CLASSES AND OBJECTS

Bùi Tiến Lên

01/01/2020

KHOA CÔNG NGHỆ THÔNG TIN
TRƯỜNG ĐẠI HỌC KHOA HỌC TỰ NHIÊN

Contents

What is an object?

What Is an Object?

Concept 1

An **object** is an **entity** with a well-defined boundary and identity that encapsulates **state** and **behavior**.

- *State* is represented by attributes and relationships.
- *Behavior* is represented by operations, methods, and state machines.

- Informally, an object represents an entity, either physical, conceptual, or software.

Physical entity 

Conceptual entity 

Soffware entity

Table	
PI	uniqueId
	row 1
	row 2
	row 3

An Object Has State

- State is a condition or situation during the life of an object, which satisfies some condition, performs some activity, or waits for some event.
- The state of an object normally changes over time.

Professor Clark's attributes

- Name: J Clark
- Employee ID: 567138
- Date Hired: July 25, 1991
- Status: Tenured
- Discipline: Finance
- Maximum Course Load: 3 classes

An Object Has Behavior

- Behavior determines how an object acts and reacts.
- The visible behavior of an object is modeled by a set of messages it can respond to (operations that the object can perform).

Professor Clark's behaviors

- Submit Final Grades
- Accept Course Offering
- Set Max Load

An Object Has Identity

- Each object has a **unique identity**, even if the state is identical to that of another object.

Professor "J Clark"
teaches Biology

Professor "J Clark"
teaches Biology

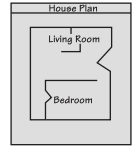
What is a class?

What Is a Class?

Concept 2

A **class** is a description of a set of objects that share the same attributes, operations, relationships, and semantics. An object is an instance of a class.

Blueprint that describes a house.



Instances of the house described by the blueprint.

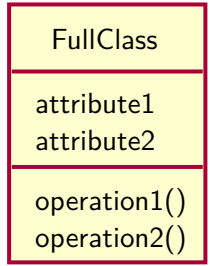
What Is a Class? (cont.)

- A class is an abstract definition of an object.
  - It emphasizes relevant characteristics.
  - It suppresses other characteristics.
  - It defines the structure and behavior of each object in the class.
  - It serves as a template for creating objects.
- Classes are not collections of objects.

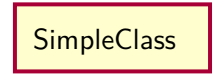
Representing Classes in the UML

A class is represented using a rectangle with three compartments:

- The **class name**
- The **attributes**
- The **operations**



A class can be represented using a simple rectangle:



What Is an Attribute/Operation?

Concept 3

An **attribute** is a named property of a class that describes the range of values that instances of the property may hold.

- A class may have any number of attributes or no attributes at all.

Concept 4

An **operation** is the implementation of a service that can be requested from any object of the class to affect behavior. In other words, an operation is an abstraction of something you can do to an object that is shared by all objects of that class.

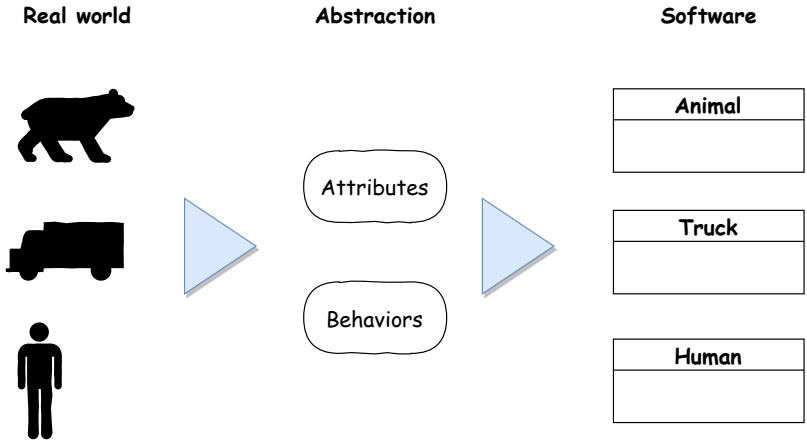
- A class may have any number of operations or none at all.

OO Design

Object-oriented design

- Abstract Data Types (ADT)
- Divide project into a set of cooperating classes
- Each class has a very specific functionality
- Think of a class as similar to a data type
- Class can be used to create instances of objects

Mapping the real world to software



Designing process

Identifying classes

- Abbott and Booch:
  - use nouns, pronouns, noun phrases to identify objects and classes
  - note: not all nouns are really going to relate to objects
- Coad and Yourdon:
  - identify individual or group "things" in the system/problem
- Ross:
  - common object categories: people, places, things, organizations, concepts, events

Designing process (cont.)

Identifying behaviors

- Decide whether behavior is accomplised by a single class or through the collaboration of a number of "related" classes
- Static behavior: behavior always exists
- Dynamic behavior: depending of when/how a behavior is invoked, it might or might not be legal
- Look for *verbs* in problem description

Example 1

Game “Tetris”, possible classes:

- Board
- Block (square block)
- Piece (composed of several blocks)
- Player (is it necessary?)
- Line of Blocks

Example 2

- e-Shopping Website, possible classes:

  `Product`
  - Attributes: Name, ID, price, status, manufacturer's name, images, technical description.

  `Product Category`
  - Attributes: Name

  `Manufacturer`
  - Attributes: Name, Country, Website

Example 3

Website “National Foolball Competition”

- People: Player, Referee, Coach, Team Manager...
- Places: Stadium, City...
- Things: Ball (is it necessary?)
- Organizations: Team, National Football Association
- Concepts: Half, Round, Season...
- Events: Match (is this a concept or an event?), Goal

Example 4

"Joe's Automotive Shop services foreign cars and specializes in servicing cars made by Mercedes, Porsche, and BMW. When a customer brings a car to the shop, the manager gets the customer's name, address, and telephone number. The manager then determines the make, model, and year of the car and gives the customer a service quote. The service quote shows the estimated parts charges, estimated labor charges, sales tax, and total estimated charges."

