CSCE 240: Advanced Programming Techniques
Lecture 9: Object Oriented Concepts - Inheritance

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

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Carolinian Creed: "I will practice personal and academic integrity."

Credits: Some material reused with permission of Dr. Jeremy Lewis. Others used as cited with thanks.

Organization of Lecture 9

- Introduction Section
  - Recap of Lecture 8

- Main Section
  - Concept: Inheritance
  - Discussion: Home work #3 – due in Class 10
  - Discussion: Prog. Assignment #2 and Project discussion

- Concluding Section
  - About next lecture – Lecture 10
  - Ask me anything

Introduction Section

Recap of Lecture 8

- We relooked at relationships between classes

- We discussed code organization – header and implementation files, when to separate

- We discussed programming assignment (PA) #1 - Sunday

About Programming Languages in Course

- C++ is the main language for the course.
  - Used to demonstrate concepts and expect everyone to know it at the level that they can do peer evaluation and testing of each other's code in **home assignments**.
  - **For projects and programming assignments**, students have option to code in Java or Python as well.

- Cross-language understanding of concepts
  - Code in multiple languages is sometimes shown to demonstrate generality of concepts and specific peculiarities in implementation
  - UML diagrams will used to conveyed cross-language concepts as well

In quizzes,
  ◦ **Questions will be about concepts, pseudo-code and UML diagram**.
  ◦ C++ code fragments may be shown or asked to be written, but they do not have to be running code. The quizzes will be in class and can be done on paper or a text editor like Google doc.

Main Section

Concept: Inheritance

What is Inheritance ?

- A class "inheriting" or reusing **characteristics** from another, existing class

- Synonyms: subclassing, specialization, derived

- Analogy: child inheriting from a parent
  - "Course-CSCE-240" sub-class of "Course-Undergraduate"
  - "USA" specialization of "Country"

- What are characteristics
  - Data members
    - Enrollment, timing, syllabus: course domain
    - Capital, head-of-state, currency: country domain
  - Functions manipulating the data members

Why Use Inheritance ?

