Pattern-Oriented Software Design

Introduction to UML Class Diagrams

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UML: Unified Modeling Language

- Successor to OOA&D methods
  - late 1980s and early 1990s
- Unifies
  - Jacobson & OMT (Booch & Rumbaugh)
- Graphical notation used to express designs
  - Use cases
  - Class diagrams
  - Interaction diagrams
    - Sequence diagrams
    - Collaboration diagrams
  - Package diagrams
  - State diagrams
  - Activity diagrams
  - Deployment diagrams

GoF Book

UML class diagrams

- Three perspectives
  - Conceptual
    - represents of the domain under study
    - relate to the class that implement them, but often no direct mapping
  - Specification
    - looking at types rather than classes
    - a type represents an interface that may have different implementations
  - Implementation
    - looking at classes

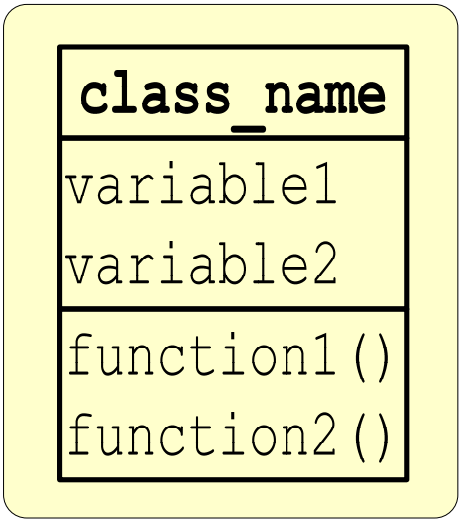
for our POSD class

UML: a class

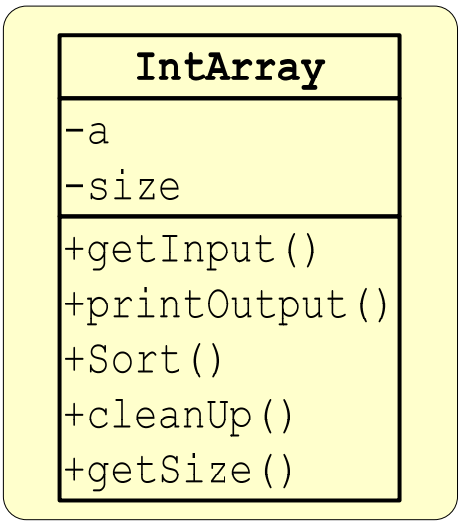
```
+   public
#   protected
-   private
```

```
Abstract
Concrete
```