- Finding the classes

Classes and Objects in C++

Class declaration in C++

Syntax

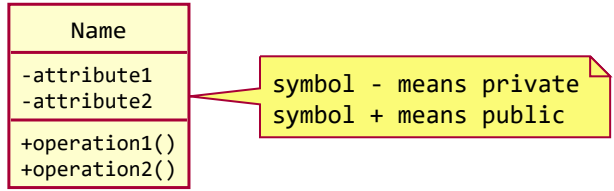
```
class <Name of the class>
{
    private:
        <private attributes and methods>
    public:
        <public attributes and methods>
};
```

Scope

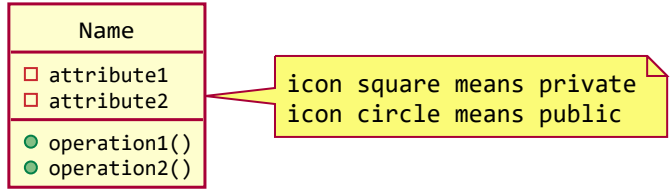
- `private`: only visible to the class itself.
- `public`: can be use from inside of the class or any client outside

UML

- Using symbol



- Using icon



An example

- A class models a date

```
class CDate {
private:
  int m_iDay, m_iMonth, m_iYear;
public:
  CDate();
  int getDay(); // return day
  int getMonth(); // return month
  int getYear(); // return year
  ...
};
```

An example (cont.)

- A class models a human

```
class Human {
   // Data attributes:
private:
   string Name;
   string DateOfBirth;
   string PlaceOfBirth;
   string Gender;

   // Methods:
public:
   void Talk(string TextToTalk);
   void IntroduceSelf();
   ...
};
```

Scope resolution operator ::

- The two colons `::` are called the *scope resolution operator*.
- It identifies methods or attributes as members of a certain class
- For example:
  `CDate::getDay()`
  `CDate::getMonth()`

Separation declaration from definition

```
//keep in one file
class CDate {
private:
  ...
public:
  int getDay();
  ...
};

int CDate::getDay() {
  return m_iDay;
}
```

```
// header file
class CDate {
private:
  ...
public:
  int getDay();
  ...
};
```

```
// implementation file
int CDate::getDay() {
  return m_iDay;
}
```

Inline Member Functions

Concept 5

When the body of a member function is written inside a class declaration, it is declared inline

```
//keep in one file
class CDate {
private:
  ...
public:
  int getDay() {
    return m_iDay;
  }
  ...
};
```

Using `const` with Member Functions

- When the key word `const` appears after the parentheses in a member function declaration, it specifies that the function will not change any data stored in the calling object.

```
class CDate {
private:
  ...
public:
  int getDay() const {
    return m_iDay;
  }
  ...
};
```

Instantiating an Object of a Class

- Instantiating an object of type `class Human` is similar to creating an instance of another type, say `double`:

```
double Pi = 3.1415;
Human Tom;
Human Jerry = Human();
```

- Alternatively, we would dynamically allocate for an instance of class Human as we would an `int` using `new`:

```
int* pNumber = new int;
delete pNumber;
Human* pAnotherHuman = new Human();
delete pAnotherHuman;
```

Accessing Members Using the Dot Operator . and Pointer Operator ->

- The dot operator (.) helps us access attributes or methods of an object.

```
Human Tom;
...
Tom.IntroduceSelf();
```

- If an object has been instantiated on the free store using new or if we have a pointer to an object, then we use the pointer operator (->) to access the member attributes and functions

```
Human* pTom = new Human();
...
pTom->IntroduceSelf();
delete pTom;
```

Data hiding

```
int main() {
  CDate today;
  CDate tomorrow, someDay;
  cout << today.m_iMonth; // compile error
  cout << today.getMonth(); // OK
  ...
}
```

Encapsulation and data hiding

- **Encapsulation**:
  A C++ class provides a mechanism for packaging data and the operations that may be performed on that data into a single entity
- **Information Hiding**:
  A C++ class provides a mechanism for specifying access

Technical Terms

Taxonomy of member functions

A common taxonomy:

- **Constructor**/**Initalization**: an operation that creates a new instance of a class
  - *Constraint Checking methods*?
- **Observer**: an operation that reports the state of the data members (aka Accessors, Getters)
  - Provides value of an internal attribute
  - Provides some value calculated from internal attributes only
  - Provides some value calculated from internal attributes AND some external parameter(s)

Taxonomy of member functions (cont.)

- **Mutator**: an operation that changes the state of the data members of an object (aka Setters)
  - Updates value of an internal attribute
  - Transforms values of internal attributes
  - *Constraint Checking methods*?
- **Iterator**: an operation that allows processing of all the components of a data structure sequentially

Workshop

Quiz

1. What is the difference between a class and an instance of the class?

   . . . . . .
   . . . . . .
   . . . . . .

2. What is the default access specification of class members?

   . . . . . .
   . . . . . .
   . . . . . .

3. Is it a good idea to make member variables private? Why or why not?

   . . . . . .
   . . . . . .
   . . . . . .

Exercises

Design and implement the following classes:

- `Date`
- `Fraction` with numerator and denominator
- `Employee`

References

Deitel, P. (2016).
C++: How to program.
Pearson.

Gaddis, T. (2014).
Starting Out with C++ from Control Structures to Objects.
Addison-Wesley Professional, 8th edition.

Jones, B. (2014).
Sams teach yourself C++ in one hour a day.
Sams.