

A large, two-story, light-colored building with a red-tiled roof and a central tower, surrounded by green grass and trees under a clear blue sky.

MAHARISHI UNIVERSITY of MANAGEMENT

Engaging the Managing Intelligence of Nature

Computer Science Department

**CS401 Modern Programming
Practices (MPP)
Professor Paul Corazza**

Lecture 5:

Abstract Classes and Interfaces

Engaging Abstract Levels to Enrich Life

Wholeness of the Lesson

Both abstract classes and interfaces can be used in conjunction with polymorphism, but interfaces provide even more flexibility.

Likewise in the universe, objects form hierarchies of wholeness which express the unmanifest field of pure creative intelligence into all the specific structures of existence and intelligence.

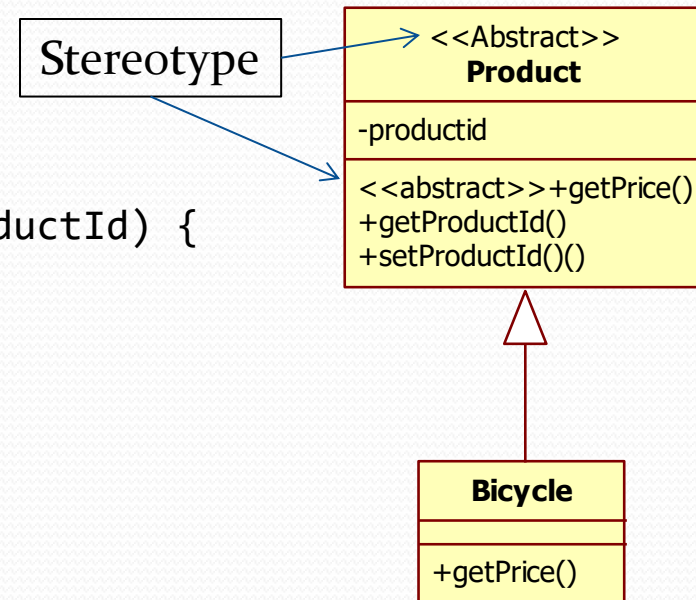
Rules About Abstract Classes

- An abstract class is declared using the `abstract` keyword.
- Cannot Be Instantiated
- Can have both abstract and non-abstract methods
- Can have constructors
- Can have member variables (fields)
 - Fields can be final, static, etc.
- Can include static, final methods and static blocks
- Can't be final
- A subclass must implement all abstract methods
- When a method is declared to be abstract, its enclosing class must also be declared abstract.

Abstract Class Example

```
public abstract class Product {  
    private String productId;  
  
    public abstract double getPrice();  
  
    public String getProductId() {  
        return productId;  
    }  
    public void setProductId(String productId) {  
        this.productId = productId;  
    }  
}
```

```
public class Bicycle extends Product {  
  
    @Override  
    public double getPrice() {  
        return 230.45;  
    }  
}
```



Abstract Classes and Polymorphism

When using polymorphism:

- *Default implementation.* Sometimes, a method common to subclasses has a natural default implementation.

Example: The `getSalary` method of `Employee`. (Lesson 3)

```
//from Employee
public double getSalary() {
    return salary;
}
```

```
//from Manager
public double getSalary() {
    double baseSalary = super.getSalary();
    return baseSalary + bonus;
}
```

- *Abstract method.* At other times, a common method has no default implementation and so it is declared *abstract* – the implementation of the method in this case must be handled by subclasses.

Example: The `computeStipend` method of `StaffPerson` (Lesson 3)

```
public abstract class StaffPerson {
    abstract public double computeStipend();
}
```

```
public class Faculty extends StaffPerson {
    public double computeStipend() {
        return 4000.0;
    }
}
```

Pre-Java 8 Interfaces

- Abstract Methods Only
 - are automatically public and abstract
- No Instance Fields
- Fields Must Be Constants
 - Interfaces could only contain constant fields (public static final)
 - All fields were implicitly public, static, and final
- No Constructors
- Can implement more than one interface. [Note: no class can have more than one *superclass*.] Syntax:

`MyClass implements Intfacel1, Intface2, Intface3`

- Can also extend *and* implement. Syntax:

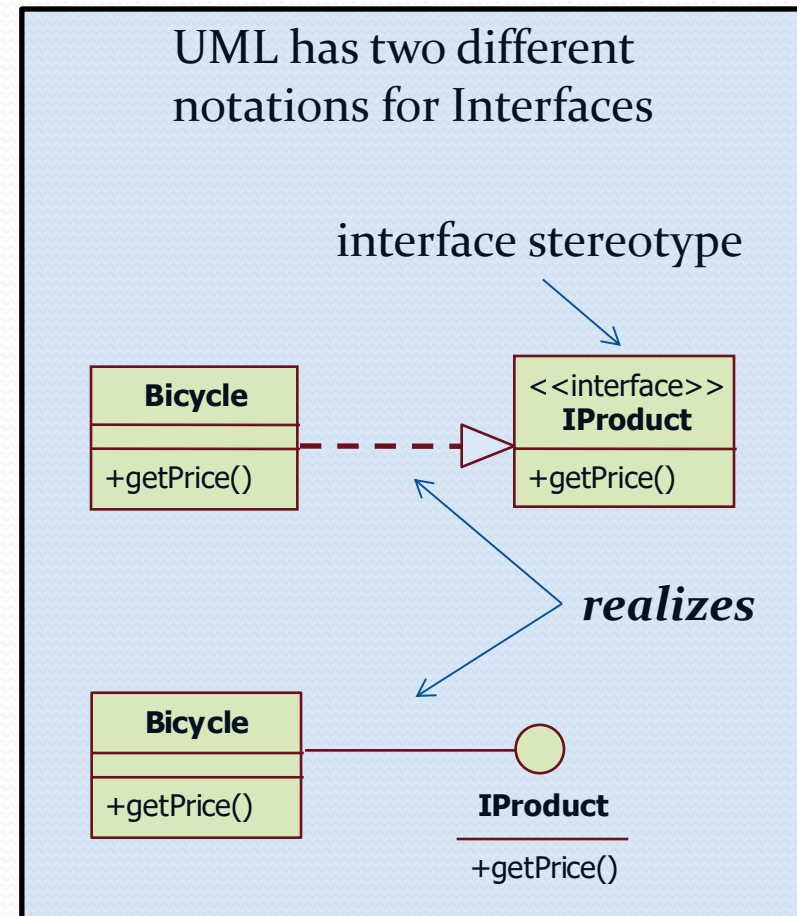
`MyClass extends SuperClass implements Intfacel1, Intface2`