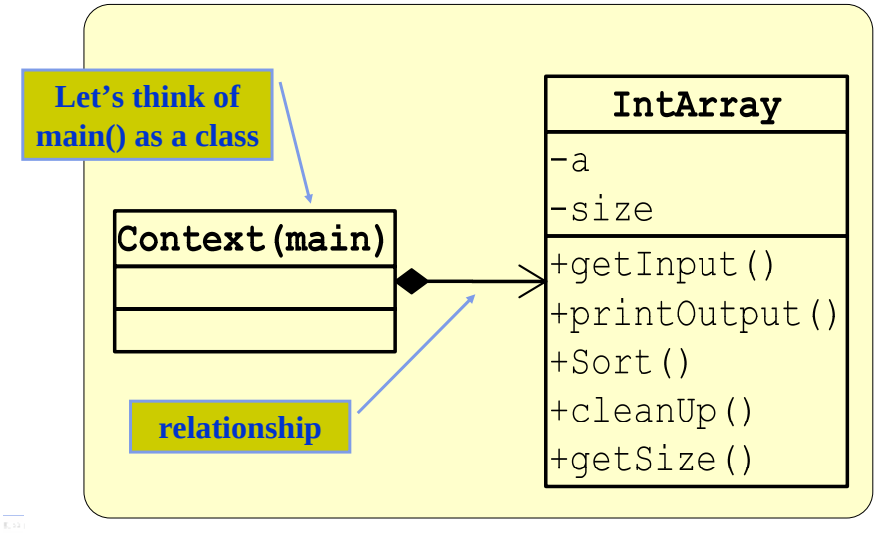
```
•data type
•parameter
```



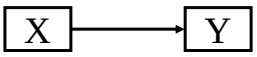
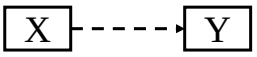
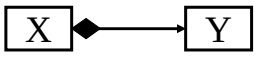
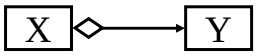
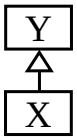
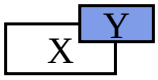
Example: OBSort1.cpp



Example: OBSort1.cpp

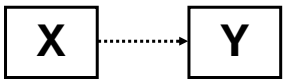


UML: class relationship

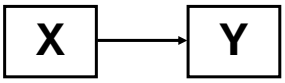
- Association  (knows a)
- Dependency  (uses a)
- Composition  (has a)
- Aggregation  (has a)
- Inheritance  (is a)
- Class template  (parameterized class)

"Uses a" ⇔ "Knows a" relationship

- "Uses a"
  - Dependency
  - One object issues a function call to a member function of another object

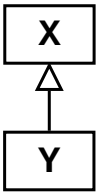


- "Knows a"
  - Association
  - One object is aware of another; it contains a pointer or reference to another object

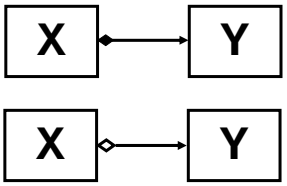


“Is a” ⇔ “Has a” relationship

- “Is a” relationships
  - Inheritance
  - A class is derived from another class



- “Has a” relationships
  - Composition or Aggregation
  - A class contains other classes as members

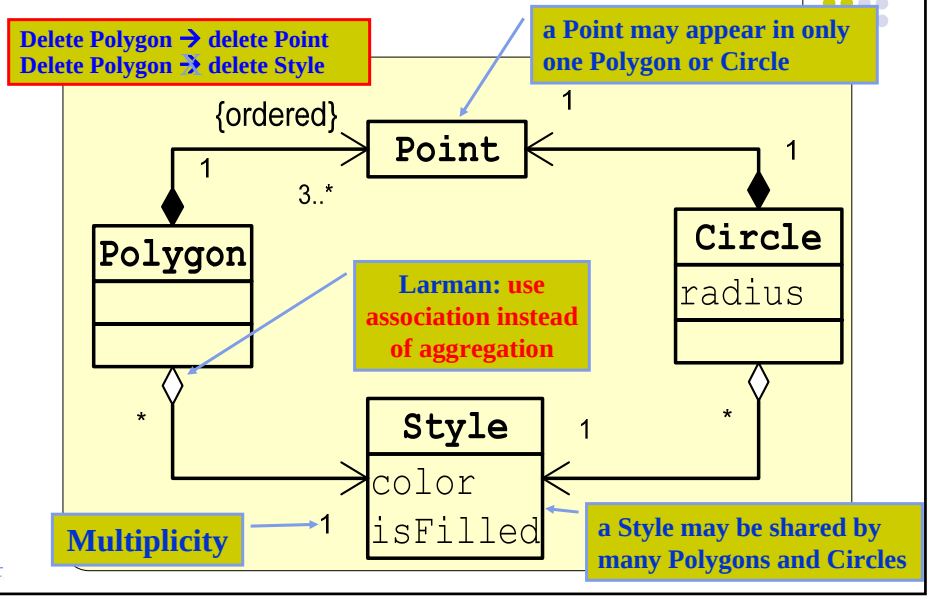


Aggregation ⇔ Composition

- Both are “Has a” or “part-of” relationship
- Composition
  - A stronger variety of aggregation
  - The part object may belong to only one whole
  - Expected to live and die with the whole
    - delete whole → delete part
- Aggregation
  - Cascading delete is often
  - An aggregated instance can be shared