- Promote reuse

- Make code understandable, improve maintainability

- Promote security and data integrity

- Improve testing

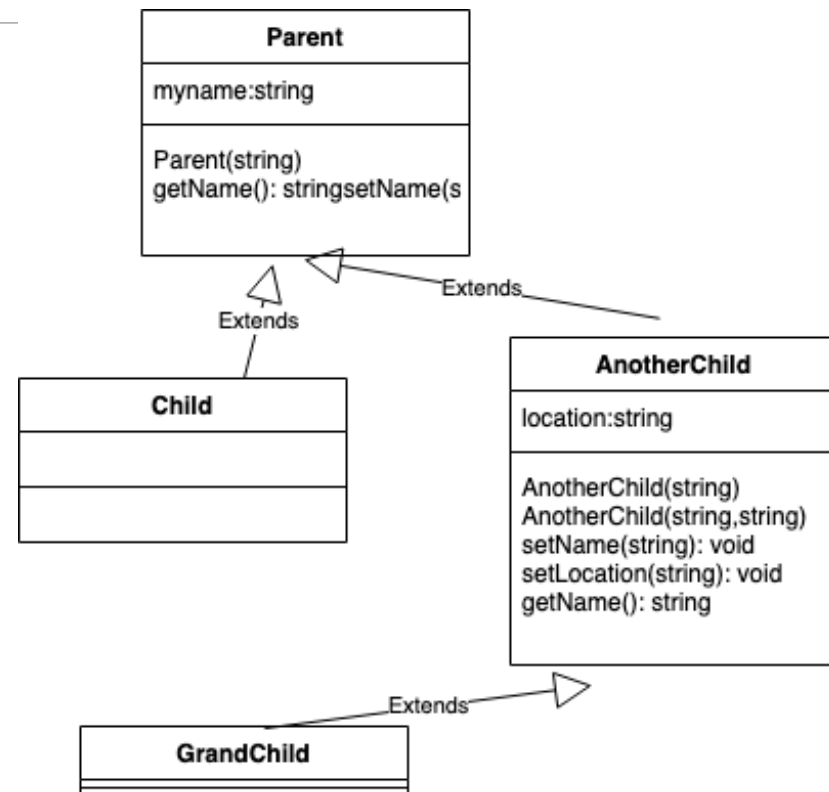- Improve code development productivity
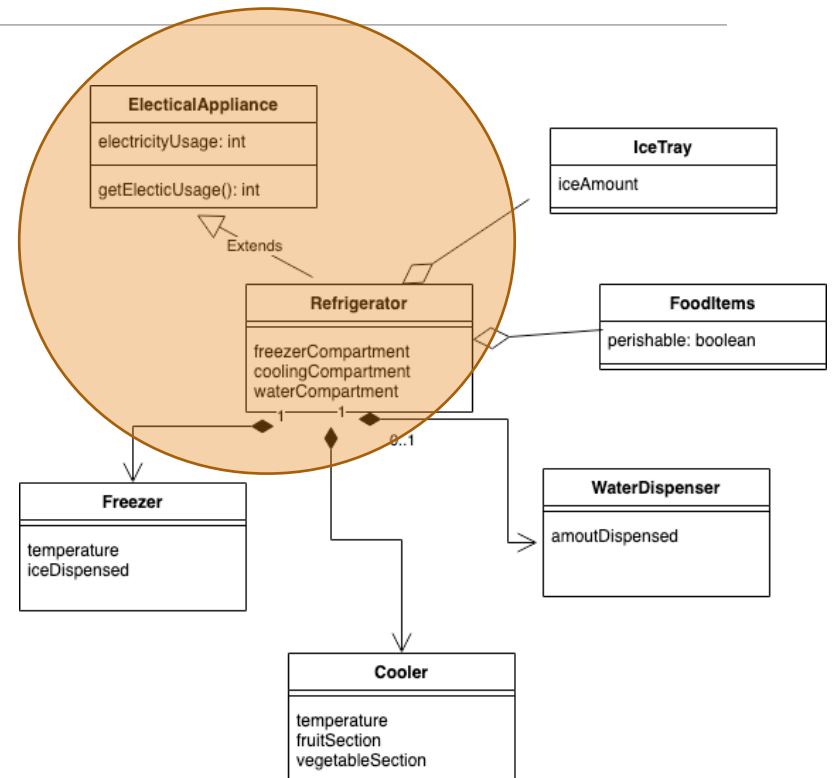
How to Use Inheritance ?

- Language independent syntax

- Illustration
  - 4 classes
  - 2 data members: myname, location
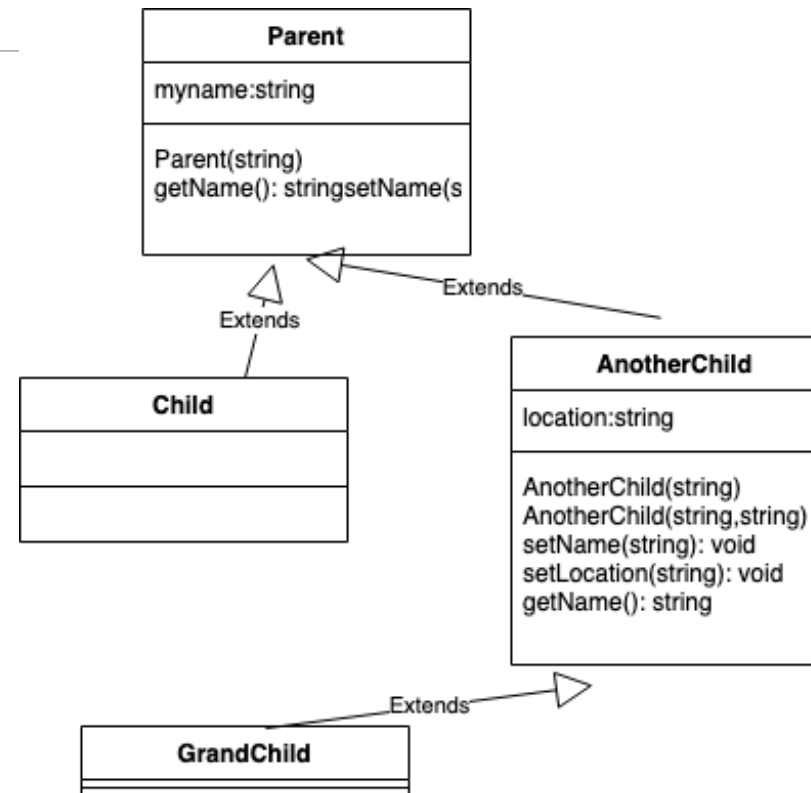 - Access restrictions: private, protected, public

