SYNTAX:

try (open ***auto-closable*** resources) {

 . . .

} **catch** {

 . . .

} **finally** {

 . . .

}

AutoClosable

- Implemented by:
  - BufferedReader
  - FileReader
  - BufferedWriter
  - FileWriter
  - DatagramSocket

CSYE 6200

Concepts of Object Oriented Design

Interface and Inner Class

Daniel Peters

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- Lecture
  1. Java Inner Interface
  2. Java Inner Class
  3. Java Interface

Private Inner Interface

```
public class OuterClass {
 . . .
        private interface InnerHelperInterface {
 . . .
        }
 . . .
}
```

Inner Interface

- Inner Interface
  - CAN NOT be defined in an inner class.
  - A Outer Class member (like member data)
    - Public, Private or Protected
      - Controls outside visibility to inner class
      - NOTE: outer class is ALWAYS public
    - Static: implicit (and redundant) for Java Interfaces (like all Interface methods are implicitly public and public access modifier is redundant)

Public Inner Interface

```
public class OuterClass {
 . . .
        public interface InnerHelperInterface {
 . . .
        }
 . . .
}
```

Private Inner Class

```
public class OuterClass {
 . . .
        private class InnerHelperClass {
 . . .
        }
 . . .
}
```

Inner Class

- Inner Class
  - A Outer Class member (like member data)
    - Public, Private or Protected
      - Controls outside visibility to inner class
      - NOTE: outer class is ALWAYS public
    - Static: belongs to Class
    - Non-static: belongs to each object instance
      - Must be instantiated from object instance

        OuterClass **outerClass** = new OuterClass();

        InnerClass innerClass = **outerClass.new** InnerClass();

Public Inner Class

```
public class OuterClass {
 . . .
        public class InnerRelatedClass {
 . . .
        }
 . . .
}
```

Inner Class

- Inner Class
  - A Outer Class member (like member data)
    - Public, Private or Protected
      - Controls outside visibility to inner class
      - NOTE: outer class is ALWAYS public
    - Static: belongs to Class
    - Non-static: belongs to each object instance
      - Must be instantiated from object instance

        OuterClass **outerClass** = new OuterClass();

        InnerClass innerClass = **outerClass.new** InnerClass();

Inner Class

- Inner Class
  - Methods:
    - Static: requires inner class to ALSO be static
    - Non-static: belongs to each object instance

Anonymous Inner Class

- Anonymous Inner Class
  - In-Line unnamed class specification
    - Supplied to method as a parameter
    - Usually an implementation of an Interface

Anonymous Inner Class

```
List<Student> students = new ArrayList<>();

students.sort(new Comparator<Student>() {

   @Override
   public int compare(Student o1, Student o2) {
           return o1.getAge().compareTo (o2.getAge());
   }
});
```

Java AutoBoxing

"*Autoboxing* is the automatic conversion that the Java compiler makes between the primitive types and their corresponding object wrapper classes."

https://docs.oracle.com/javase/tutorial/java/data/autoboxing.html

Java AutoBoxing

- AutoBoxing
  - Character ch = 'a';
  - Double n = 2.2;
  - Integer i = 3;

Integer class and Primitive int

- AutoBoxing int literal values with Integer class

```
List<Integer> numbers = new
   ArrayList<>(Arrays.asList(1,3,2));
```

- UnBoxing int from List of Integer objects

```
int i = numbers.get(1);
```

Integer class and Primitive int

- Integer number = 7;
  1. Reference type
  2. Class must be instantiated or set to null
  3. Object has helpful members
  4. Requires additional storage

Integer class and Primitive int

- int n = 7;
  1. Primitive type
  2. Does NOT require instantiation
  3. Does NOT have any members
  4. Requires minimal storage
  5. Fast access

Java Interface

- Java Interface
  - Reference type, similar to a class
  - Contains ONLY:
    - Data
      - Public Static Final (Constants)
    - Methods:
      - ALL METHODS IMPLICITLY PUBLIC
        - » Keyword public may be omitted from methods.
      - abstract methods (no body)
      - Static methods
      - Default methods (Java 8)

Java Interface

- Java Interface
  - Public:
    - Public interface is accessible to all classes
    - Otherwise, only accessible to classes in same package
  - Keyword interface
    - Must be implemented by a class
      - Class MUST implement all interface methods
    - Can be extended by other interfaces

Java Interface

```
public interface GroupedInterface extends Interface1,
Interface2, Interface3 {
        // constant declarations
        // base of natural logarithms
        double E = 2.718282;
        // method signatures
        void doSomething (int i, double x);
        int doSomethingElse(String s);
}
```

https://docs.oracle.com/javase/tutorial/java/IandI/interfaceDef.html

Java Interface

public interface GroupedInterface

- Public: interface available to all classes
- Private: interface available to package ONLY
- Keyword interface required
- Keyword extends:
  - An interface can use multiple other interfaces
- ALL methods are public
  - Keyword ‘public’ optional for all methods
  - Abstract methods are signature only
  - Default and Static methods with implementations

Java Interface

- Java Interface Use
  - Must be implemented by a class
    - Class MUST implement all interface methods
  - Can be extended by another interface

Java Interface

- Java Interface as API

- “The robotic car example shows an interface being used as an industry standard *Application Programming Interface (API)*. **APIs are also common in commercial software products.** Typically, a company sells a software package that contains complex methods that another company wants to use in its own software product. An example would be a package of digital image processing methods that are sold to companies making end-user graphics programs. The image processing company writes its classes to implement an interface, which it makes public to its customers. The graphics company then invokes the image processing methods using the signatures and return types defined in the interface. While the image processing company's **API is made public (to its customers), its implementation of the API is kept as a closely guarded secret—**in fact, it **may revise the implementation at a later date as long as it continues to implement the original interface that its customers have relied on**.”

  https://docs.oracle.com/javase/tutorial/java/IandI/createinterface.html

Java Interface

- Java Interface Examples
  1. Comparable
     1. Implement to make your class sortable by default in natural order.
  2. Comparator
     1. Implement and use to specify a specific sort order.
  3. Runnable
     1. Implement to make your class executable on a new thread.

Comparable Interface

- Sort Pizza objects by pizza price
  - Comparable Interface provides a natural order

```
public class Pizza implements Comparable < Pizza> {
 . . .
   public int compareTo (Pizza o) {
    return Double.compare(this.getPrice(), o.getPrice());
   }
}
List<Pizza> pizzaList = new ArrayList<>();
Collections.sort(pizzaList);    // Comparable (natural) order
```

Comparable Interface

```
public class Student extends Person implements Comparable <
Student > {
 . . .
   public int compareTo ( Student o) {
           return Double.compare(this.getGpa(), o.getGpa());
   }
}
List< Student > students = new ArrayList<>();
Collections.sort(students);     // Comparable (natural) order
```

Comparator Interface

```
public class CompareByPrice implements Comparator<Price>
{

   @Override
   public int compare(Pizza o1, Pizza o2) {
           return Double.compare(o.getPrice(), o.getPrice());
   }
}
List<Pizza> pizzaList = new ArrayList<>();
pizzaList.sort(new CompareByPrice());        // Comparator
order
```

Comparator Interface

```
public class CGPA implements Comparator<Student> {

   @Override
   public int compare(Student o1, Student o2) {
         return Double.compare(o.getGpa(), o.getGpa());
   }
}
List< Student > students = new ArrayList<>();
students.sort(new CGPA());   // Comparable (natural) order
```

Comparator Interface

```
public class Student extends Person implements Comparable < Student > {
 . . .
  private static class Ranking implements Comparator<Student> {
  @Override
        public int compare(Student o1, Student o2) {
          // sort by GPA High to Low
          return Double.compare(o2.getGpa(), o1.getGpa());
        }
  }
  public static void ranking(List<Student> students) {
        students.sort(new Ranking());
  }
}
 . . .
List< Student > students = new ArrayList<>();
Student.ranking(students); // Comparator GPA order
```

Comparator Interface

```
public class Student extends Person implements Comparable < Student > {
 . . .
  private static class Ranking implements
Comparator<Student> {
  @Override
          public int compare(Student o1, Student o2) {
            // sort by GPA High to Low
            return Double.compare(o2.getGpa(), o1.getGpa());
          }
  }
 . . .
}
```

Comparator Interface

- Class implements a static sorting method

```
public class Student extends Person implements Comparable < Student > {
 . . .
   public static void ranking(List<Student> students) {
       students.sort(new Ranking());
   }
}
```

Comparator Interface

- Use the static class sorting method

```
List< Student > students = new ArrayList<>();
Student.ranking(students);      // Comparator GPA order
```

CSYE 6200

Concepts of Object Oriented Design

Java File Input Output

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- Lecture
  1. Loops
  2. Array
  3. Map
  4. Scanner
  5. File Handling
  6. Exception Handling