Following Larman OOAD: use of aggregation is NOT recommended

Example: “has a” relationship



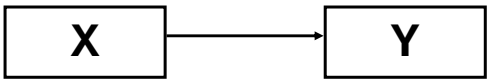
Relationship Examples

- Car ⇔ Engine ? → Composition
- Person ⇔ Cell Phone ? → Association/Composition/Dependency
- Human ⇔ Brain ? → Composition
- Fighter ⇔ Bomb ? → Association
- Fighter ⇔ F16 → Inheritance
- Bomb ⇔ Explosive → Composition/Association/Inheritance
- Bomb ⇔ Nuclear Bomb → Inheritance
- MyComplex ⇔ Math ? → Dependency
- Tree Node ⇔ Child Node ? → Composition
- Tree Node ⇔ Parent Node ? → Association (if needed)
- Hero ⇔ Life ? → Composition/Attribute
- Hero ⇔ Score ? → Association/Dependency
- Hero ⇔ Map ? → Association/Dependency

Relationship Examples

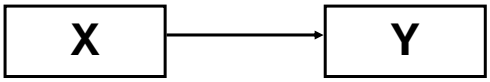
- Flight 123 ⇔ Airplane ? → Association/Dependency
- Flight 123 ⇔ Airport ? → Association
- Flight 123 ⇔ Passenger ? → Association/Dependency
- Flight 123 ⇔ Flight Captain ? → Association/Dependency
- Flight 123 ⇔ Flight Attendant ? → Association/Dependency
- Airplane ⇔ Boeing 747 ? → Inheritance
- Airplane ⇔ Seat ? → Composition
- Airplane ⇔ Fuel ? → Composition/Attribute
- Passenger ⇔ Flight ? → Association/Dependency
- Passenger ⇔ Ticket ? → Association/Dependency
- Passenger ⇔ Travel Agent ? → Association/Dependency
- Ticket ⇔ Price ? → Composition/Attribute

UML Example (C++): Association




```
class X {
  X(Y *y) : y_ptr(y) {}
  void SetY(Y *y) {y_ptr = y;}
  void f() {y_ptr->Foo();}
...
  Y *y_ptr; // pointer
};
```

UML Example (C++): Association



How is an association created?

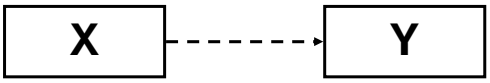
Example #1

```
…
Y an_y();
X an_x(&an_y);
an_x.f();
…
…
```

Example #2

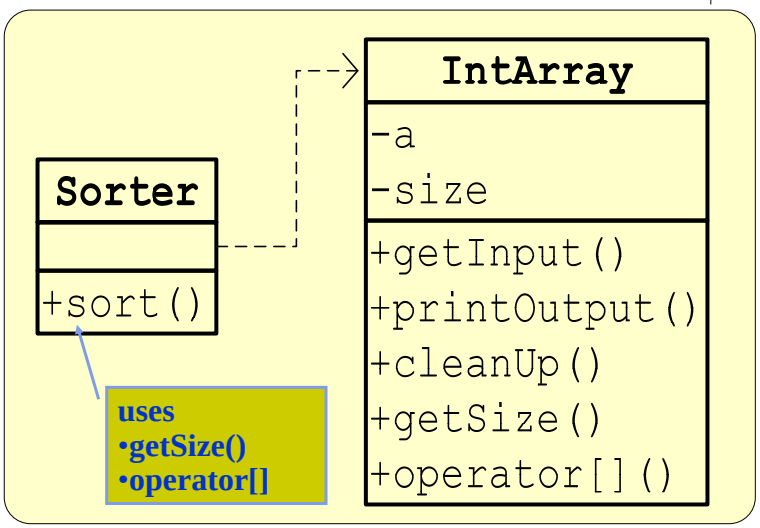
```
…
Y an_y();
X an_x();
…
an_x.SetY(&y);
…
an_x.f();
```

