Cairo University, Faculty of Computers and AI

CS213 – 2022/2023

Programming II

Lecture 3: OOP - II

By

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Lecture Objectives

1. Learn the Characteristics of Object-Orientation
    1. Identity
    2. Classification
    3. Abstraction
    4. Encapsulation
    5. Inheritance
    6. Polymorphism
    7. Genercity
2. Learn the OO Development Methodology
    - Steps of OOP Development
3. Examples of OO Modeling

What is OO ?

- ***Object-orientation*** is a way of thinking about problems using models built from real-world concepts.
- The fundamental unit is the ***Object***
- An object has ***data*** and ***behavior***
- ***OO Software*** means we write our program in terms of objects, each tightly integrates data and operations on the data
- In ***Structured programming***, data and operations on the data were separated or loosely related.

1. OO Characteristics

1. Identity
2. Classification
3. Abstraction
4. Encapsulation
5. Inheritance
6. Polymorphism
7. Genercity

1.1 Identity

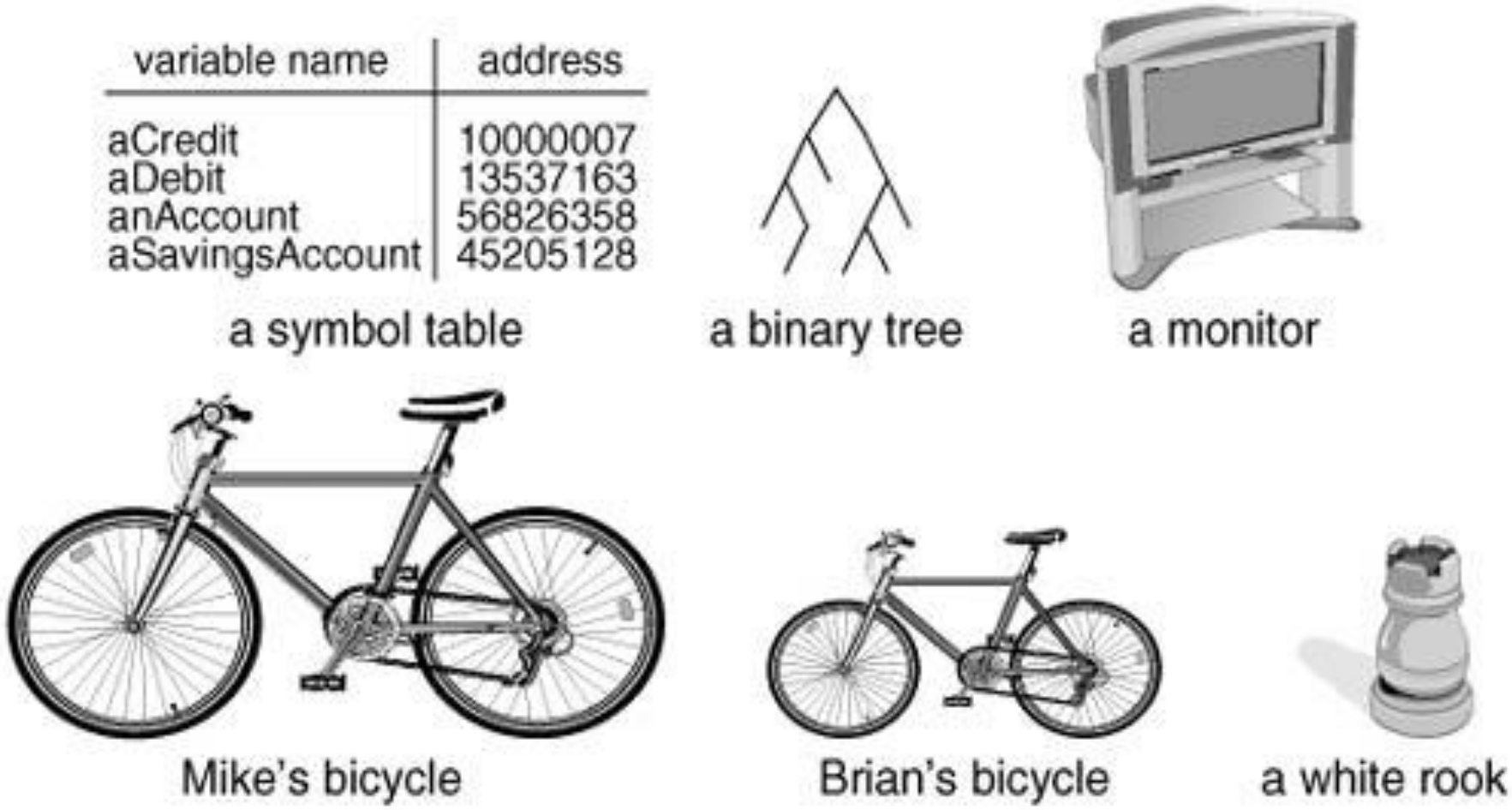


Figure 1.1 Objects. Objects lie at the heart of object-oriented technology.

Identity

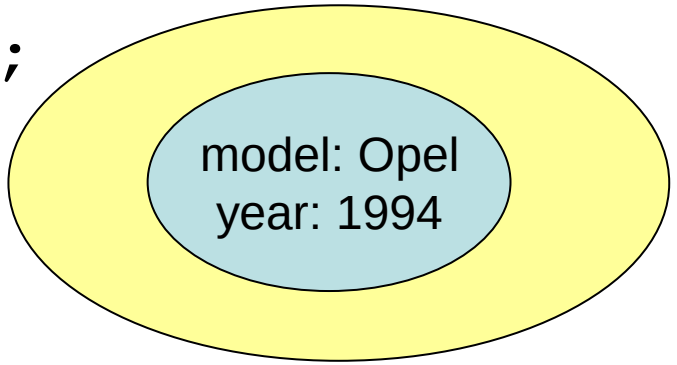
- ***Identity*** means that data is quantized into discrete, distinguishable, entities called ***objects***
- An object can be ***concrete*** like a ***car***, a ***file***, …
- An object can be ***conceptual*** like a ***feeling***, a ***plan***,…
- Each object has its own ***identity*** even if two objects have exactly the same ***attributes***. They are still different separate objects.

Ali's car

Khaled's car

Identity

- ***Object identity*** is the property by which each object can be identified and treated as a distinct software entity
- Each object has something unique which distinguishes it from all its fellow objects. It is its memory address (or ***handle***) that is referred to by one or more ***object identifiers*** (OID)
- **`Car  myCar("Opel", 2005);`**
- The object handle is 0x00FDA610 is referenced by an object identifier **`myCar`**

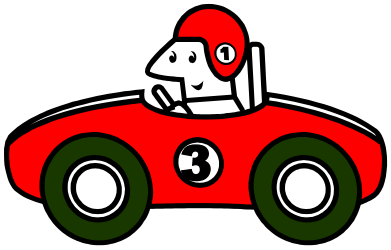


`myCar:0x00FDA610`

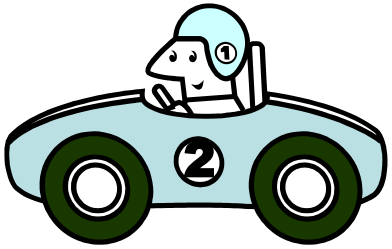
1.2 Classification

- ***Classification*** means that objects with the same data structure (***attributes)*** and behavior (***operations***) belong to the same ***class***
- A class is an ***abstraction*** that describes the properties important for a *specific* application
- The choice of classes is arbitrary and application-dependent.