Range Loop

Syntax:

```
for ( type item : container)
Example:
String[] names =
    {"Adam", "Eve", "Cain", "Able"};
for (String name : names) {
    System.out.println(name);
}
```

Range Loop Example

```
List<String> col = new ArrayList<String>();

col.add("Peter");
col.add("Paul");
col.add("Mary");

for (String item : col) {
        System.out.print(item.toUpperCase() +", ");
}
```

Produces Output:

PETER, PAUL, MARY,

Iterator Loop

Syntax:

Iterator<Integer> it;

Example:

List<Integer>**numbers** = new Vector<>();

Iterator<Integer> it = **numbers**.iterator();

•Use with collections supporting Iterator interface

•Iterator type is specific to type of collection (*Vector*) and type of it's contents (*Integer*)

Iterator Loop

```
List<String> names = new Vector<String>();
Iterator<String> it = names.iterator()
while (it.hasNext()) {
    System.out.println(it.next());
}
```

Iterator Loop Example

```
List<Integer> numbers = new ArrayList<Integer>();
numbers.add(1); // auto-boxing
numbers.add(2); // same as
numbers.add(3); // numbers.add(new Integer(3));

Iterator<Integer> it = numbers.iterator();
while (it.hasNext()) {
        System.out.print(it.next() +", ");
}
```

Produces Output:

1, 2, 3,

Iterator Loop Example

```
List<String> names= new ArrayList<String>();
names.add("Peter");
names.add("Paul");
names.add("Mary");

Iterator<String> it = names.iterator();
while (it.hasNext()) {
        System.out.print(it.next() +", ");
}
```

Produces Output:

Peter, Paul, Mary,

ListIterator Loop

Syntax:

```
ListIterator<Integer> it;
Example:
List<Integer> numbers = new Vector<>();
ListIterator<Integer> it = numbers.listIterator();
```

- Use with collections supporting ListIterator interface
- Can iterate forward and backwards
- Can modify element (set)

ListIterator Loop

```
List<String> names = new Vector<String>();
ListIterator <String> it = names.listIterator()
while (it.hasNext()) {
    System.out.println(it.next());
    }
while (it.hasPrevious()) {
    System.out.println(it.previous());
    }
```

ListIterator Loop Example

```
List<String> names= new ArrayList<String>();
names.add("Peter");
names.add("Paul");
names.add("Mary");

ListIterator<String> it = names.listIterator();
while (it.hasNext()) {
        String item = it.next();
        item = item.toUpperCase() + ", ";
        it.set(item);  // only in ListIterator
        System.out.print(it2.next() +", ");
}
```

Produces Output:

PETER, PAUL, MARY,

ListIterator Loop Example

```
List<String> numbers= new ArrayList<String>();
numbers.add(1);
numbers.add(2);
numbers.add(3);

ListIterator<Integer> it = numbers.listIterator();
while (it.hasNext()) {
        System.out.print(it.next() +", ");
}
```

Produces Output:

1,2,3,

Array

Syntax:

```
String[] names = {“adam”, “eve”};
int[] numbers = { 1, 2, 3 };
String[] strArray = new String[3];
```

- contains multiple items of same type
- Items in contiguous memory
- Fixed size
- Random access
- Array is an object (Reference Type)

Array Examples

```
int[] numbers = { 1,2,3 };

for (int number : numbers ) {
        System.out.print(number +", ");
}
```

Produces Output:

1, 2, 3,

Array Examples

String[] **names** = {“adam”, “eve”};

for (String name : **names**) {
    System.*out.print(name +", ");*
}

Produces Output:

adam, eve,

Array Examples

```
String[] threeFruit = {"Apple", "Pear", "Orange"};

for (String fruit : threeFruit) {
        System.out.print(fruit +", ");
}
```

- Produces Output:

Apple, Pear, Orange,

Associative

Map

Syntax:

Map<KeyType, ValueType> m;

eg. **Map**<Integer, String> m =
new **HashMap**<Integer, String>();

- Interface
- Implemented by HashMap class

Map Examples

```
Map<String, String> states = new HashMap<String, String>();

states.put("NH", "New Hampshire");
states.put("NJ", "New Jersey");
states.put("NY", "New York");
System.out.println(“NY: " + states.get("NY"));
System.out.println(“NJ: " + states.get("NJ"));
```

Produces Output;

NY: New York

NJ: New Jersey

Scanner

- Text scanner
- Parses tokens using delimiter
- Converts to primitive types and Strings

Scanner Examples

```
Student dan = new Student();

Scanner in = new Scanner("peters,dan,17,3.25,james,peters");
in.useDelimiter(",");

dan.setLname(in.next());    // no conversion, String token is String
dan.setFname(in.next());
dan.setAge(in.nextInt());   // convert String token to int
dan.setGpa(in.nextDouble());        // convert String token to double
dan.setParentFname(in.next());
dan.setParentLname(in.next());
in.close();
students.add(dan);          // add Student object to students container
```

Scanner Examples

```
// show collection of students
System.out.println(students.size() + " Students in roster.");
for (Student student : students) {
        System.out.println(student.getLname()
                + ", " + student.getFname()
                +", Age " + student.getAge()
                +", GPA: " + student.getGpa());
}
```

- Produces Output

1 Students in roster.

peters, dan, Age 17, GPA: 3.25

Scanner Examples

```
// show collection of students
System.out.println(students.size() + " Students in roster.");
for (Student student : students) {
        System.out.println(student); // Student toString()
}
```

- Produces Output

1 Students in roster.

peters, dan, Age 17, GPA: 3.25

BufferedReader

Syntax:

```
BufferedReader in = new BufferedReader( new
FileReader(“inputFile.txt”));
String thisLine = in.readLine();
in.close();
```

- BufferedReader uses FileReader
- Adds efficiency by buffering data before calling FileReader

Buffered Reader Example

```
String  thisLine = null;

// try with resources: all resources in () are closed at conclusion of try clause
try (  // open input stream from input file for reading purpose.
        FileReader fr = new FileReader(fileName);
        BufferedReader in = new BufferedReader(fr);   )  {
        System.out.println("BufferedReader: '" + this.inputFileName + "'");
        while ((thisLine = in.readLine()) != null) {
                System.out.println(thisLine);
        }
} catch(Exception e){
        e.printStackTrace();
  }
```

Try with Resources

- Use with resources (i.e. file descriptors used for file I/O)
  - **MUST** Instantiate class INSIDE of try parenthesis
    - **try (… new…)**
- Class **MUST** implement **AutoCloseable** Interface
  - Will be automatically closed at conclusion of **try { … }**

```
try (    FileReader fr = new  FileReader(fileName);
    BufferedReader in = new  BufferedReader(fr);   )  {
. . .
} catch(Exception e){
    e.printStackTrace();
}
```

BufferedWriter

Syntax:

```
FileWriter fw = new FileWriter ("outputFile.txt");
BufferedWriter bw = new BufferedWriter (fw);
PrintWriter pr = new PrintWriter (bw);
```

- BufferedWriter uses a FileWriter object
- Newline is system specific
  - bw.newLine()
- flush after write

  bw.flush();

Buffered Writer Example

```
String[] fiveNames = {"Dan", "Jim", "Eve", "Ina"};

// try with resources: all resources in () are closed at conclusion of try clause
try (        // open output stream to output file for writing purpose.
        FileWriter fw = new FileWriter(fileName);
        BufferedWriter out= new BufferedWriter(fw);
        ) {
    System.out.println("BufferedWriter: '" + this.outputFileName + "', write " + fiveNames.length + " items");
        for (String name : fiveNames) {
                out.write(name);
                out.newLine();
        }
        out.flush();
} catch (Exception e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
}
```

Buffered Writer Example

```
// try with resources:
// all resources in () are closed at conclusion of try clause
try (    // open output stream to output file for writing.
         FileWriter fw = new FileWriter(fileName);
         BufferedWriter out= new BufferedWriter(fw);
  ) {
         for (String name : fiveNames) {
                 out.write(name);
                 out.newLine();
         }
         out.flush();
```

Buffered Writer Example

```
} catch (Exception e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
}
```

Read CSV Example 1

```
List<Student> students = new ArrayList<Student>();
// Read entire ASCII comma separated value file: each line becomes a student object
// try with resources: all resources in () are closed at conclusion of try clause
try (BufferedReader inLine = new BufferedReader(new FileReader(fileName));
) {
        String inputLine = null;        // read one line from file at a time
        while ((inputLine = inLine.readLine()) != null) {
                // Parse line converting each string token into a Student object field
                String[] fields = inputLine.split(",");
                String lname = fields[0];
                String fname = fields[1];
                int age = new Integer(fields[2]);
                double gpa = new Double(fields[3]);
                String parentFname = fields[4];
                String parentLname = fields[5];

                // instantiate Student object from line in file and add to list
                students.add(new Student (fname,lname,age,gpa,parentFname,parentLname));
        }
} catch (IOException e) {
        // catch IOException (and implicitly FileNotFoundException)
        e.printStackTrace();
}
```