UML Example (C++): Dependency

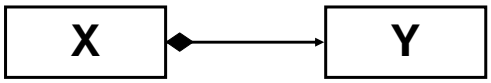



```
class X {
...
   void f1(Y y) {…; y.Foo();}
   void f2(Y *y) {…; y->Foo();}
   void f3(Y &y) {…; y.Foo();}
   void f4() {Y y; y.Foo();…}
   void f5() {…; Y::StaticFoo();}
};
```

Example: OBSort3.cpp



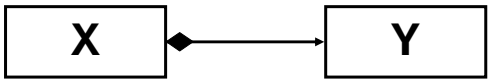
UML Example (C++): Composition 1




```
class X {
...
  Y a;          // 1; Composition
  Y b[10];      // 0..10; Composition
};
```

Java?

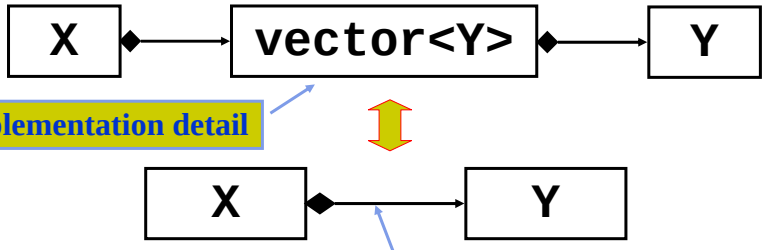
UML Example (C++): Composition 2




```
class X {
  X() { a = new Y[10]; }
  ~X(){ delete [] a; }
...
  Y *a;         // 0..10; Composition
};
```

NOT Association

UML Example (C++): Composition 3



Implementation detail

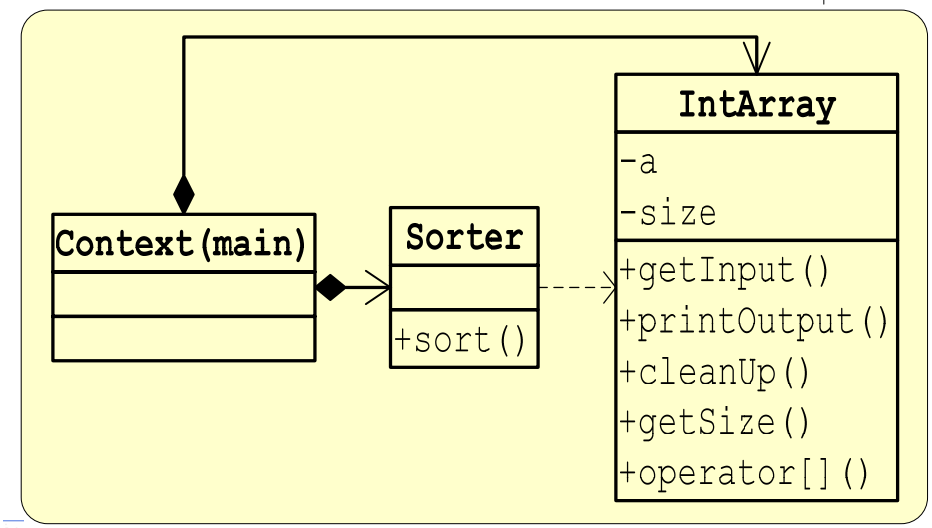

```
class X {
  ...
  vector<Y> a;
};
```

Hiding implementation detail

Composition of `vector<Y>`

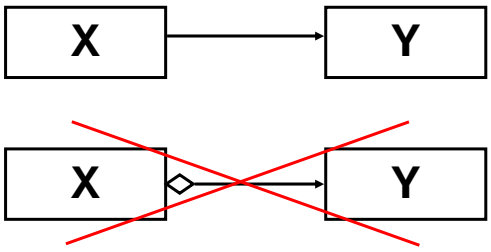
NOT Composition of Y

UML Example: OBSort3.cpp



UML Example (C++): Aggregation

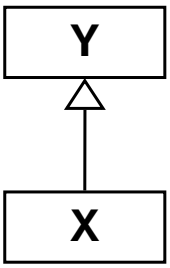
- No example here
  - Use Association instead of Aggregation