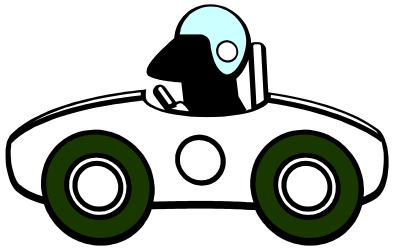
Mina's car



Ali's car



Samir's car



A Car

Classification

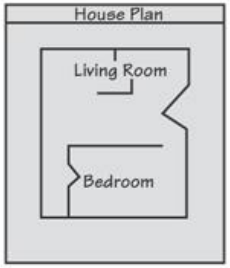
- Each object is an ***instance*** of a class
- Each object has a reference to its class (knows which class it belongs to)

Figure 1.2 Objects and classes. Each class describes a possibly infinite set of individual objects.

Classes and Objects

- A Class is like a blueprint (template) and objects are like houses built from the blueprint

Blueprint that describes a house.



Instances of the house described by the blueprint.

1.3 Abstraction

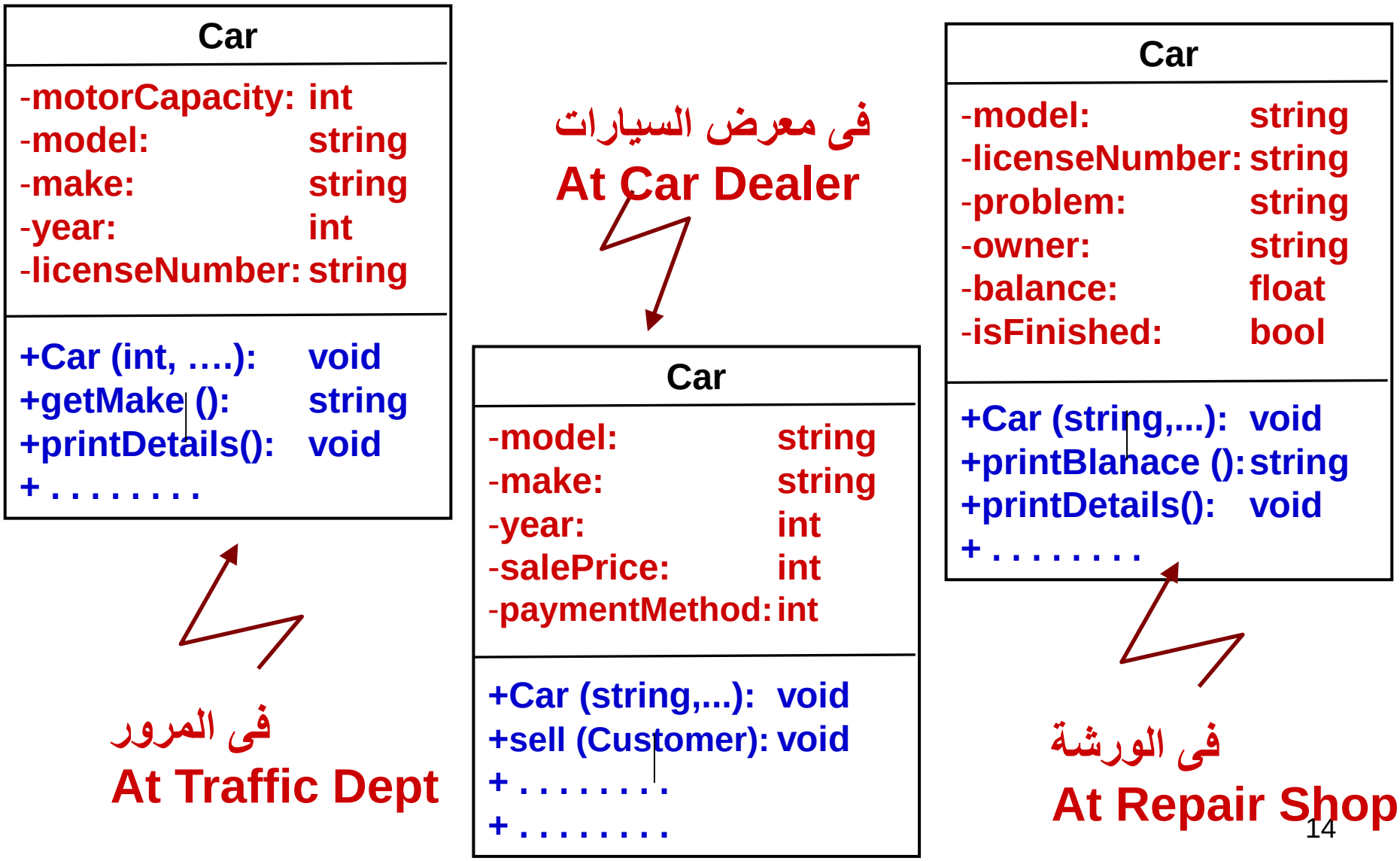
- ***Abstraction*** is the selective examination of certain aspects of a problem.
- Abstraction aims to isolate the aspects that are important for some purpose and suppress the unimportant aspects.
- The purpose of abstraction determines what is important and what is not.

Abstraction

- All abstractions are incomplete and inaccurate.
- In modeling, do not search for the truth but for adequacy for some purpose.
- There is *no single correct model* for a problem. Only adequate and inadequate ones.
- A ***good model*** captures the crucial aspects of a problem and omits the rest.
- A class abstracts a real concept *according to the needs of a specific application.*

Abstraction

Different abstractions for the concept of a car according to the application.

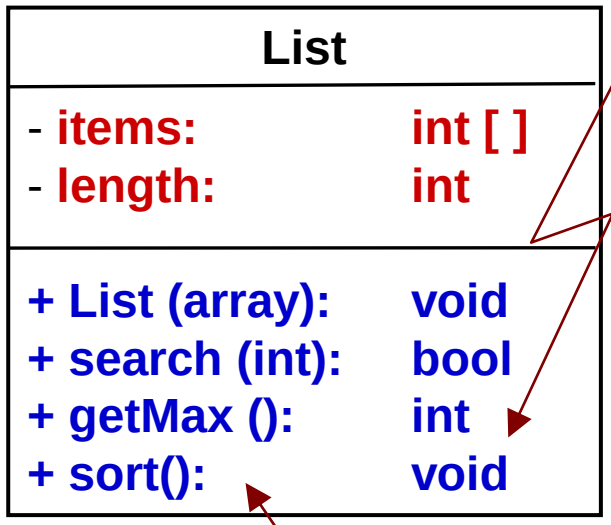


1.4 Encapsulation

- ***Encapsulation*** separates the **external aspects** of an object, that are accessible to other objects, from the **internal implementation details** that are hidden from other objects.
- Encapsulation reduces ***interdependency*** between different parts of the program.
- You can *change the implementation* of a class (to enhance performance, fix bugs, etc.) *without affecting* the applications that use objects of this class.