Code:
https://github.com/biplav-s/course-adv-proglang/tree/main/sample-code/CandC%2B%2B/Class9and10_C%2B%2B_OOAdv/src

Notes on Inheritance

- Code for classes Child and GrandChild are minimal
  - Code reuse happens by default

- A child can override the behavior of its parent

In-class Exercise

- Numbers and their operations
  - Operations: Addition, subtraction, division multiplication
  - Number types: natural numbers, whole numbers, rational numbers (fractions), irrational numbers, decimal numbers, binary, complex numbers

- Every one should take a number type and define its class

Home Work 3

Due Thursday, Feb 16, 2022

Programming Home Work (#3) – C++

Home Work #2

- Write a program called GeometricPropertyCalculator.
  - The program reads an input file (called input.txt). Each line in the file contains dimensions of a geometric shape – rectangle, shape and triangle. Specifically:
    - For rectangle, it contains – RECTANGLE <length-in-cm> <breadth-in-cm>
    - For circle, it contains – CIRCLE <radius-in-cm>
    - For triangle, it contains – TRIANGLE <side-1-in-cm> <side-2-in-cm> <side-3-in-cm>
  - The user specifies the property to calculate as argument to the program: 1 for AREA and 2 for PERIMETER
  - The program writes output lines to an output file (called output.txt) for each shape that it reads and the property – AREA or PERIMETER.
    - For example, for RECTANGLE and property as AREA, the program should write – RECTANGLE AREA <calculated value>

  - Write GeometricPropertyCalculator in C++
    - It should support RECTANGLE, CIRCLE and TRIANGLE
    - It should support properties AREA and PERIMETER
    - If there is insufficient information, the program should give an error. E.g. TRIANGLE AREA "Not enough information to calculate"

Home Work #3

- Build a program called **OOGeometricPropertyCalculator**
  - Your new code will do the same as Home Work#2 but with OO design
  - It will have **4 classes: Shape – the parent, and its three children - Rectangle, Circle and Triangle**
  - Shape will have three members: **area**, **perimeter** and **errorMessage**; and at least **three functions getArea(), getPerimeter() and getErrorMessage().**
  - In your code, there will be a utility file (OOGeometricPropertyCalculator.cpp) with main() and will call the classes and functions. You can choose to have one or more files for the classes.
    (E.g, For the 4 classes, 4 headers + 4 .cpp files).
  - **You will also draw UML class diagrams for it**

- Functionality Reminder
  - The user specifies the property to calculate as argument to the program: 1 for AREA and 2 for PERIMETER
  - The program writes output lines to an output file (called output.txt) for each shape that it reads and the property – AREA or PERIMETER.

Programming Home Work (#3) – C++

- Code guidelines for the OO code you will write
  - Have sub-directories in your folder
    - src sub-folder, (or code) for code
    - data sub-folder, for input.txt and output.txt
    - doc sub-folder, for documentation on what the code does or sample output.

- In documentation
  - **Have a UML class diagram for the classes**
  - Observe how long was the code earlier and now. If you have to add a new functionality (like getVertices() to get all the vertices in a shape), how easy or hard will it be in HW2 code or HW3 code?

Discussion: Course Project

Course Project – Building and Assembling of Prog. Assignments in Health

- **Project**: Develop collaborative assistants (chatbots) that offer useful information about diseases

- Specifically, use the CDC dataset on diseases at: https://wwwnc.cdc.gov/travel/diseases
  - For polio, it is: https://wwwnc.cdc.gov/travel/diseases/poliomyelitis
  - Each student will choose two diseases (from 47 available).
  - Each student will also use data about the disease from WebMD. Example for polio - https://www.webmd.com/children/what-is-polio
  - Programming assignment programs will: (1) extract data about a disease from two sites, (2) process it, (3) make content available in a command-line interface, (4) handle any user query and (5) report on interaction statistics.

Discussion: Nature and Simplifications

- Once you select a disease, the scope of answers is fixed.