UML Example (C++): Inheritance

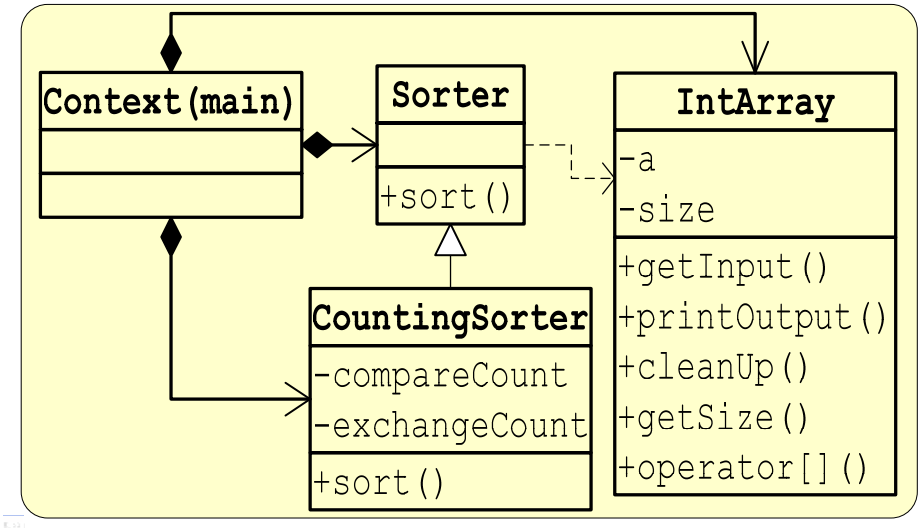
```
class Y {
...
};

class X : public Y {
...
};
```



"is a" relationship

Example: OOSort2.cpp



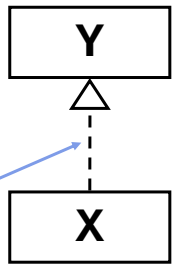
UML Example (C#): Implementation

```
public interface Y {
   int Foo();
}

class X : Y
{
   public int Foo()
   {
      …
   }
}
```

No fields

X implements Y



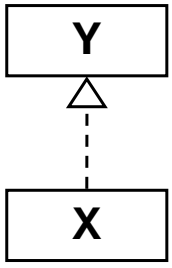
"Can do" relationship

UML Example (C++): Implementation

```
class Y {
...
};

class X : public Y {
...
};
```

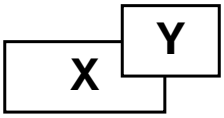
No variables
Only pure virtual functions