Encapsulation

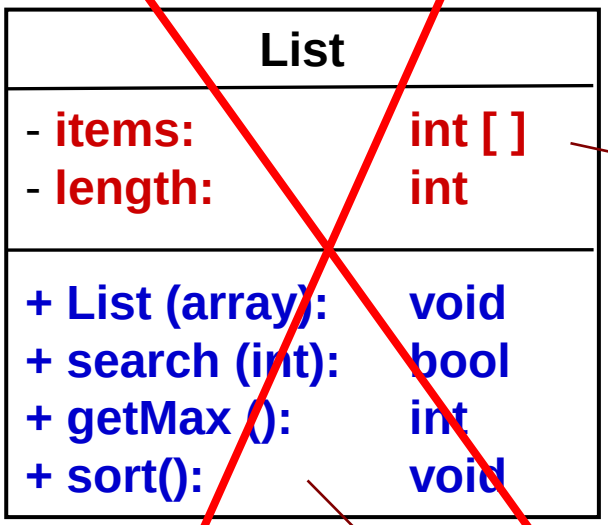
It allows you to replace an algorithm with a faster one while keeping the class interface (public methods) the same.

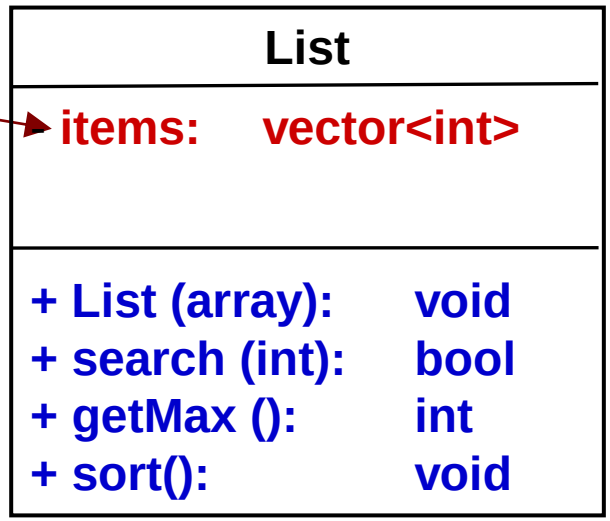



```
void sort () {   // Bubble Sort
    int i, j;
    for (i = length - 1; i > 0; i-) {
        for (j = 0; j < i; j++) {
            if (items [j] > items [j + 1]) {
                int temp = items [j];
                items [j] = items [j + 1];
                items [j + 1] = temp;
            }
        }
    }
}`
```

```
void sort () {   // Quick Sort
    ……..
}`
```

Encapsulation





It allows you to replace a data item with another one while keeping the class interface (public methods) the same.

```
void sort () {  // Bubble Sort
   int i, j;
   for (i = items.size()- 1; i > 0; i-) {
      for (j = 0; j < i; j++) {
         if (items [j] > items [j + 1]) {
            swap (items [j], items [j + 1]);
         }
      }
   }
}
```

Encapsulation

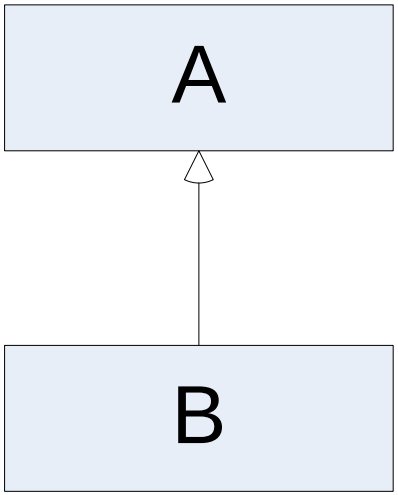
- ***Data hiding.*** Information from within the object cannot be seen outside the object.
- ***Implementation hiding.*** implementation details within the object cannot be seen from the outside.

1.5 Inheritance

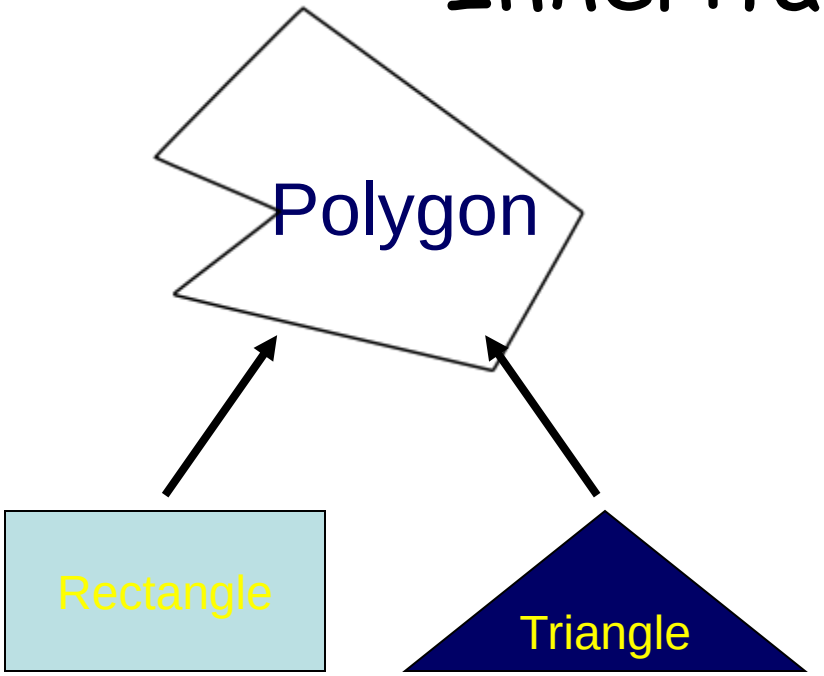
- ***Inheritance*** is the sharing of ***features*** (attributes and operations) among classes based on a hierarchical relationship.
- A ***superclass*** (also ***parent*** or ***base***) has general features that ***sublcasses*** (***child*** or ***derived***) refine and elaborate.
- Each subclass ***inherits*** all the features of its superclass.
- Inheritance is one of the strongest features of OO technology.

Inheritance

- Inheritance is the facility by which objects of a class (say B) may use the methods and variables that are defined only to objects of another class (say A), as if these methods and variables have been defined in class B
- Inheritance is represented as shown in ***UML*** notation.