Read CSV Example 1

```
List<Student> students = new ArrayList<Student>();

// Read entire ASCII comma separated value file:
// each line becomes a student object
// try with resources:
// all resources in () are closed at conclusion of try clause
try (BufferedReader inLine = new BufferedReader(new
FileReader(fileName));
) {
…
```

Read CSV Example 1

```
) {

// read one line from file at a time
        String inputLine = null;
        while ((inputLine = inLine.readLine()) != null) {
                // Parse line converting each string token
                // into a Student object field
                String[] fields = inputLine.split(",");
                String lname = fields[0];
. . .
} catch (IOException e) {
```

Read CSV Example 1

. . .

```
while ((inputLine = inLine.readLine()) != null) {
            // Parse line converting each string token into a Student object field
            String[] fields = inputLine.split(",");
            String lname = fields[0];
            String fname = fields[1];
            int age = new Integer(fields[2]); // see *
            double gpa = new Double(fields[3]); // see *
            String parentFname = fields[4];
            String parentLname = fields[5];
```

. . .

* String type conversion

- *** Conversion from String type to int requires exception handling**
  - **Catch exception thrown from failure to convert bad String**

```
. . .
    int age = 0;
    try {
        age = new Integer(fields[2]);
    } catch (NumberFormatException e) {
        age = 0;
        e.printStackTrace();
    }
. . .
```

* String type conversion

- * **Conversion from String type to double requires exception handling**
  - **Catch exception thrown from failure to convert bad String**

```
. . .
  double gpa = 0;
  try {
        gpa = new Double(fields[3]);
  } catch (NumberFormatException e) {
        gpa = 0.0;
        e.printStackTrace();
  }
. . .
```

Read CSV Example 1

```
. . .
        // instantiate a Student object from EACH line
        // in file and add to list
        students.add(new Student ( fname,
                        lname,
                        age,
                        gpa,
                        parentFname,
                        parentLname ) );
        } // end while loop
. . .
```

Read CSV Example 1

```
…
} catch (IOException e) {
        // catch IOException (and implicitly
FileNotFoundException)
        e.printStackTrace();
}
```

Read CSV Example 2

```
List<Student> students = new ArrayList<Student>();
  try {
          Scanner inLine = new Scanner(new BufferedReader(new FileReader(fileName)));

          while (inLine.hasNextLine()) {
                  String inputLine = inLine.nextLine();
                  Scanner in = new Scanner(inputLine);
                  in.useDelimiter(",");
                  String lname = in.next();
                  String fname = in.next();
                  int age = in.nextInt();
                  double gpa = in.nextDouble();
                  String parentFname = in.next();
                  String parentLname = in.next();

                  students.add(new Student (fname,lname,age,gpa,parentFname,parentLname));
                  in.close();
          }
          inLine.close();
  } catch (FileNotFoundException e) {
          // TODO Auto-generated catch block
          e.printStackTrace();
  }
```

Read CSV Example 2

```
List<Student> students = new ArrayList<Student>();
  try {
        // Scanner used to read each line from file
        Scanner inLine = new Scanner(new
BufferedReader(new FileReader(fileName)));

        while (inLine.hasNextLine()) {
                String inputLine = inLine.nextLine();
. . .
        }
        inLine.close();  // scanner resource must be closed
  } catch (FileNotFoundException e) {
. . .
  }
```

Read CSV Example 2

```
while (inLine.hasNextLine()) {
        String inputLine = inLine.nextLine();
        // Scanner ALSO used to read each token in line
        Scanner in = new Scanner(inputLine);
        in.useDelimiter(",");
        String lname = in.next();
        String fname = in.next();
        int age = in.nextInt();  // See *
        double gpa = in.nextDouble();  // See *
        String parentFname = in.next();
        String parentLname = in.next();

. . .
}
```

Read CSV Example 2

```
        while (inLine.hasNextLine()) {
                String inputLine = inLine.nextLine();
                Scanner in = new Scanner(inputLine);
                in.useDelimiter(",");   // CSV file usees comma
                String lname = in.next();
. . .
                students.add(new Student
(fname,lname,age,gpa,parentFname,parentLname));
                in.close();       // must close scanner
                }
        inLine.close();           // must close scanner
  } catch (FileNotFoundException e) {
. . .
  }
```

Read CSV Example 2

```
} catch (FileNotFoundException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
  }
```

CSYE 6200

Concepts of Object Oriented Design

Packaging

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- Lecture:
    1. Java Jar Files

Java JAR Files

java.lang.String

- Java Archive
  - Zip archive file format
  - Use Java Archive tool (jar) in Java Development Kit (JDK)
  - Online Information

    https://docs.oracle.com/javase/tutorial/deployment/jar/basicsindex.html

Java JAR Tool

- Create a jar file

jar cf *jar-file input-file(s)*

  - c: create
  - f: name of jar file for tool output

- Example:

jar cf mydriver.jar DriverProject.class

Eclipse JAR Tool

1. Select Project in Eclipse Project Explorer
2. Select menu: File > Export
3. Select Export Destination
   a. Type jar
   b. Select Runnable JAR or JAR file
   c. Select Next

Eclipse JAR Tool (cont’d)

4. Select Options or accept defaults
5. JAR file:
   a. Browse to directory
   b. Type jar file name, e.g. myjar.jar
6. Select FINISH

Java JAR Tool on Windows

1. Copy java classes to single folder
2. Start cmd prompt window as admin
3. Change to folder containing java classes
4. Insure java JDK bn directory is in path:
   a. C:\Program Files\Java\jdkn.n.nn\bin
5. Create jar from all java classes
   a. jar cf myjar.jar c1.class c2.class … cn.class

Java JAR Tool

- View contents of a jar file

jar tf *jar-file input-file(s)*

  - t: view table of contents
  - f: name of jar file for tool output

- Example:

jar tf mydriver.jar DriverProject.class

Java command

- Run a class (which contains a main method)

java classNameWithout.*class*Extension

- Example
  - Working directory: ./Proj/bin
  - Class file: ./Proj/bin/c1.class
  - Package: (class in default package):

java c1

Java command

- Run a class (which contains a main method)

java classNameWithout.*class*Extension

- Example
  - Working directory: ./Proj/
  - Class file: ./Proj/bin/edu/neu/java1/c1.class
  - Package: edu.neu.java1

java –cp bin edu.neu.java1.c1

-

Java command

- Run an executable jar file

java -jar *jar-file*

- Example:

java –jar mydriver.jar

Java JAR Tool

- Create a jar file with specific entry point

jar cfe *jar-file input-file(s)*

  - c: create
  - f: name of jar file for tool output
  - e: entry point (class with main method)

- Example:

jar cfe mydriver.jar c1.class c2.class c1.class

CSYE 6200

Concepts of Object-Oriented Design

Java GoF Factory Design Pattern

Daniel Peters

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- Lecture
  - Simple Factory Pattern
  - Factory Method Pattern