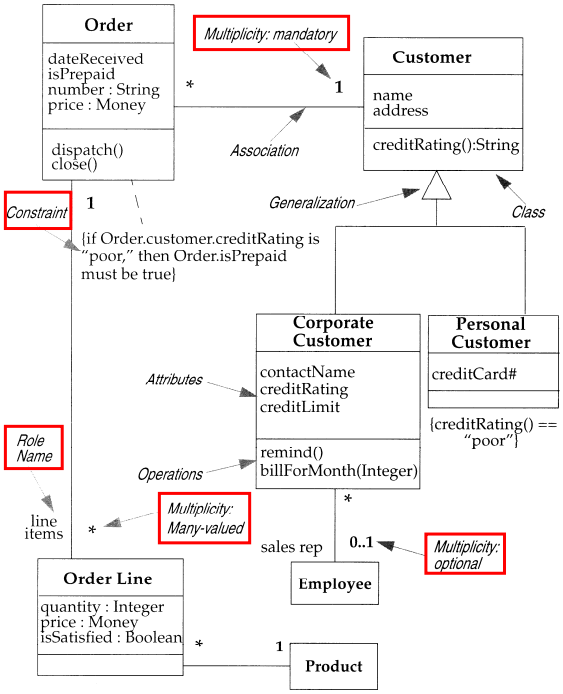
C++ allows multiple inheritance

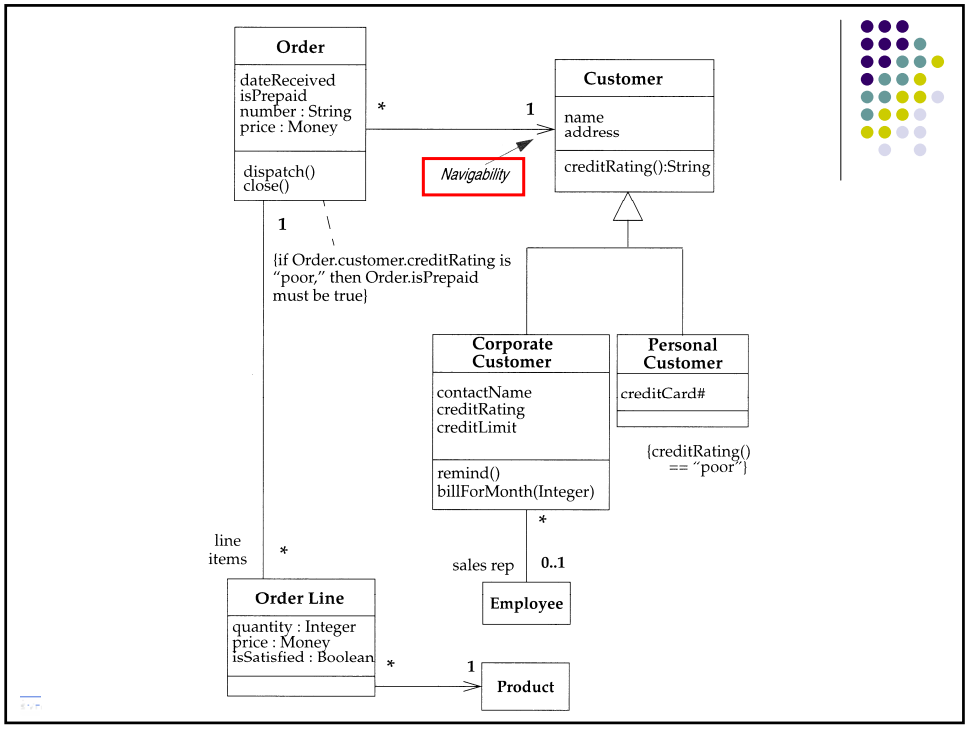
UML Example (C++): Template Class

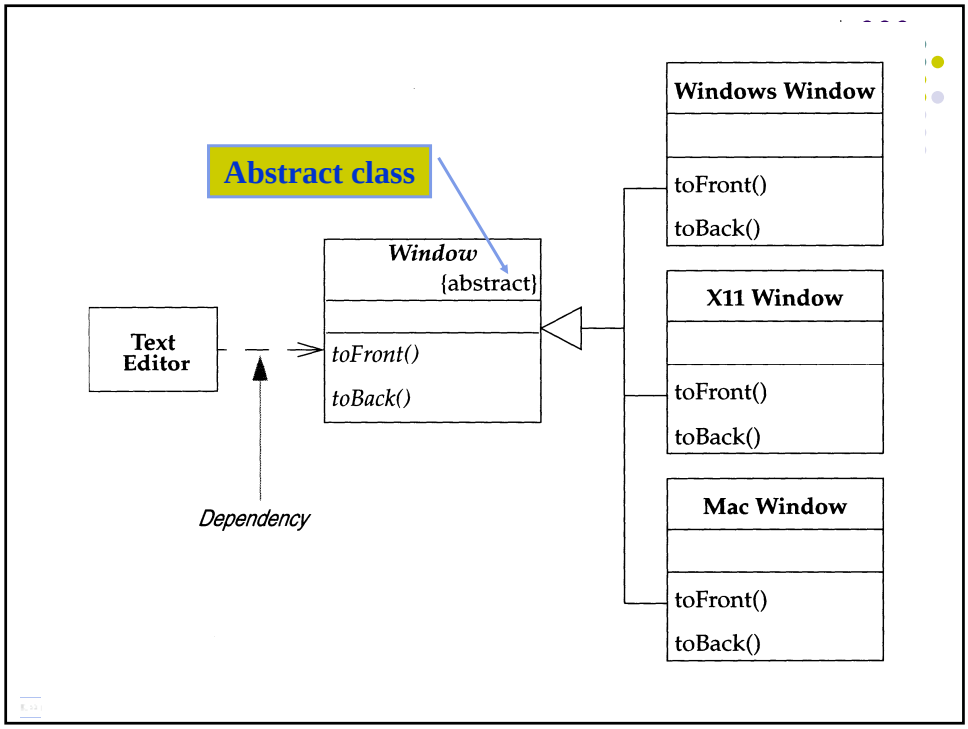
```
template <class T>
class X {
...
...
...
};
```