Inheritance Concept



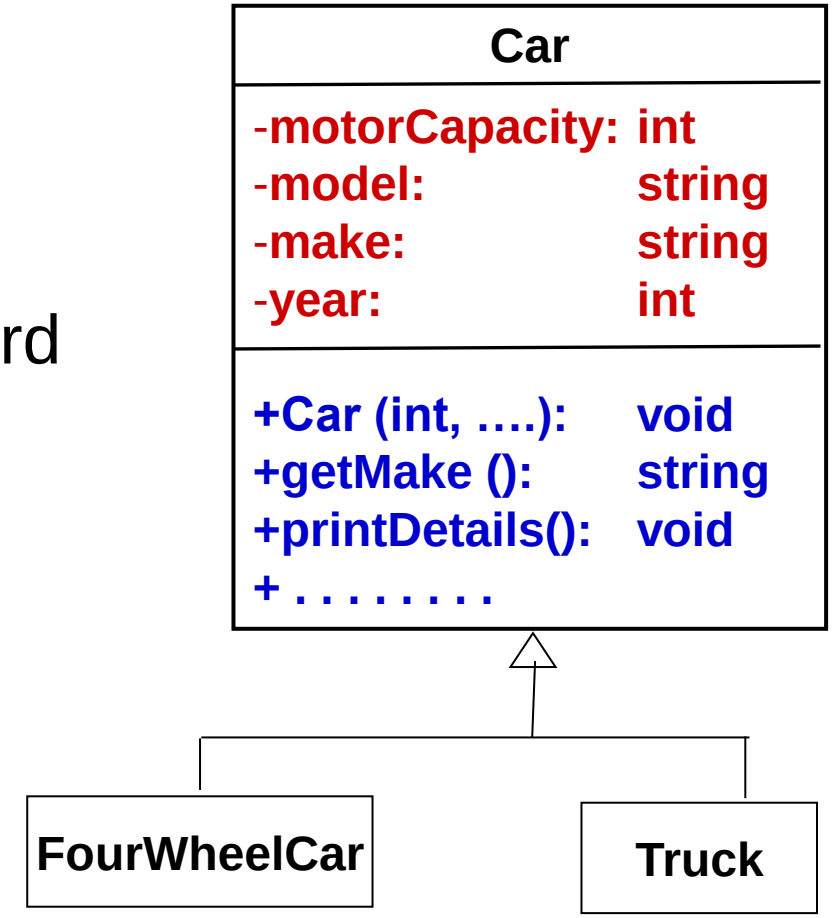

```
class Polygon{
    protected:
        int numVertices;
        float *xCoord, float *yCoord;
    public:
        void set(float *x, float *y, int nV);
};
```

```
class Triangle : public
    Polygon{
    public:
     float area();
};
```

```
class Triangle{
    protected:
        int numVertices;
        float *xCoord, float *yCoord;
    public:
        void set(float *x, float *y, int nV);
        float area();
};
```

How to use Inheritance?

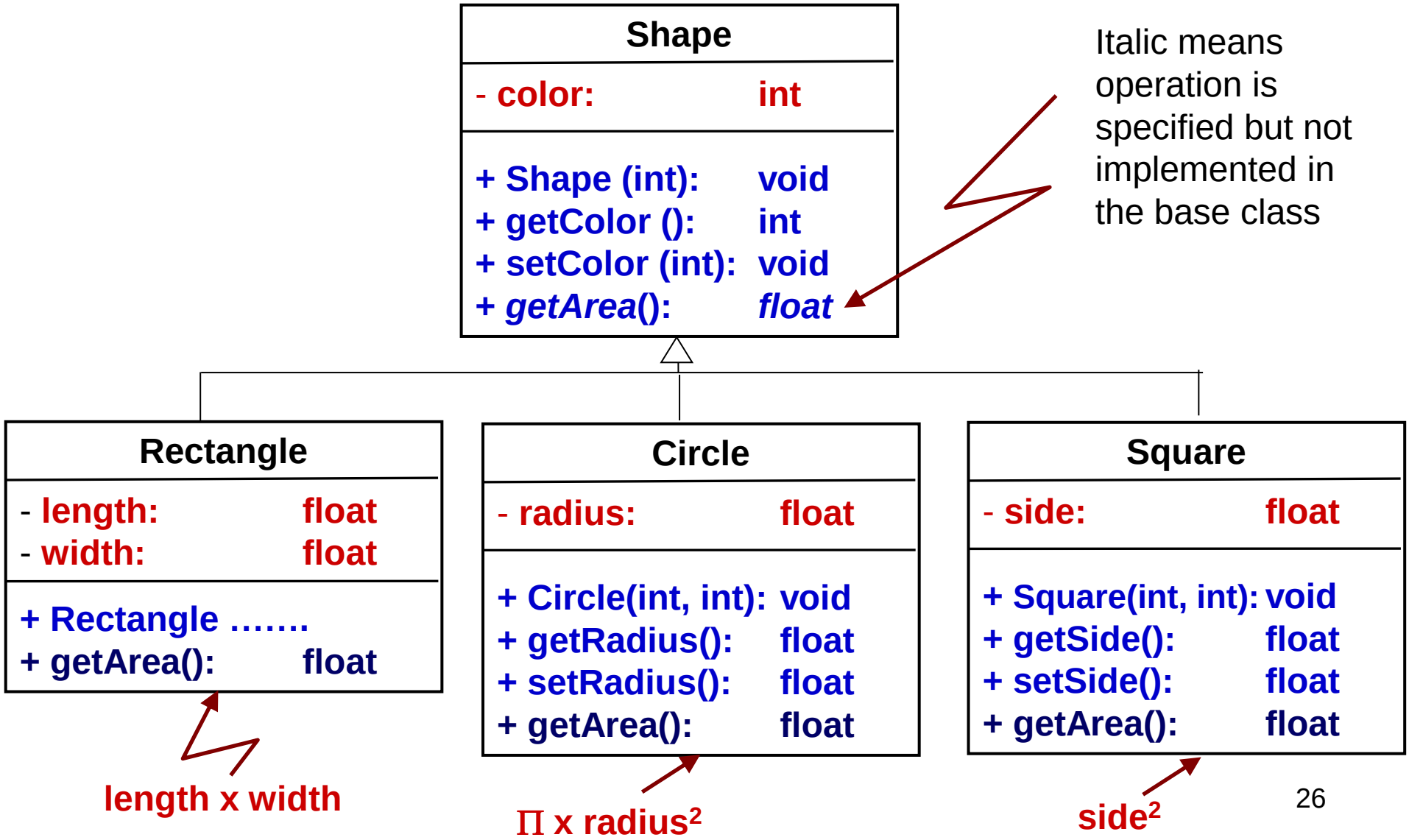
- Inheritance helps building software incrementally:
- *First*; build classes to cope with the most straightforward (or general) case,
- *Second*; build the special cases that inherit from the general base class. These new classes will have the same features of the base class plus their own.