Design Patterns

- Gang of Four (GoF) Book

Design Patterns

Elements of Reusable Object-Oriented Software

by Erich Gamma, Richard Helm, Ralph Johnson John Vlissides

ISBN-10: 0201633612

ISBN-13: 9780201633610

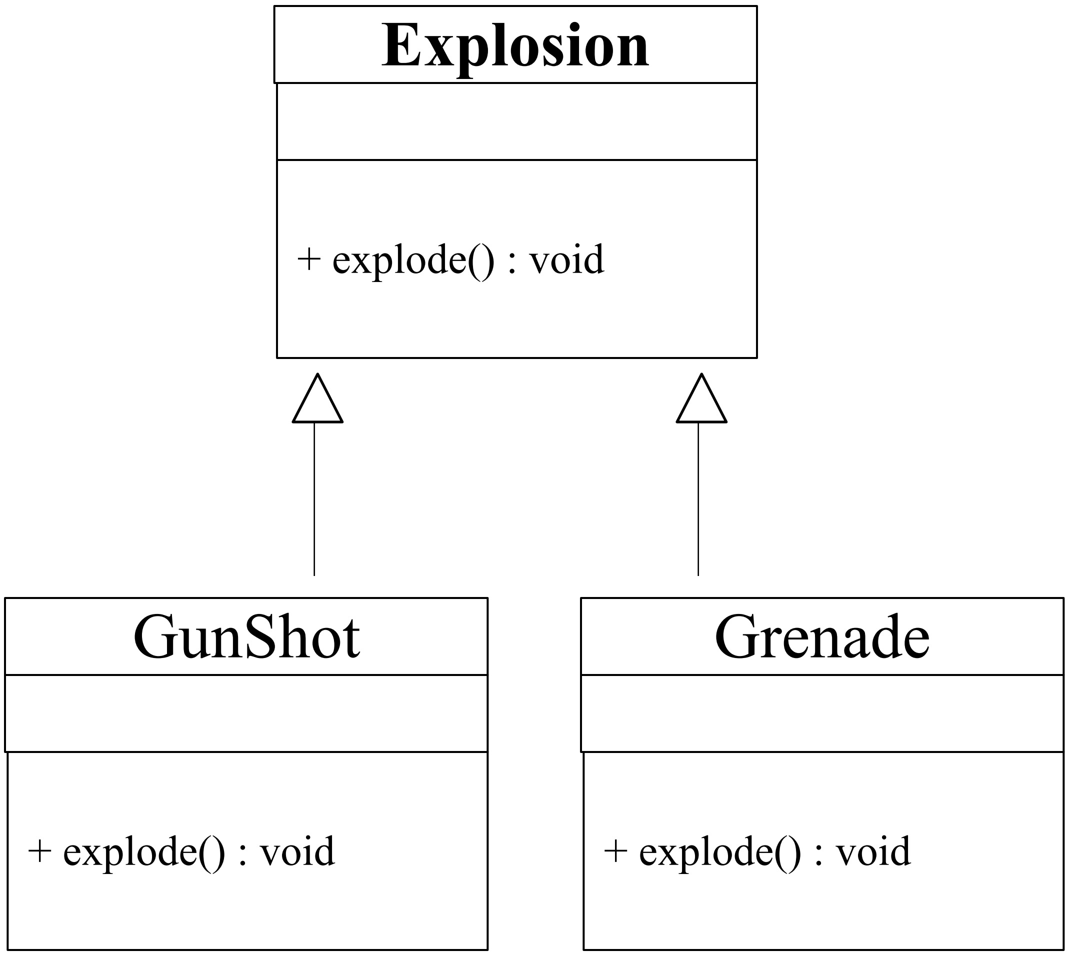
Simple Factory Pattern

- Creational Design Pattern
  - Abstraction: Functionality Hiding
    - Abstracts Class Constructor
- Employs Inheritance
  - Superclass as API
    - Interface
    - Abstract Class
- Single Factory class creates an instance of a **concrete derived target** class
  - Return instantiated **target object** to caller

Simple Factory Pattern Components

1. Design ONE **target Superclass**
   – API to Abstract all derived classes
     • Example: **Explosion**
2. Design **concrete derived target subclasses**
   – Example: **GunShot, Grenade**
3. Design ***one*** *factory class*
   – Factory class instantiates **ALL** derived target subclasses based on supplied criteria *AND SWITCHING LOGIC*

Explosion Class Diagram



Simple Factory Pattern

- NOT mentioned in GoF
- Violates S.O.L.I.D. Design Principles
  - Must be changed for new derived classes violating Open/Closed principle
  - Sole Responsibility principle
- Switching logic for criteria Complicates unit testing

Simple Factory Pattern Usage

1. Instantiate Simple Factory class
2. Use “get object” method, supplying criteria for specific target
3. Method returns instantiated target object after switching logic to determine which concrete derived subclass meets criteria

Simple Factory Pattern

```
public class SimpleExplosionFactory {
  enum ExplosionCriteria {
        GUNSHOT,
        GRENADE
  }
  public Explosion getObject( ExplosionCriteria criteria ) {
        if (criteria == GUNSHOT) {
              return new Gunshot();
        } else {
              return new Grenade();
        }
  }
}
```

Usage Simple Factory Pattern

```
public static void demo() {
  // Simple Factory: one factory creates all derived objects
  SimpleExplosionFactory factory =
        new SimpleExplosionFactory();

  List<Explosion> explosions = new ArrayList<>();

  explosions.add(factory.getObject(GUNSHOT ));
  explosions.add(factory.getObject(GRENADE ));
}
```

Updated Simple Factory Pattern

```
public static void demo() {
  // Simple Factory: one factory creates all derived objects
  SimpleExplosionFactory factory =
        new SimpleExplosionFactory();

  List<AbstractExplosion> explosions = new ArrayList<>();

  explosions.add(factory.getObject(GUNSHOT ));
  explosions.add(factory.getObject(GRENADE ));
  explosions.add(factory.getObject(ABOMB));
}
```

Factory Pattern Benefits

- Best for large projects with many developers
- Provides Loose coupling
  - Eliminates widespread hard coding of object instantiation
  - Flexibility: Easy to change class implementation
  - Robust: Supports Best Practices
    - Code depends on Interface or Abstract class
    - Less dependence on concrete classes
  - Greater flexibility than constructor overloading
    - Business case to limit instantiations

Factory Anti-Pattern Detriments

- Anti-Pattern: Using patterns just to use patterns
  - Usually a not a good fit and only adds complexity
- Skip Factory Pattern
– Simple small project won't benefit much
– Small group work little benefit
– No dependencies
– Few changes
– No Business logic

Target Classes: example 1

- AbstractExplosion Super Class
  1. Gunshot concrete target subclass
  2. Grenade concrete target subclass
  3. ABomb concrete target subclass

GoF Factory Method Pattern

- Factory Method Pattern is introduced in GoF Design Patterns Book:
  - **Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory Method lets a class defer instantiation to subclasses"**
- Creational Design Pattern
  - Abstraction: Functionality Hiding
    - Abstracts Class Constructor

Factory Method Design Pattern

- Anatomy of the Factory Method Design Pattern
  1. Who (are): Constituent Components (parts)
  2. What (happens): Operational
  3. Where (useful): Scenarios
  4. Why (design) Rationale
  5. When (used): Benefits

Factory Method Design Pattern

- Who:

  Constituent components, roles or parts participating in the deployment and use of the design pattern

  1. Product API
     - API for all target objects created by factory
  2. Concrete Product implements Product API
  3. Factory API used by Application (Creator)
  4. Concrete Factory implements Factory API to create a Concrete Product (target object)

Factory Method Design Pattern

- What:

  A brief description of what happens with the use of the design pattern

  1. Application uses Concrete Factory via Factory API
  2. Concrete Factory returns an instance of the Concrete Product (targeted object) conforming to Product API

Factory Method Design Pattern

- Where:

  A list of suitable scenarios for the use of the design pattern

  –In a Loosely coupled system where (1 or more of the following):

  1.Class wants to delegate object creation to subclass

  2.Need to Localize knowledge of creation process including any helper subclasses

Factory Method Design Pattern

- Why:

  A brief description of rationale behind the design of the design pattern

  1. APIs define and use derived objects in an abstract loosely coupled relationship
     - Factory method abstracts the creation process to maintain the loosely coupled relationship

Factory Method Design Pattern

- When:

  A brief description of the benefits obtained when using the design pattern

  1. Abstraction: Factory eliminates creation of objects directly providing flexibility
  2. Supports loose coupling and S.O.L.I.D. design principles because the derived class used to create the target object isn't explicitly used by application code