- Some simplifications
  - **Download local copy** v/s web query
  - **Read static content first**
  - **Handle a subset of content**
  - **Have default handling for questions** the chatbot does not understand

- Do project in a language you are most comfortable with

- Use all advanced programming concepts to simplify coding

Suggested Scope is a Drastic Simplification

- **Users**: 1

- **Modality**: text

- **Data:** static
  (no data in S1 and S2 is dynamic)

- **Personalization**: none

- **Form**: command line

- **Purpose**: information provider

- **Domain**: specific to disease chosen

Core Programs Needed for Project

- Prog 1: extract data from the disease pages

- Prog 2: process it based on questions

- Prog 3: make content available in a command-line interface

- Prog 4: handle any user query and

- Prog 5: report statistics on interaction of a session, across session

Programming Assignment # 1

- Goal: extract data from the disease of choice
  - Language of choice: Any from the three (C++, Java, Python)

- Program should do the following:
  - Take disease as input
  - Read content about the disease
    - from the disease's URL from CDC and WebMD, OR
    - a local text version of the disease pages   // Keep them as separate files with names <disease>-<source>.txt
  - Report statistics of content: lines, words, chars
  - Write content out in an output file formatted with indentation

- Code organization
  - Create a folder in your GitHub called "prog1-extractor"
  - Have sub-folders: src (or code), data, doc, test
  - Write a 1-page report in ./doc sub-folder
  - Send a confirmation that code is done to instructor, and update Google sheet

PA: Code **Reviewing** Rubric

- Look out for
  - Can one understand what the code is doing ?
  - Can one explain the code to someone else (non-coder) ?
  - Can one spot possible issues without running it?
    - Are the variables initialized ?
    - Are files closed?
    - Is their unnecessary code bloat ?

- What not to judge
  - Usage of language features, unless they are inappropriate

Assign rating (out of 100 -/+)
- -100: code not available
- -80: code with major issues
- -60: code with minor issues
- -20:
- 0: (full marks): no issues
- +20: special features

PA: Code Testing Rubric

- Look out for
  - Does the program run as the coder wanted it to be (specification) ?
  - Does the program run as the instructor wanted it to be (requirement - customer) ?
  - Does the program terminate abruptly ?
  - Is there a hardcoding of directory ? Paths should be relative to code base directory.
  - Any special feature?

- What not to judge
  - Length of documentation. It can just be short and accurate.
  - Person writing the code

Assign rating (out of 100 -/+)
- -100: code not available
- -80: code with major issues (e.g., abnormal termination, incomplete features)
- -60: code with minor issues
- -20:
- (full marks): no issues
- +20: special features

Core Programs Needed for Project

- Prog 1: extract data from the district

- **Prog 2: process it (extracted data) based on questions**

- Prog 3: make content available in a command-line interface

- Prog 4: handle any user query and

- Prog 5: report statistics on interaction of a session, across session

Content Reference: Disease

- What (is the disease)?
  - What are they types?*
  - What causes it?
  - What are the symptoms?
  - What should one do to treat the disease ?

- Who is affected?
  - Who is at risk?

- How is the disease diagnosed?

- When to call doctor?

- More information
  - After travel*

S1: https://www.cdc.gov/travel/diseases/malaria
- What is malaria? [I1]
- Who is at risk? [I2]
- What can travelers do to prevent malaria? [I3]
- After Travel [I4]
- More Information [I5]

S2: https://www.webmd.com/a-to-z-guides/malaria-symptoms
- What Is Malaria? [I1]
- Malaria Causes and Risk Factors [I2]
- Types of Malaria [I6]
- Symptoms [I7]
- When to Call a Doctor About Malaria [I8]
- Malaria Diagnosis [I9]
- Malaria Treatment [I10]
- Malaria Complications [I11]
- Malaria Vaccine [I12]

* Possible to omit ?

* Too specialized? Consider omitting for a super-class

Programming Assignment # 2

- Goal: **process extracted text based on questions**
  - Language of choice: Any from the three (C++, Java, Python)

- Program should do the following:
  - Take input from a local file with whose content is obtained from Prog#1 (when **disease** name given as input)
  - Given an information type as input, the program will return its content
    - Examples: what is disease (I1), who is at risk (I2), disease vaccine (I12)
    - Input type can be given as command line argument. Examples:
      - prog2processor –t "what is **malaria**?" // Tell about disease
      - prog2processor –t "more information" // Get more info

  - For demonstrating that your program works, have a file called "test_output.txt" showing the set of supported commandline options and output in the doc folder.