1.6 Polymorphism

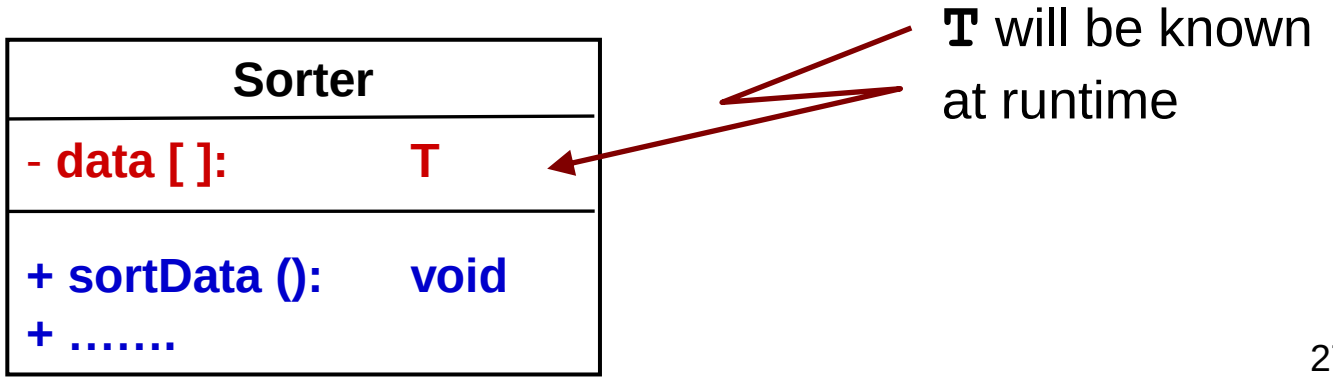
- ***Polymorphism*** means that the same operation may behave differently for different classes.
- An ***operation*** is a procedure or a transformation that the object performs or is subject to.
- An implementation of an operation by a specific class is called a ***method***.
- Because an OO operation is polymorphic, it may have more than one method for implementing it, each for a different class.

Polymorphism



1.7 Genericity

- ***Genericity*** is the construction of class ***A*** so that one or more of the classes it uses internally is supplied only at run-time (at the time that an object of class ***A*** is instantiated)
- This means that the class is ***parameterized***, i.e., the class gets a parameter which is the name of another type.



2. OO Development Methodology

- **Why building models?**

1. To test the system before building it
2. To communicate with the customer
3. To visualize your ideas
4. To reduce complexity

2. OO Development Stages

- System conception → **There is a need or idea**
- Analysis → **What will / will not be done**
- System design → **Overall architecture**
- Class design → **Detailed design**
- Implementation → **Programs**
- Testing → **Make sure it works well**
- Training → **Train the end user to use it**
- Deployment → **Install it**
- Maintenance → **Fix bugs & add functions to stay relevant**

http://www.computerweekly.com/news/2240105488/Olympic-software-engineers-enter-final-leg-of-marathon-IT-development-project

Class Model

- A ***class model*** captures the static structure of the system by characterizing
  - the *objects* in the system,
  - the *relationships* among the objects and
  - the *attributes* and *operations* for each class of objects
- Class model is the *most important* UML model
- **UML** is Unified Modeling Language for OO systems

Object and Class Concepts

Objects

- The class model describes the system's ***objects***
- Objects often appear as ***proper nouns*** in the problem description or discussion with the customer.
- Some object correspond to ***real world entities*** (Dr El-Ramly, Oxford University, the old turtle in the zoo)
- Some objects correspond to ***conceptual entities*** (the formula for solving an equation, operand checker, etc.)
- The choice of objects depends on the analyst's judgment and the problem in hand. There can be *more than one correct representation*.

Objects

- Objects have ***identities*** and are distinguishable from each other
- Each object has a memory address that is referred to by one or more ***object identifiers*** (OID)

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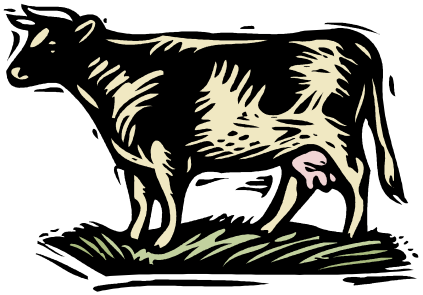
Class

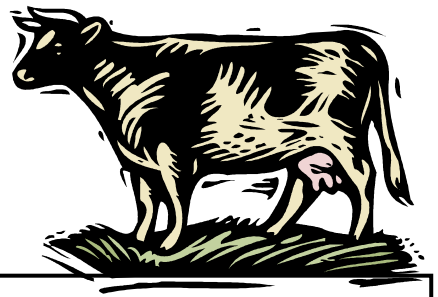
- An object is an ***instance of*** or ***occurrence*** of a class
- A class describes a group of objects with the same
  - Properties (attributes)
  - Behavior (operations)
  - Kinds of relationships and
  - Semantics
- *Person, Company and Window* are all classes
- Classes often appear as ***common nouns*** and ***noun phrases*** in problem description and discussion with customers or users

Class



- Objects in a class share a common ***semantic*** purpose in the system model
- Both car and cow have *price* and *age*
- If both were modeled as pure *financial assets*, they both can belong to the same class.
- If the application needs to consider that:
  - Cow eats and produces milk
  - Car has speed, make, manufacturer, etc.
- Then model them using separate classes.
- ***So the semantics depends on the application***

Class



Financial Asset
-type: int -age: float -currentValue: float -. . . -. . .
+getCurrentValue: int +printDetails(): void + ...

في معرض
السيارات

Car at Dealer

Car
-model: string -make: string -year: int -maxSpeed: int -paymentMethod: int
+Car (string,...): void +sell (Customer): void + ... + ...

Cow
-wight: float -age: string -spices : string -owner: string -gender: char -isPregnant: bool
+Cow (string,...): void +getOwner (): string +printDetails(): void + ...