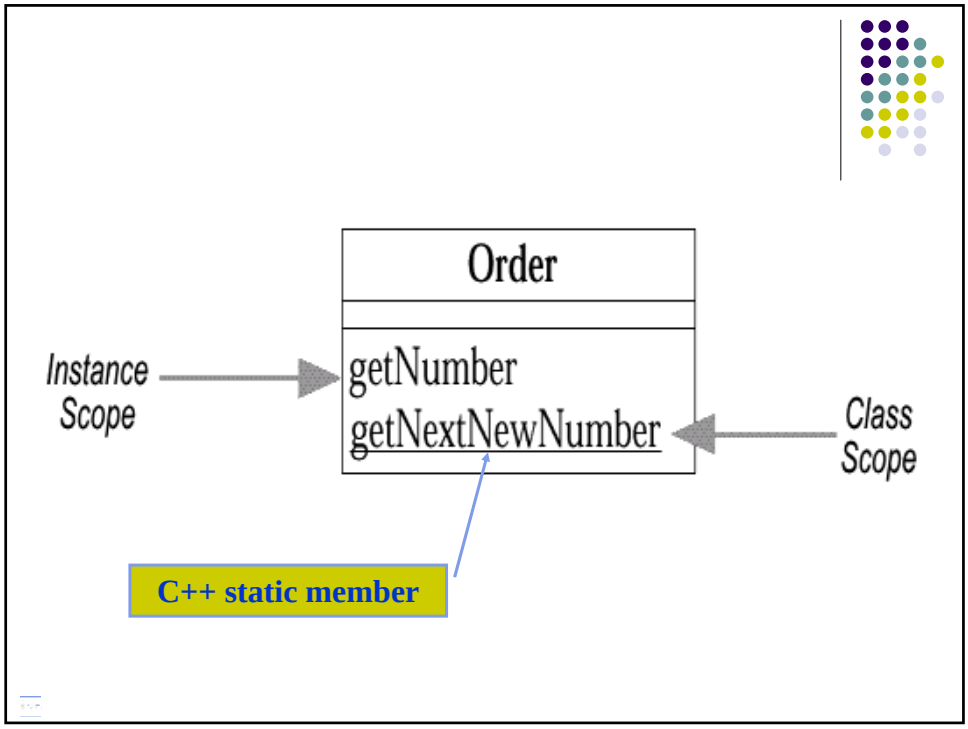



```
...
X<Y> a;
...
```




Order
dateReceived
isPrepaid
number : String
price : Money
dispatch()
close()
*
1
Customer
name
address
creditRating():String
Navigability
1
{if Order.customer.creditRating is "poor," then Order.isPrepaid must be true}
Corporate Customer
contactName
creditRating
creditLimit
remind()
billForMonth(Integer)
Personal Customer
creditCard#
{creditRating() == "poor"}
line items
*
sales rep
0..1
Order Line
quantity : Integer
price : Money
isSatisfied : Boolean
*
1
Employee
Product


Abstract class
Window
{abstract}
toFront()
toBack()
Text Editor
Dependency
Windows Window
toFront()
toBack()
X11 Window
toFront()
toBack()
Mac Window
toFront()
toBack()


Order
getNumber
getNextNewNumber
Instance Scope
Class Scope
C++ static member