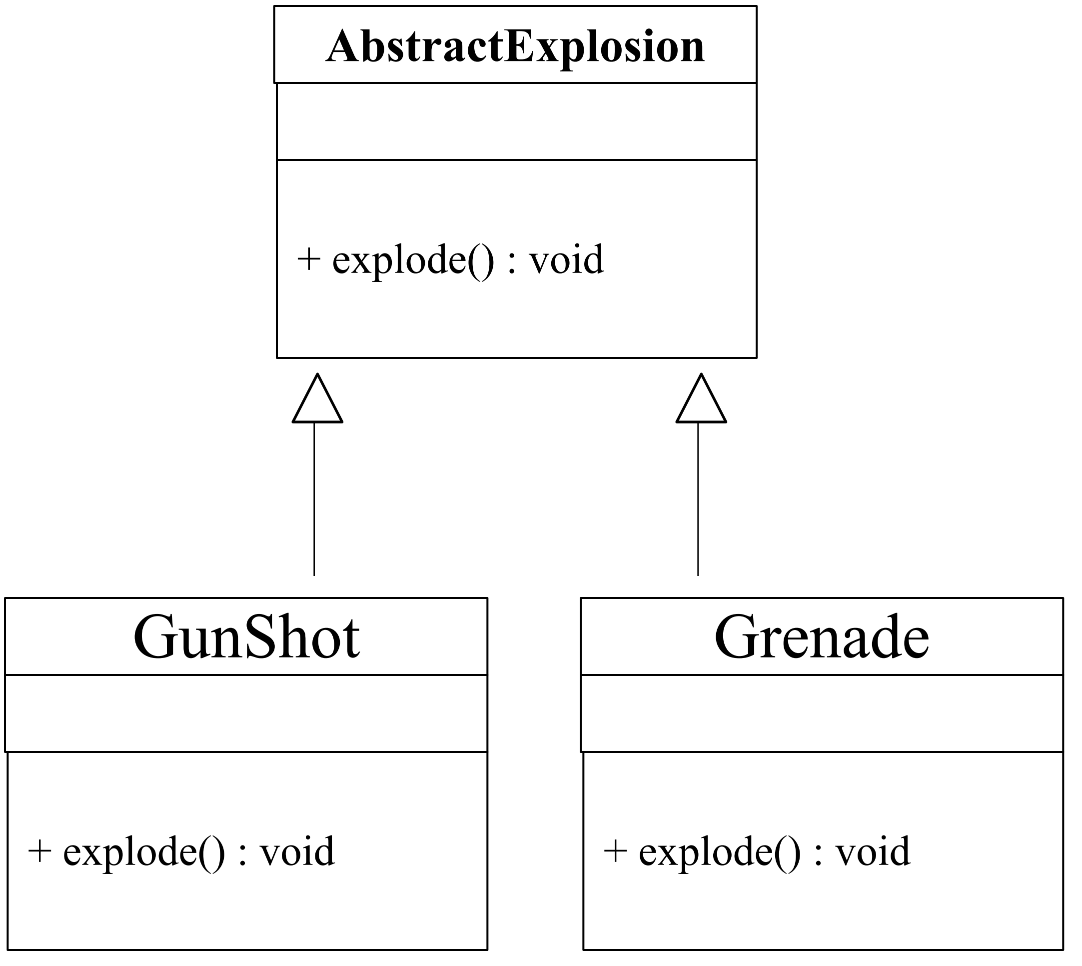
GoF Factory Pattern Method

- Employs Inheritance
- Abstract class or interface as API for target subclasses
  - Just like Simple Factory Pattern
- Abstract class as API for Factory classes
  - Creates instances of a concrete derived Factory subclasses
    - Each Concrete derived factory subclass creates an instance of a concrete derived target subclass
    - Return target object to caller

Factory Pattern Method Components

1. Design **target Abstract super class**
2. Design **concrete derived target subclasses**
3. Design *factory Abstract super class*
4. Design *concrete derived factory subclasses*
    1. Each concrete derived factory class specializes in instantiating one concrete derived target class
    2. No SWITCHING LOGIC simplifies unit testing.

AbstractExplosion Class Diagram



AbstractExplosion

```
public abstract class AbstractExplosion {
  public abstract void explode();
}
```

- API for each derived object returned by a factory

GunShot

```
public abstract class GunShot extends
AbstractExplosion {
   @Override
   public abstract void explode();
}
```

•Each derived object implements AbstractExplosion API

Grenade

```
public abstract class Grenade extends
AbstractExplosion {
   @Override
   public abstract void explode();
}
```

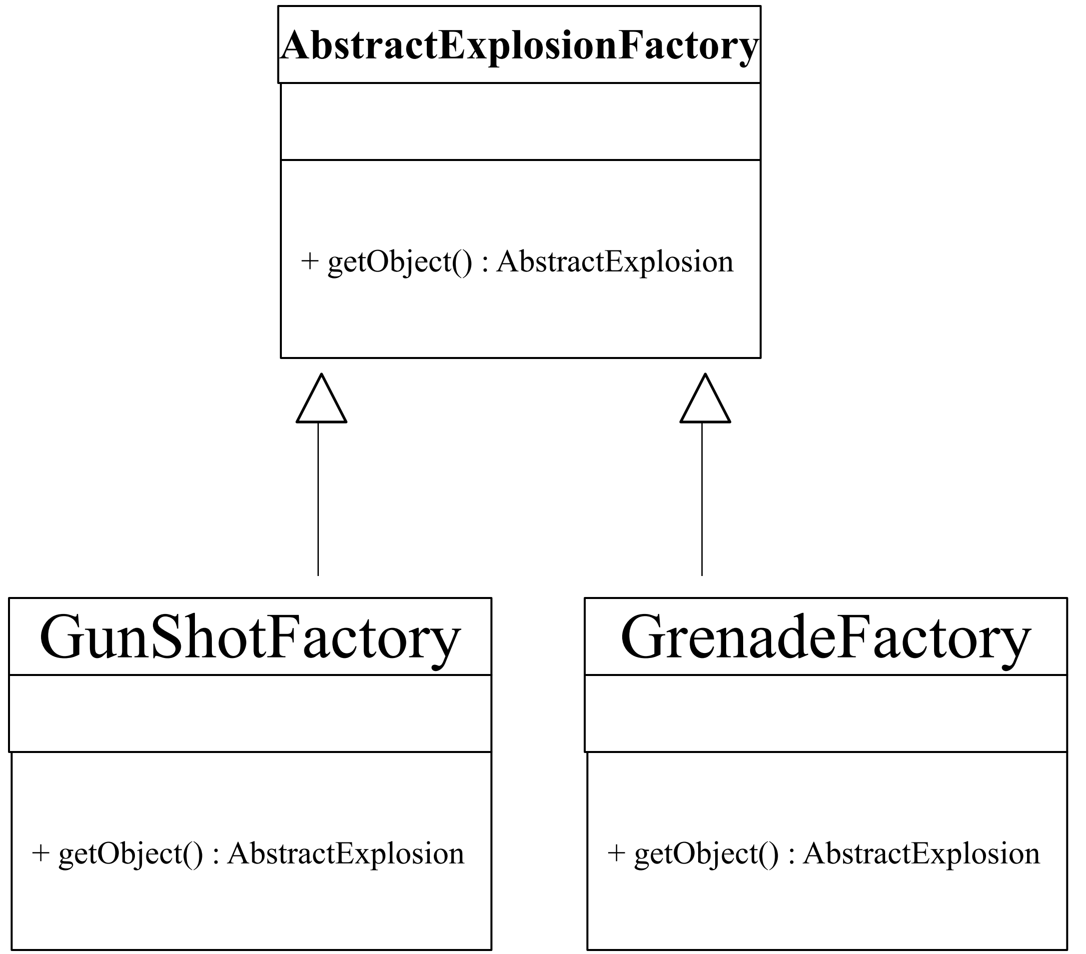
- Each derived object implements AbstractExplosion API

AbstractExplosionFactory

```
public abstract class AbstractExplosionFactory {
  public abstract AbstractExplosion getObject();
}
```

•API for used by each factory to create a derived explosion object

AbstractExplosionFactory
Class Diagram



Gunshot Factory derived subClass

```
public class GunshotFactory extends
AbstractExplosionFactory {
  public AbstractExplosion getObject() {
        return new Gunshot();
  }
}
```

Grenade Factory derived subClass

```
public class GrenadeFactory extends
AbstractExplosionFactory {
  public AbstractExplosion getObject() {
        return new Grenade();
  }
}
```

ABomb Factory derived subClass

```
public class ABombFactory extends
AbstractExplosionFactory {
    public AbstractExplosion getObject() {
        return new ABomb();
    }
}
```

Usage Factory Pattern

```
public static void demo() {
  // Factory Pattern: each factory specializes in one derived objects
 AbstractExplosionFactory factory1 = new GunshotFactory();
 AbstractExplosionFactory factory2 = new GrenadeFactory();
 AbstractExplosionFactory factory3 = new ABombFactory();

  List<AbstractExplosion> explosions = new ArrayList<>();
   explosions.add(factory1.getObject());
   explosions.add(factory2.getObject());
   explosions.add(factory3.getObject());
}
```

Factory Design Patterns Summary

- Simple Factory Pattern
  - Single Factory uses supplied criteria and switching logic to create one of several specific instantiated target subclasses
- GoF Factory Pattern Method
  - Several Factories EACH of which can create A SINGLE specific instantiated target subclass.