البقرة و السيارة
فى نفس الكلاس

Cow & Car
Same Class

فى المزرعة

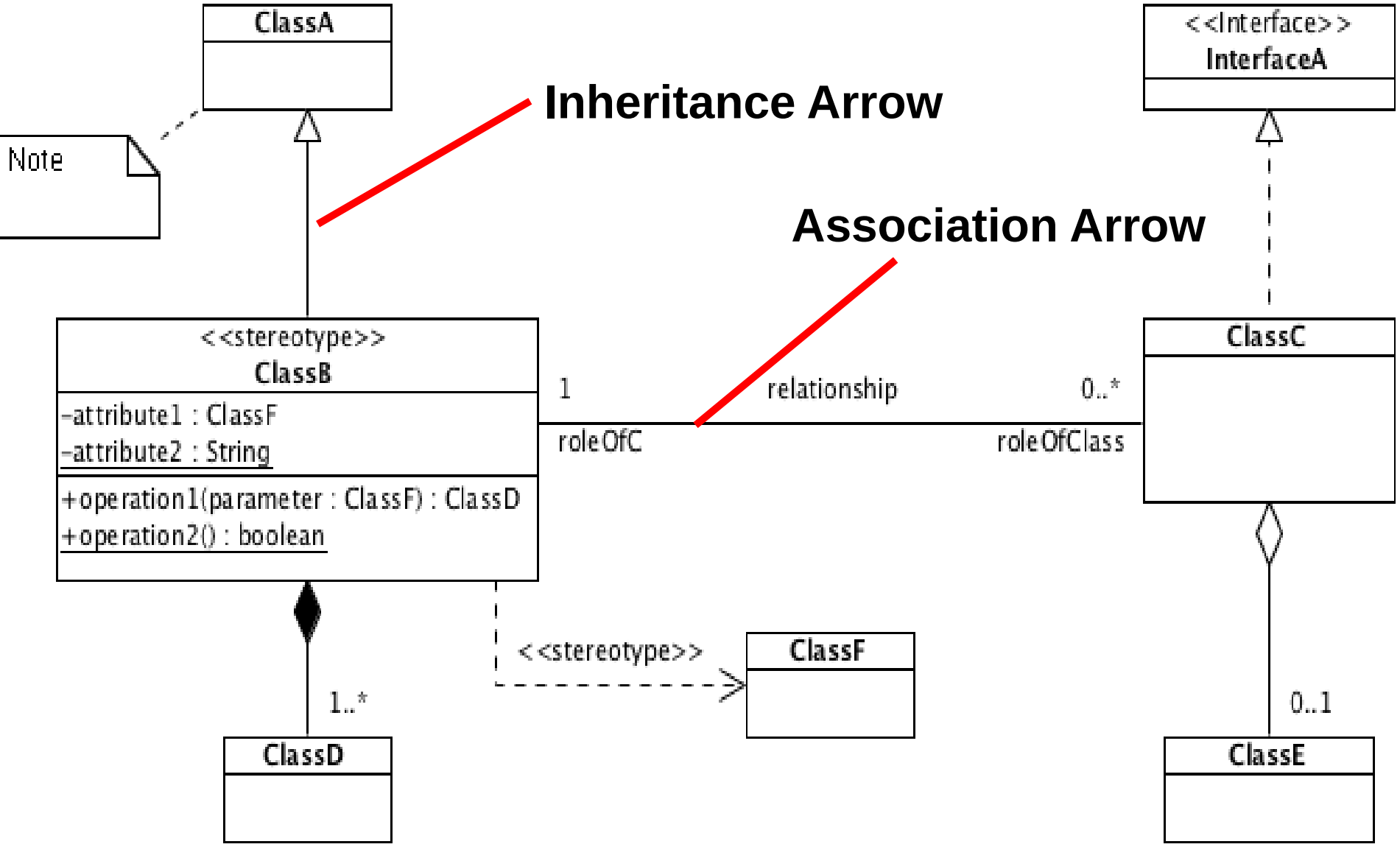
Cow in Farm

Problem Domain

- ***Problem domain*** is the set of objects, events and relations that define the environment of the problem.
- It is very very important to understand the problem domain before solving the problem.
- If needed get a *domain expert.*
- **An important task in OOP is identifying the classes that will represent the problem domain**
- This is not required for all classes but for the classes related to the problem solution.

UML Class Diagram Summary

- UML is the dominant OO modeling language today.



UML Class Diagram Links

- http://www.idt.mdh.se/kurser/cd5490/2004/lectures/UML%20Intro.pdf
- http://www.step-10.com/SoftwareDesign/UML/UMLClassDiagramsASummaryOfTheBasics.html
- http://www.ibm.com/developerworks/rational/library/content/RationalEdge/sep04/bell/

3.1 Example 1: Car Service Quotes

- Ali’s Mechanic Shop services expensive cars like Mercedes and BMW. When a customer brings a car to the shop, the manager gets the customer’s name, address and phone number. Then the manager fills the car make, model and year. After inspection, the manager gives the customer a service quote. The quote shows the estimated parts charges, estimated labor charges and the total estimated charges.

3.1 Example 1: Car Service Quotes

1. Read the problem description very carefully
2. Identify all the nouns in the problem description
3. Refine the noun list
   - Remove nouns that represent the same concept
   - Remove nouns that represent concepts irrelevant to the problem solution
   - Remove nouns that represent objects or instances of classes
   - Remove nouns that can be data fields in classes represented by primitive data types
4. Identify the responsibilities of each class

3.1 Example 1: Car Service Quotes

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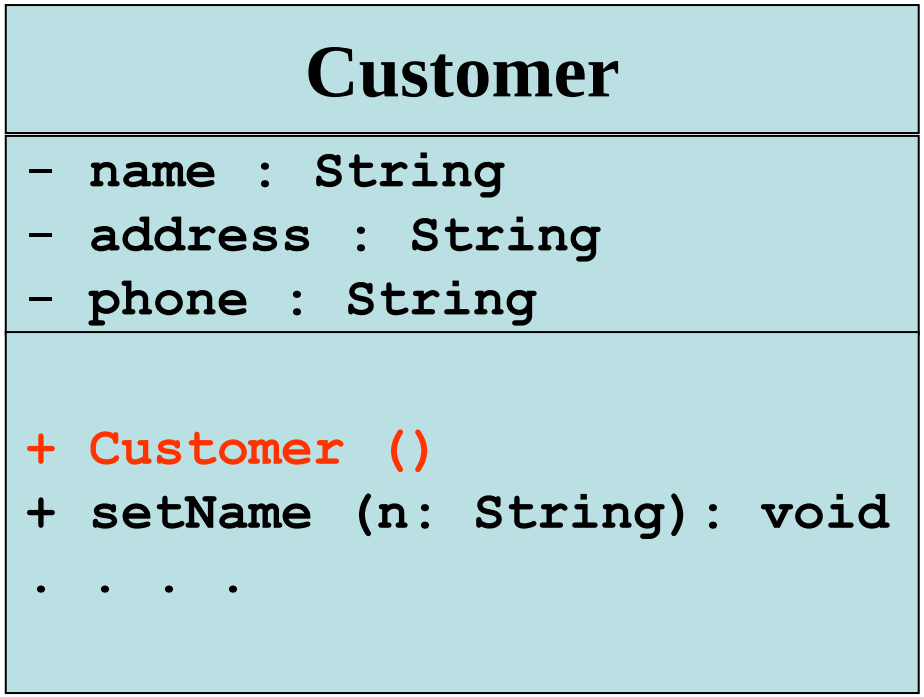
3.1 Example 1: Car Service Quotes