- Code organization
  - Create a folder in your GitHub called "prog2-processor"
  - Have sub-folders: src (or code), data, doc, test
  - Write a 1-page report in ./doc sub-folder
  - Send a confirmation that code is done to instructor and TA, and update Google sheet

S1: https://www.cdc.gov/travel/diseases/malaria
- What is malaria? [I1]
- Who is at risk? [I2]
- What can travelers do to prevent malaria? [I3]
- After Travel [I4]
- More Information [I5]

S2: https://www.webmd.com/a-to-z-guides/malaria-symptoms
- What Is Malaria? [I1]
- Malaria Causes and Risk Factors [I2]
- Types of Malaria [I6]
- Symptoms [I7]
- When to Call a Doctor About Malaria [I8]
- Malaria Diagnosis [I9]
- Malaria Treatment [I10]
- Malaria Complications [I11]
- Malaria Vaccine [I12]

Example: Representative Information

Input:

prog2processor –t "what is **malaria**?"" // Tell about disease

Output:

Malaria is a serious and sometimes fatal disease caused by a parasite that commonly infects a certain type of mosquito which feeds on humans. People who get malaria are typically very sick with high fevers, shaking chills, and flu-like illness. Four kinds of malaria parasites infect humans: *Plasmodium falciparum, P. vivax, P. ovale*, and *P. malariae.* In addition, *P. knowlesi*, a type of malaria that naturally infects macaques in Southeast Asia, also infects humans, causing malaria that is transmitted from animal to human ("zoonotic" malaria). *P. falciparum* is the type of malaria that is most likely to result in severe infections and if not promptly treated, may lead to death. Although malaria can be a deadly disease, illness and death from malaria can usually be prevented.

About 2,000 cases of malaria are diagnosed in the United States each year. The vast majority of cases in the United States are in travelers and immigrants returning from parts of the world where malaria transmission occurs, including sub-Saharan Africa and South Asia.

...

https://www.cdc.gov/malaria/about/faqs.html

The Disease

What is malaria?

Malaria is a serious and sometimes fatal disease caused by a parasite that commonly infects a certain type of mosquito which feeds on humans. People who get malaria are typically very sick with high fevers, shaking chills, and flu-like illness. Four kinds of malaria parasites infect humans: *Plasmodium falciparum, P. vivax, P. ovale*, and *P. malariae.* In addition, *P. knowlesi*, a type of malaria that naturally infects macaques in Southeast Asia, also infects humans, causing malaria that is transmitted from animal to human ("zoonotic" malaria). *P. falciparum* is the type of malaria that is most likely to result in severe infections and if not promptly treated, may lead to death. Although malaria can be a deadly disease, illness and death from malaria can usually be prevented.

About 2,000 cases of malaria are diagnosed in the United States each year. The vast majority of cases in the United States are in travelers and immigrants returning from parts of the world where malaria transmission occurs, including sub-Saharan Africa and South Asia.

Globally, the World Health Organization estimates that in 2020, 241 million clinical cases of malaria occurred, and 627,000 people died of malaria, most of them children in Africa. Because malaria causes so much illness and death, the disease is a great drain on many national economies. Since many countries with malaria are already among the poorer nations, the disease maintains a vicious cycle of disease and poverty.

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Concluding Section

Lecture 9: Concluding Comments

- We looked at inheritance relationship among classes

- Home Work #3 – due Feb 16

- Prog. Assignment #2 - due Feb 21

9	Feb 7 (Tu)	OO – inheritance	Prog 2 - start
10	Feb 9 (Th)	Regex, OO - polymorphism	Remote
11	Feb 14 (Tu)	In class test	Quiz 1 – Remote, due end of day
12	Feb 16 (Th)	Review: inheritance, Polymorphism	HW 3 due

About Next Lecture – Lecture 10

Lecture 10: Object Oriented - Polymorphism

- OO – Polymorphism.

- Regular expressions – needed for project 2

9	Feb 7 (Tu)	OO – inheritance	Prog 2 - start
10	Feb 9 (Th)	Regex, OO - polymorphism	Remote
11	Feb 14 (Tu)	In class test	Quiz 1 – Remote, due end of day
12	Feb 16 (Th)	Review: inheritance, Polymorphism	HW 3 due