CSYE 6200

Concepts of Object-Oriented Design

Java GoF Singleton Design Pattern

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- Lecture
  - Singleton pattern

Design Patterns

- Gang of Four (GoF) Book

Design Patterns

Elements of Reusable Object-Oriented Software

by Erich Gamma, Richard Helm, Ralph Johnson John Vlissides

ISBN-10: 0201633612

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Singleton Design Pattern

- Singleton Pattern is introduced in GoF Design Patterns Book:
  - **Ensure a class has ONLY ONE SINGLE instance and provide a GLOBAL point of access to it"**
- Abstraction: Functionality Hiding
  - Abstracts Class Constructor
- Used for Logging, Configuration, Factories
- Creational Design Pattern

Singleton Design Pattern

- Anatomy of a Design Pattern
  1. Who (are): Constituent Components (parts)
  2. What (happens): Operational
  3. Where (useful): Scenarios
  4. Why (design) Rationale
  5. When (used): Benefits

Singleton Design Pattern

- Who:

  Constituent components, roles or parts participating in the deployment and use of the design pattern

  1. Get Instance method
     - Allows clients global access to one unique object instance of the Singleton class
  2. May create its own one and only unique instance

Singleton Design Pattern

- What:

  A brief description of what happens with the use of the design pattern

  1.Client uses Get Instance method to obtain the one and only unique object instance of the Singleton class

Singleton Design Pattern

- Where:

  A list of suitable scenarios for the use of the design pattern

  –Where only one instance of a class is required which must be globally accessible to clients

  1.A Factory class requires only a single instance

  2.Unique Subsystem facilities, i.e., Logging, Print Spooler, GUI Window Manager, Configuration settings, require only a single instance

Singleton Design Pattern

- Why:

  A brief description of rationale behind the design of the design pattern

  1.Some classes require only a single instance and a global accessibility to that instance

Singleton Design Pattern

- When:

  A brief description of the benefits obtained when using the design pattern

  1. Requirement for exactly one object instance of a class.
  2. Requirement for Global accessibility of that instance.

Singleton Design Pattern

- Allows for easy extension of design
  - Can extend or replace created object with a new class
    - S.O.L.I.D. principles (O.L.D.) saves re-test
      - Never touch existing code once tested and deployed

Singleton Design Pattern

- **Private** constructor is never used by caller
- Public **getInstance**() method returns the one and only instance of singleton class
- Singleton class ensures that one and **ONLY one instance** of itself is instantiated

Singleton Design Pattern

- Serves as a ‘better’ global variable
  - Accessible like a global
  - Guarantees ONLY SINGLE INSTANCE
- ALL GLOBALS ARE BAD
  - Bad for multithreaded implementations
  - Global access is problematic

Singleton Design Pattern

- Singleton useful for subsystems which MUST have one common instance
  - Object instantiation Factories
  - System Printer spooler
  - System Logging facility
  - System Configuration facility
  - System Graphic Window Manager
  - A/D converter for a digital filter
  - Company’s official accounting system

Singleton Design Pattern

- Alternative to Singleton: Static class operations (methods) insure a single instance BUT…
  - No Loose Coupling
  - Explicitly used
  - Without S.O.L.I.D. principles

Singleton Design Pattern

- Singleton can be modified to variable number of instances
  - Change design to allow for more than a single instance
  - Control the number of application instances used

Eager Singleton Example

```
public class EagerSingleton {
   private static final EagerSingleton instance =
         new EagerSingleton();

   private EagerSingleton() {
   }
   public static EagerSingleton getInstance() {
         return instance;
   }
}
```

Simple Singleton

- **Early** or **Eager** initialization

1. Resource is always available
   – Allocated From beginning of program execution
2. Resource immediately available without delay
   - Real-Time Performance Benefit
3. Resource is allocated EVEN IF NEVER USED

   Can be a waste resources

Lazy Singleton Design Pattern

```
public class LazySingleton {
   private static LazySingleton instance;
   private LazySingleton() {
           instance = null;
   }
   public static synchronized LazySingleton getInstance() {
           if (instance == null) {
                   instance =  new LazySingleton();
           }
           return instance;
   }
}
```

Lazy Singleton

- **Late** or **Lazy** initialization

1. Resource allocated WHEN REQUESTED
   - Preserves resources until actually required
2. Resource NOT immediately available
   - Allocation delay can be a Real-Time Performance Hit

Singleton Example

```
public class OnlyOne {
   private static OnlyOne instance;     // data member
   private OnlyOne() {
          instance = null;
   }
   public static synchronized OnlyOne getInstance() {
          if (null == instance) {
                   instance = new OnlyOne();
          }
                   return instance;
   }
}
```

Singleton: Private Constructor

```
public class OnlyOne {
   private static OnlyOne instance;
   private OnlyOne() {
         instance = null;
   }
 . . .
}
```

Singleton: Public API

```
public class OnlyOne {
  private static OnlyOne instance;    // data member
 . . .
  public static synchronized OnlyOne getInstance() {
        if (null == instance) {
              instance = new OnlyOne();
        }
              return instance;
  }
}
```

Singleton design Pattern Usage

```
OnlyOne singletonInstance = null;
singletonInstace = OnlyOne.getInstance();
singletonInstance.toString();
```

Singleton Design Pattern Summary

- Eager or Early Initialization:
  - Resource allocated at program start before run.
  - Waste of resource if never actually requested.

- Lazy or Late Initialization:
  - Resource allocated at run-time when requested.
  - Conserves Resource until actually required.

CSYE 6200

Concepts of Object Oriented Design

SOLID

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- Lecture **S O L I D**:

- **S**ingle Responsibility Principle:
- **O**pen-Closed Principle:
- **L**iskov Substitution Principle:
- **I**nterface Segregation Principle:
- **D**ependency Inversion Principle:

SOLID

- Acronym coined by Michael Feathers
- Design principles promoted by Robert C. Martin.
  - Benefits:
    - Flexibility
    - Maintainability
    - Understandability
- https://en.wikipedia.org/wiki/SOLID

Single Responsibility Principle:

- Design each class (or module) with ONLY one **Single** responsibility (*purpose* or task);
- Employ Encapsulation
  - 1. All data (supporting *purpose*) class private;
  - 2. Supply public API (supporting *purpose*);

Single Responsibility Principle:

```
public class Person {
        private int age = 17;
        private String name = “Dan”;
        public String toString() {
            return name + “, age “ + age;
        }
}
```

NOT Single Responsibility Principle:

public class **Person** {

private int age = 17;

private String **name = “Dan”**;

private double **gpa = 4.0**;

private double **wage = 25.75**;

private String **toString**() {

return name+“ “+gpa+“ $ “+wage+,/hour age “+ age +”;

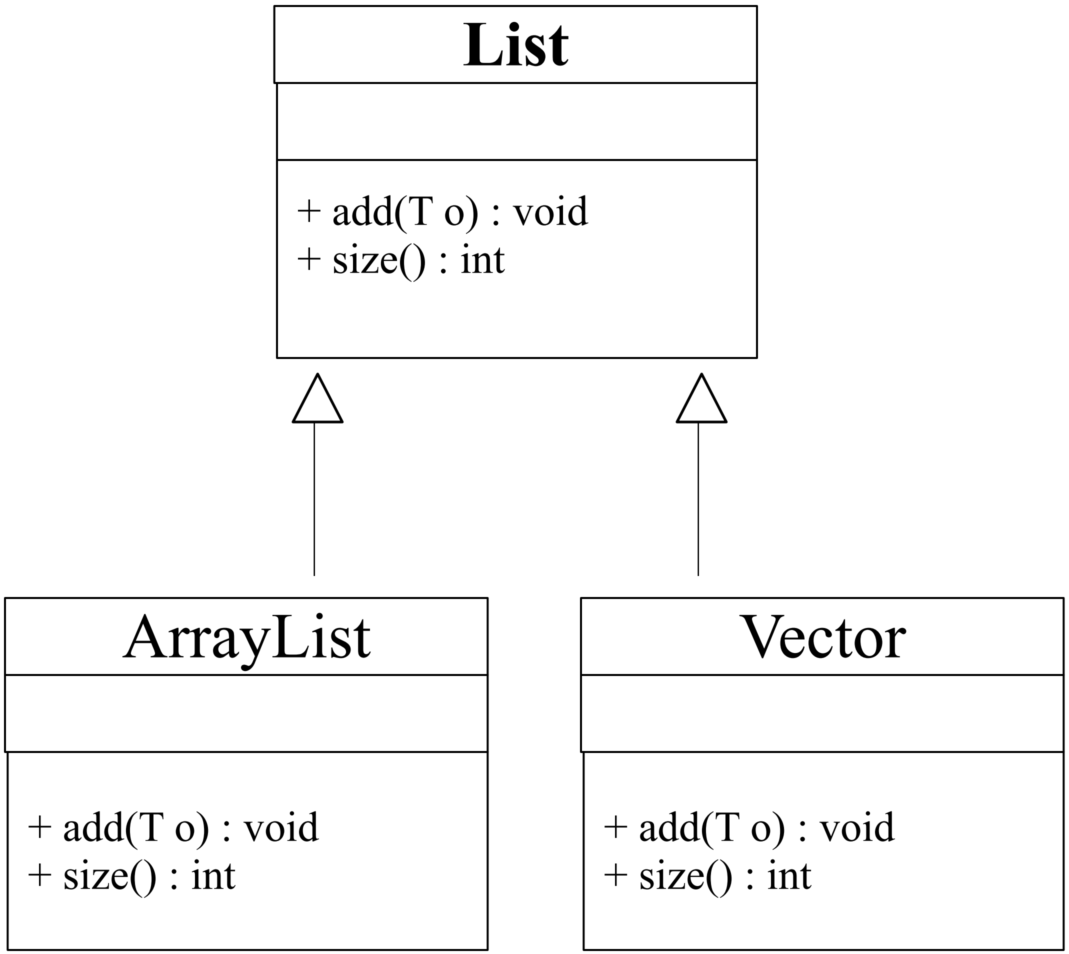
}

}

Open-Closed Principle:

- Design and each class is **Open** to extension;
  - Use NEW subclasses and Polymorphism
- Each class is **Closed** to modifications;
  - Once tested, use class as a Super class

List Class Diagram



Open-Closed Principle:

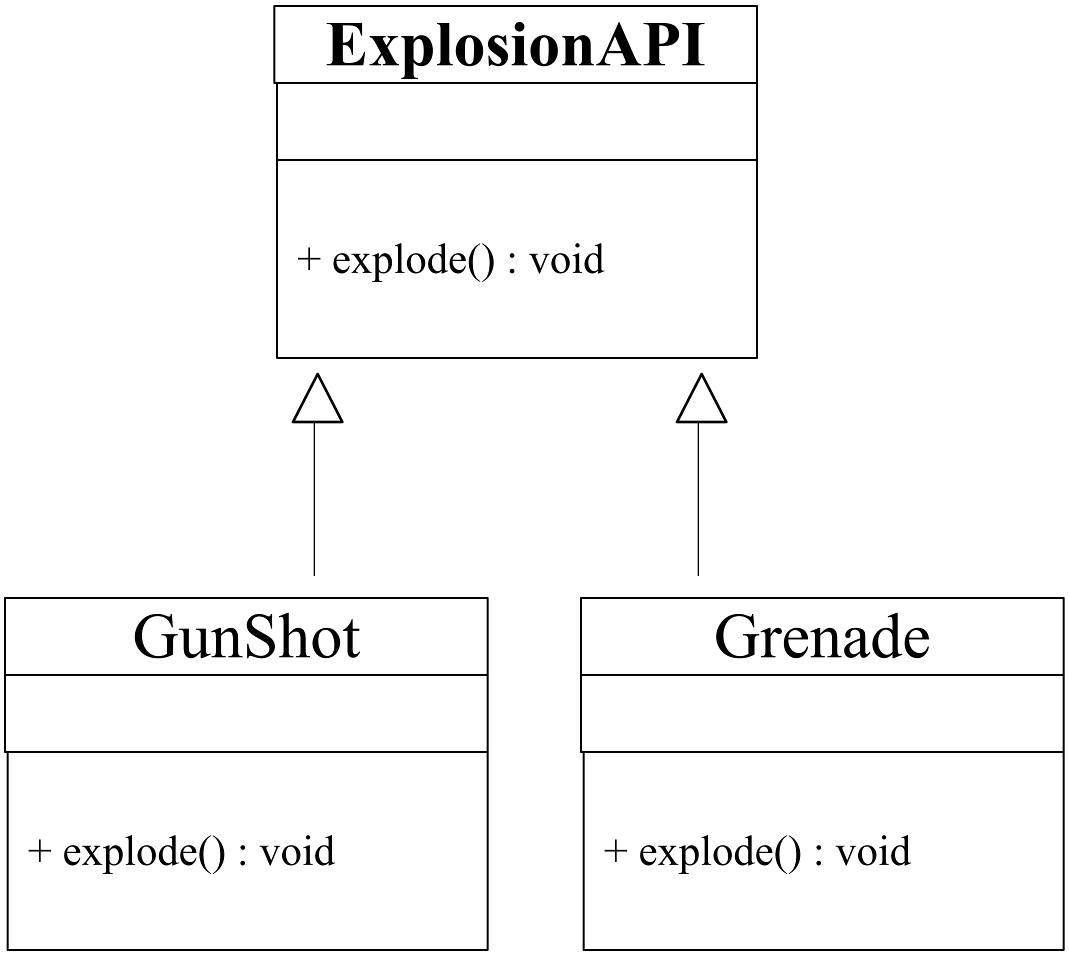
- use derived objects through superclass API

List<String> names = **new** ArrayList<>();

- NOT: use derived objects explicitly

ArrayList<String> names = **new** ArrayList<>();

Explosion Class Diagram



Liskov Substitution Principle:

- IS-A Relationship: Any subclass may be **Substituted** for its Super class;
- Run-time Polymorphism;
- Employ Strong subtyping by implementing specific interfaces in subclass;
  – Can be used to differentiate subclasses;

Liskov Substitution Principle:

- use derived objects in substitution of superclass API

List<String> names = **new** ArrayList<>();

List<String> names = **new** Vector<>();

List<String> names = **new** LinkedList<>();

Interface Segregation Principle:

- No class should depend on any method it does not implement (use);
  - Design Interface:
    - Small granularity
      - fine grained like Salt, not Snowballs
    - Less IS More: Few methods in interface;
    - Very focused and Specific purpose;
    - Class implements multiple interfaces for desired functionality;

Interface Segregation Principle:

http://developer.classpath.org/doc/java/lang/Runnable-source.html

```
public interface Runnable {
        void run();
}
```

http://developer.classpath.org/doc/java/lang/Comparable-source.html

```
public interface Comparable<T> {
        int compareTo(T o);
}
```

Dependency Inversion Principle:

- Loosely coupled Design;
- Depend on abstractions.
  - Functionality Hiding: Subclass is never named
  - Don't Explicitly call new or static methods

Dependency Inversion Principle:

- Class ExplosionController should use Class Explosion
  - Class GunShot extends Explosion
  - Class Grenade extends Explosion

Dependency Inversion Principle:

- Depend on **List** API as abstraction

List<String> names = **new** ArrayList<>();

  – Use of Factory design pattern abstracts **new** and completes the abstraction of derived classes

- NOT: use derived objects explicitly

ArrayList<String> names = **new** ArrayList<>();

SOLID and OOP

- Loose Coupling is achieved by:
  - Object Oriented Principles (OOP): AIP
    - Abstraction
    - Inheritance
    - Polymorphism
  - SOLID principles: OLD
    - Open-Closed Principle
    - Liskov Substitution Principles
    - Dependency Inversion Principles

CSYE 6200

Concepts of Object Oriented Design

Java 8 Lambda, Streams

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- Lecture
  1. Functional Programming
  2. Lambda
  3. Functional Interface
  4. Generic
  5. Streams
  6. Predicate

Functional Programming

- Imperative Programming Style
  - Low Level
  - Step by step instruction
  - Define "What" by implementing "How"
- Declarative Programming Style
  - High Level
  - Implementation is covered
  - Declare 'What' without so much 'How'

Find Dan: Imperative

```
final List<String> names = Arrays.asList("jim",
"sue", "dan", "len", "zac");
    boolean found = false;
    for (String name : names) {
        if (name.equals("dan")) {
                found = true;
                break;    // exit loop
        }
    }
    System.out.println("You found dan! " + found);
```

OUTPUT: *You found dan!* true

Find Dan: Declarative

```
final List<String> names = Arrays.asList("jim",
"sue", "dan", "len", "zac");

System.out.println("You found dan! "
                + names.stream()
                .filter(s -> s == "dan")
                .forEach(System.out::print);
);
```

OUTPUT: *You found dan!* true

Find Number 7: Declarative

Integer[] a = {0,1,2,3,4,5,6,7,8,9}; // auto-boxing

List<Integer> **mutableNumbers** = new ArrayList<Integer>(Arrays.asList(a));

```
System.out.print("\n Filter 7 from numbers 0123456789: ");
mutableNumbers.stream()
        .filter(n -> n == 7)
        .forEach(System.out::print);
System.out.println();
```

OUTPUT: Filter 7 from numbers 0123456789: 7

Lambda

- A.K.A. Closure
- Another Java 8 new feature (like Stream API)
- Borrowed from other languages like: Lisp, Clojure, Erlang, Ruby
- Also exists in other JVM languages like Scala and Groovy
- Allows for Functional Programming in Java

Functionality passable as Data

- Anonymous Class
  - Usually, an attempt to pass functionality as an argument to another method
  - Unclear cumbersome syntax
- Lambda can similarly treat code as data
  - Concise and compact
  - Anonymous Methods

Lambda

- SYNTAX

  () -> {}

  – ‘**()**’ list of formal supplied parameters
    - param1, param2,…
    - Can omit type
    - Can omit parenthesis for single parameter

  – ‘**->**’ Arrow token

Lambda

- SYNTAX

  () -> {}

  – '{}' body

    1. Single expression
    2. Statement block
    3. Curley braces may be omitted
    4. May omit 'return' keyword

Example Lambda Parameter List

- Example Parameter list:
  1. ()
  2. p
  3. (int x, int y)
  4. (x,y)