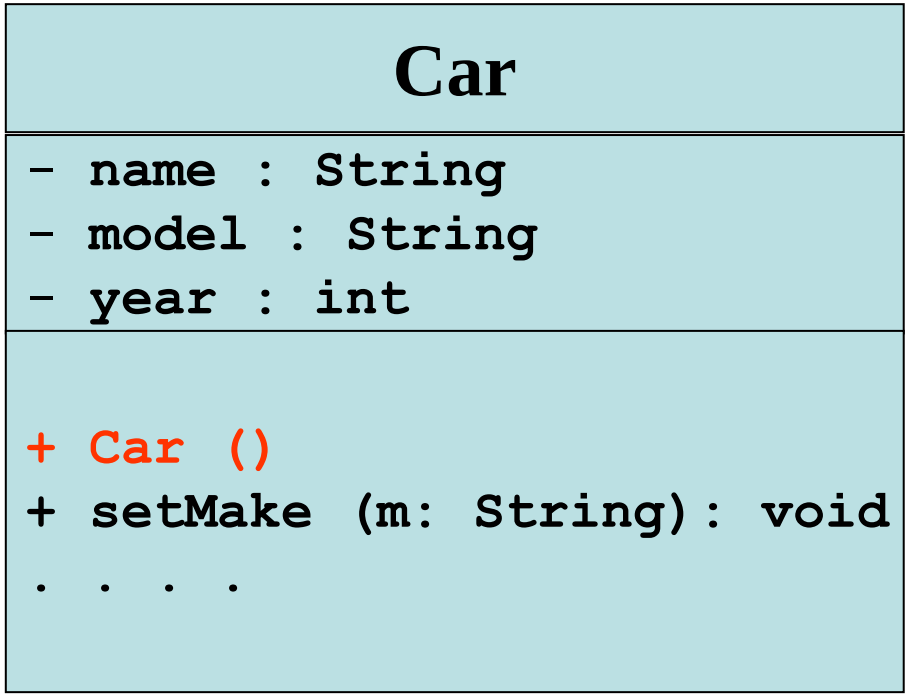
cars

customer

service quote

3.1 Example 1: Car Service Quotes





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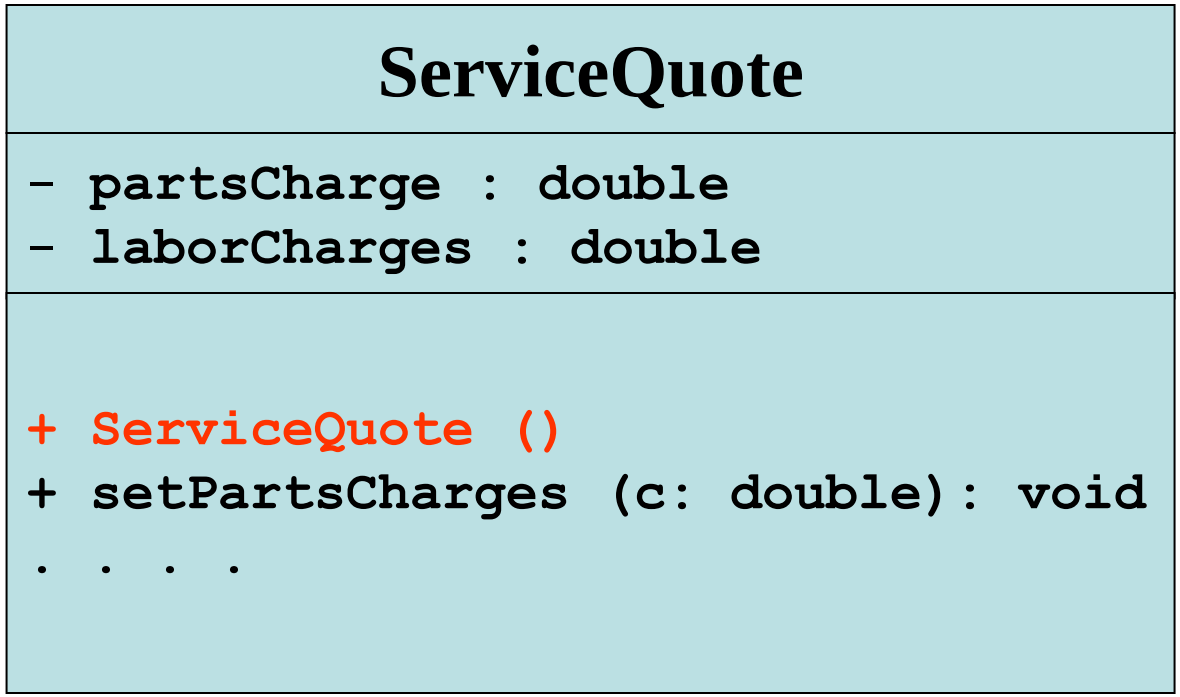


3.2 Example 2

- **وصف النظام المطلوب**
- المطلوب بناء محاكى لماكينة البيع الذاتى Vending Machine Simulator للمشروبات الباردة و الحلوى و هى الماكينة التى توضع فيها النقود و يتم طلب أحد الأشياء التى تبيعها فينزل المطلوب و باقى النقود للمشترى وتعمل كالتالى:
- عند تحميل البرنامج يبدأ بقيم تلقائية Default Values لنوعية الحلوى و المشروبات الموجودة فيه و كذلك بقيم تلقائية لكمية النقود المتاحة فيها من حيث فئات النقدية و العملات و عددها.
- الماكينة تحمل 10أنواع مختلفة و من كل نوع تحمل عشرة وحدات و محدد لديها سعر الوحدة
- للماكينة نوع واحد من المستخدمين و هم المشترون.
- المشترى يقوم بوضع عملات معدنية أو أوراق نقدية من فئة نصف ريال و ريال و خمسة ريالات و عشرة ريالات و خمسين ريالا.

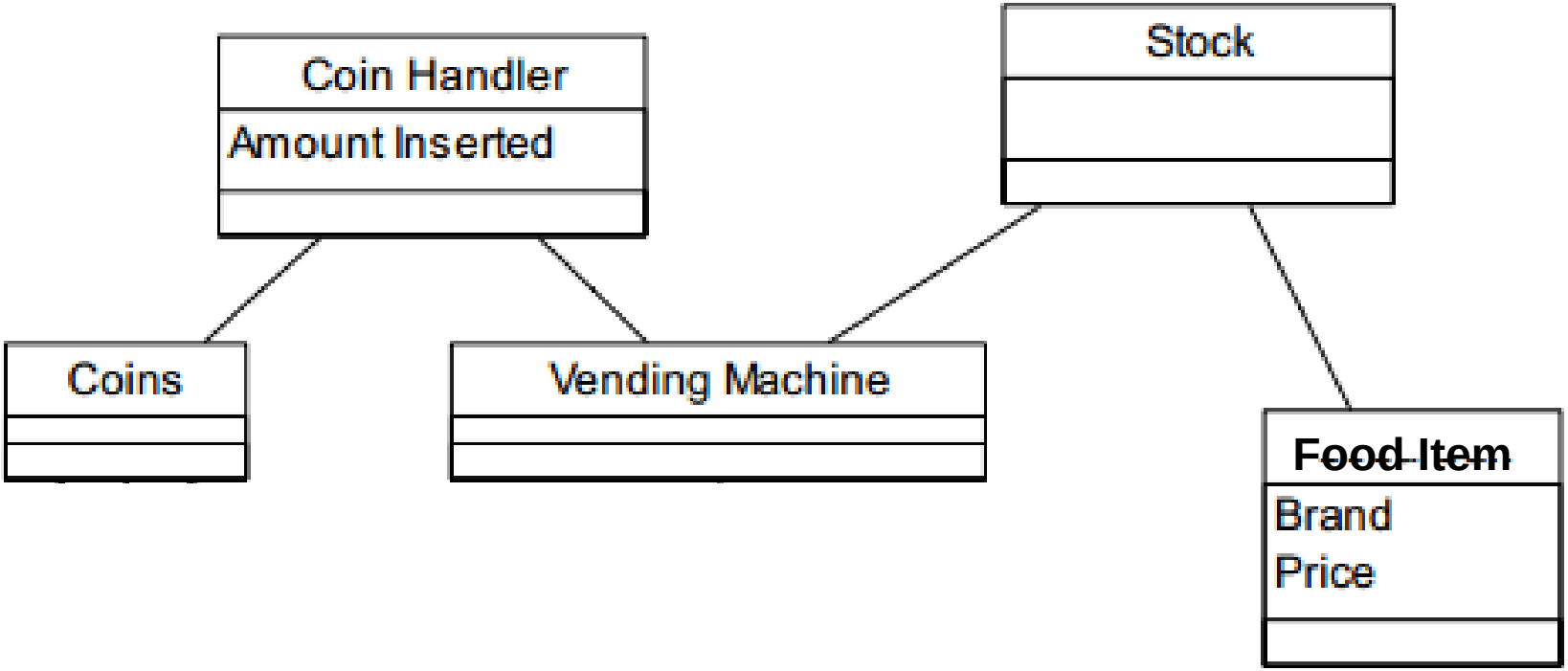
3.2 Example 2

- **وصف النظام المطلوب**
- ثم يقوم المشترى بضغط رقم النوع الذى يريده و إذا كان قد وضع نقودا كافية فإن الماكينة تصرف له العنصر المطلوب و تصرف له باقى المبلغ المدفوع بأكبر فئة نقدية متاحة فمثلا لو باقى له 6.5 جنيه فإنها تصرف له ورقة فئة خمسة جنيهات ثم ورقة أو عملة فئة جنيه وورقة أو عملة فئة نصف جنيه.
- إذا كان النوع المطلوب موجودا يتم صرفه و صرف باقى النقود.
- إذا كان النوع المطلوب غير موجود فإن الماكينة تظهر رسالة لتخبر المستخدم بعدم وجود النوع المطلوب و تطلب منه إما إختيار نوع آخر أو إستعادة النقود.
- إذا أراد المشترى إلغاء العملية بعد إدخاله النقود فإنه يقوم بإدخال الإختيار 0 فتتم إعادة نقوده له.
- إذا انتهت كل الأنواع بمعنى أنه تم إستهلاك كل البضاعة فى الماكينة فإن الماكينة تتوقف عن قبول النقود و الإختيارات من المشترين.

3.2 Example 2

- **وصف النموذج المقترح**
- الكلاس **Food Item** يمثل نوع من الأنواع التى تبيعها الماكينة و كميته
- الكلاس **Stock** يمثل المخزون من الأنواع التى تبيعها الماكينة و يحتوى على العمليات اللازمة لزيادة المخزون أو الصرف منه أو تغيير تفاصيله و الإستعلام عن أسعار الأنواع و عن وجود نوع معين من عدمه و غيرها.
- الكلاس **Money Drawer / Coin Handler** يمثل درج الفلوس الآلى المسؤول عن تلقى النقود من المشترى و صرفها له
- الكلاس **Vending Machine** هو الكلاس الرئيسى الذى يتعامل مع المشترى و يتلقى طلبه و يصرف له الباقى.
- الكلاس **Coins** يمثل العملات من فئة من الفئات

3.2 Example 2: One possible model



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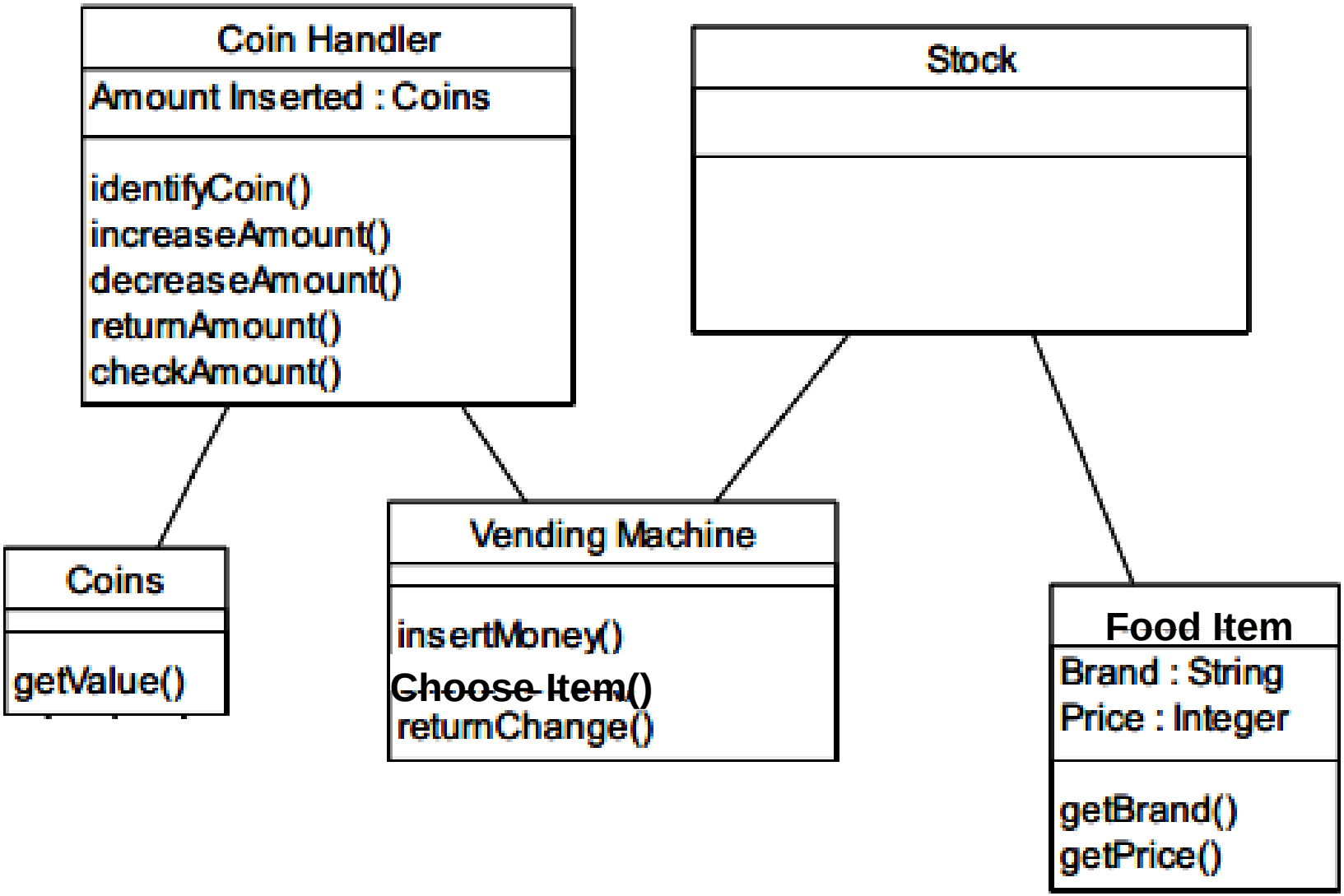

Pearls of Wisdom

- Singapore has only people
- Skills is what you should get out of here not degree
  - Loving and caring about others
  - Sharing knowledge with others
  - Teamwork and cooperation
  - Self-discipline
  - Self-learning and self-motivation
  - Research skills
  - Computer and IT stuff