- Parenthesis are optional for a single parameter; required for a multi parameter list
- Optional Parameter type declaration

Example Lambda Expression

1. Example Body Expression:
   1. 4.0 == student.getGpa()
   2. 18 >= person.getAge()
      && person.getAge() <= 35

- Java runtime will evaluate expression and return its value
- Braces optional for single statement expression

Functional Interface Example

java.util.Function

- Functional Method: Single abstract method called Annotated: @FunctionalInterface
- Target Types
  - Lambda expression

    Arrays.**sort**(rosterAsArray,
     (a, b) -> Person.compareByAge(a, b));
  - Method reference

    Arrays.**sort**(rosterAsArray, Person**::**compareByAge);

Example Lambda

- Use Lambda as in-line implementation of a Functional Interface

```
class LambdaDemo {
    @FunctionalInterface
    public interface GreatDivide {
        int divide(int t1, int t2);
    }
    public void simpleLambda() {
        GreatDivide intDivide = (int x, int y) -> x / y;
        System.out.println(intDivide.divide (21, 3)); // 7 to stdout
    }
}
```

Example Lambda

- Use inner class rAnonymous as implementation of the Java Runnable Interface

```
void runnableAnonymous() {
   Runnable rAnonymous = new Runnable() {
    @Override
    public void run() {
        System.out.println("Run rAnonymous, run!");
    }
   };
    Thread t = new Thread(rAnonymous);
    t.start();      // begin execution on new Thread
}
```

Example Lambda

- Use Anonymous inner class as implementation of the Java Runnable Interface

```
void runnableAnonymous() {
    Thread t = new Thread(new Runnable() {
     @Override
     public void run() {
            System.out.println("Run anonymous, run!");
     }
    }
);
    t.start();
}
```

Example Lambda

- Use Lambda as in-line implementation of the Java Runnable Interface

void runnableLambda() {

Runnable ***r*** = () -> System.*out.println(”run thread in background...");*

Thread t = new **Thread(*r*)**;

t.start();

}

Example Lambda

- Use Lambda as in-line implementation of the Java Runnable Interface

```
void runnableLambda() {
    Thread t = new Thread(
    () -> System.out.println(”run thread in background..."')
    );
    t.start();
}
```

Example Lambda

- Use Lambda as in-line implementation of the Java Runnable Interface

```
void runnableLambda() {
    Runnable r = () -> System.out.println(”run");
    Thread t1 = new Thread(r);
    t1.start();
    Thread t2 = new Thread(
    () -> System.out.println(”run")  );
    t2.start();
}
```

String Collection Show method

```
void showList(String title, List<String> list) {
        System.out.println(l.size() + title);
        for (String n : list) {
                System.out.print(n +",");
        }
        System.out.println();
}
```

Generic Collection Show method

```
<E> void showList(String title, List<E> l) {
        System.out.println(l.size() + title);
        int i = 1;
        for (E n : l) {
                System.out.print(i + ". " + n + " ");
                i++;
        }
        System.out.println();
}
```

Example Lambda

- Use Lambda as in-line implementation of the Show Generic Functional Interface
- Creates a customized method for the SomeComodity class

```
@FunctionalInterface
public interface Show<T> {
   void show(T t);
}
```

Example Lambda

```
List<SomeCommodity> shoppingList = new ArrayList<>();
shoppingList.add(new SomeCommodity("iPhone", 399));
shoppingList.add(new SomeCommodity("iPad", 599));
shoppingList.add(new SomeCommodity("macBook", 1599));

// Implement the Show Functional interface with a Lambda
Show<SomeCommodity> showPrice = o ->
System.out.println(o.getName() + " only $ " + o.getPrice());

for (SomeCommodity item : shoppingList) {
        showPrice.show(item);
}
```

Example Stream API

```
public void simpleStream() {
        List<Integer> list = Arrays.asList(5,2,4,1,3);
        list.forEach(n -> System.out.print(n + " "));
        System.out.println("reduce to sorted odd subset");
        list.stream()
        .filter(n -> n % 2 == 1)          // odd ONLY
        .sorted()                         // ascending
        .map(n -> 100*n)                  // scale by 10
        .forEach(n -> System.out.print(n + ", "));    // output
        System.out.println();
}
OUTPUT: 100, 300, 500,
```

Predicate

java.util.function

Interface Predicate<T>

public interface Predicate<T>

•Represents a function which returns a boolean value (i.e. a boolean-valued function, a predicate) that accepts a single argument.

•Method

boolean Test(T t)

Predicate Example

```
public  void simplePredicate () {
        List<Integer> ints = Arrays.asList(1,2,3,4,5,6,7,8,9);
        Predicate<Integer> over5Predicate = n -> { return n >
5; };
        for (Integer n : ints) {
                if (over5Predicate.test(n)) {
                        System.out.print(n + " <** ");
                } else {
                        System.out.print(n + " ");
                }
        }
}
```

OUTPUT: 1 2 3 4 5 6 <** 7 <** 8 <** 9 <**

Using a Predicate for Stream Filter

- Given the Collection ‘states’

List<String> states =
 Arrays.asList("ma","ny","ct","vt","ri","nh","nv","nc","nd","wa","wv","ut","ca","az","al","ak","ok","pa","me","ms","il","id","mn","wy","mt","wi","ia","ar","hi","sd","sc","md","nj","de","ga","fl","mi","oh","in","or","ky","tn","va","mo","ks","co","la","tx","nm","ne");

- And the Predicate ,‘uStates‘

Predicate<String> ***uStates***= s -> { return s.startsWith(“u"); } ;

Example for Stream Filter

- The following Stream Processing sourced by the ‘states’ String Collection filters using a lambda:

```
states.stream()
        .filter(s -> s.startsWith(“u"))
        .map(String::toUpperCase)
        .sorted()
        .forEach(s -> System.out.print(s + ", "));
```

•Produces the OUTPUT:

UT,

Using a Predicate for Stream Filter

- The following Stream Processing sourced by the ‘states’ String Collection filters using the uStates predicate:

```
states.stream()
        .filter(uStates)
        .map(String::toUpperCase)
        .sorted()
        .forEach(s -> System.out.print(s + ", "));
```

•Produces the OUTPUT:

UT,

Imperative: Total Price

```
final List<Double> prices
=Arrays.asList(5.0,10.0,15.0,20.0);
double totalOfDiscountedPrices = 0.0;


for (double price : prices) {
        totalOfDiscountedPrices += price * 0.9;        // 10 %
discount
}
System.out.println(”Total: $" + totalOfDiscountedPrices);
```

OUTPUT: *Total: $45.0*

Declarative: Total Price

```
final List<Double> prices
=Arrays.asList(5.0,10.0,15.0,20.0);
final Double totalOfDiscountedPrices =
        prices
        .stream()
        .mapToDouble((Double price) -> price * 0.9)
        .sum();

System.out.println("Total: $" + totalOfDiscountedPrices);
```

OUTPUT: *Total: $45.0*

Method Reference

- Static method Reference
  SomeClass::aStaticMethod

- Object instance method Reference
  myObject::anInstanceMethod

- Constructor method Reference
  SomeClass::new

Method Reference

"*Method references … are compact, easy-to-read **lambda** expressions for methods that already have a name.*"

https://docs.oracle.com/javase/tutorial/java/javaOO/methodreferences.html

Method Reference

- Lambda is use to create a anonymous method that can be passed as data, i.e. as formal parameter in sort method.
- Used Method Reference in place of lambda when ***only a reference to a method*** is required
- Refers to Method by name

Static Method Reference

List<String> list

= Arrays.*asList("Jen", "Zac", "Dan");*

list.**forEach(System.*out::print)***;*

System.*out.println(list.size() + " elements in above list.");*

Object Instance Method Reference

```
class ComparisonProvider {
  public int compareByName(Person a, Person b) {
    return a.getName().compareTo(b.getName());
  }
  public int compareByAge(Person a, Person b) {
    return a.getBirthday().compareTo(b.getBirthday());
  }
}
ComparisonProvider myComparisonProvider = new
ComparisonProvider();
Arrays.sort(rosterAsArray,
myComparisonProvider::compareByName);
```

Online Information: Lambda Links

- Oracle:
  https://community.oracle.com/docs/DOC-1003597
  https://docs.oracle.com/javase/tutorial/java/javaOO/lambdaexpressions.html#syntax
  http://www.oracle.com/webfolder/technetwork/tutorials/obe/java/Lambda-QuickStart/index.html

Online Information: Method Links

- Method Reference

https://docs.oracle.com/javase/tutorial/java/javaOO/methodreferences.html

Online Information: Streams Links

- Streams

http://www.oracle.com/technetwork/articles/java/ma14-java-se-8-streams-2177646.html