Example: In Java, `ArrayList` implements 6 interfaces and extends one class. (What are they?)

Interface Example

```
public interface IProduct {  
    public abstract double getPrice();  
}  
  
public class Bicycle implements IProduct {  
    @Override  
    public double getPrice() {  
        return 230.45;  
    }  
}
```

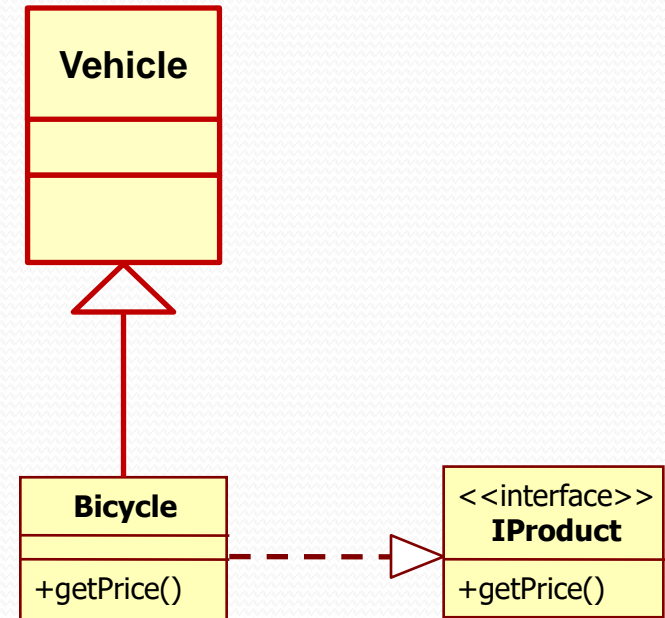
Question: Is there a good reason to use an interface instead of an abstract class?



Interface Example

```
public interface IProduct {  
    public abstract double getPrice();  
}  
  
public class Bicycle extends Vehicle  
    implements IProduct {  
    @Override  
    public double getPrice() {  
        return 230.45;  
    }  
}
```

One benefit: Bicycle can be treated as a subclass of Vehicle at the same time as it *implements* IProduct (as does every product in our system).



Static Factory method

- The traditional way for a class to allow a client to obtain an instance is to provide a public constructor.
- A class can provide a public static factory method, which is simply a static method that returns an instance of the class.

```
public class MySingleton {  
    private static MySingleton instance = new MySingleton();  
    private MySingleton() {}  
    public static MySingleton getInstance() {  
        return instance;  
    }  
}
```

Built-in Static Factory Method Examples

- In Java's `Collections` class, there are 32 static factory methods.

Examples:

```
public static <T> List<T> unmodifiableList(List<T> list)
```

```
public static <T> List<T> synchronizedList(List<T> list)
```

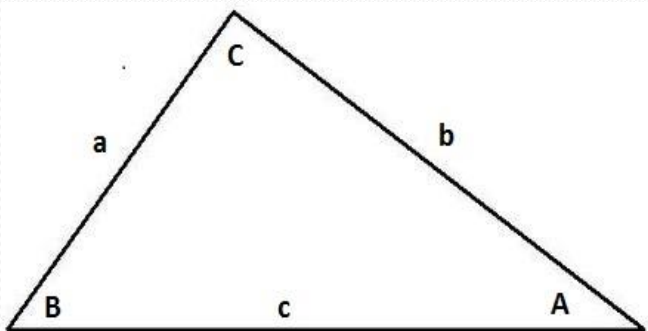
Advantages of Using Static Factory Method

- Static factory methods have a name(What if a class has 5 different constructors ? Example: Collections)
- Unlike constructors, static factory methods are not required to create a new instance every time they are invoked. (Example: Singleton)
- Solves the problem that a class can have only one constructor with a given signature. (Example: Triangle – next slide)
- More from Effective Java, 3rd edition, Page 5

Application: Problem of Multiple Constructors with Same Signature

Sometimes you may have a class that should provide two (or more) constructors that do different things, accept different input arguments, but the arguments are all of the same type. Java does not allow you to overload constructors with identical signatures. Using factory methods solves this problem

Triangle Example. By the laws of geometry, we can specify a triangle by specifying three of its sides, or by specifying two sides and the included angle. See demo: `lesson5.lecture.factorymethods5.triangle`



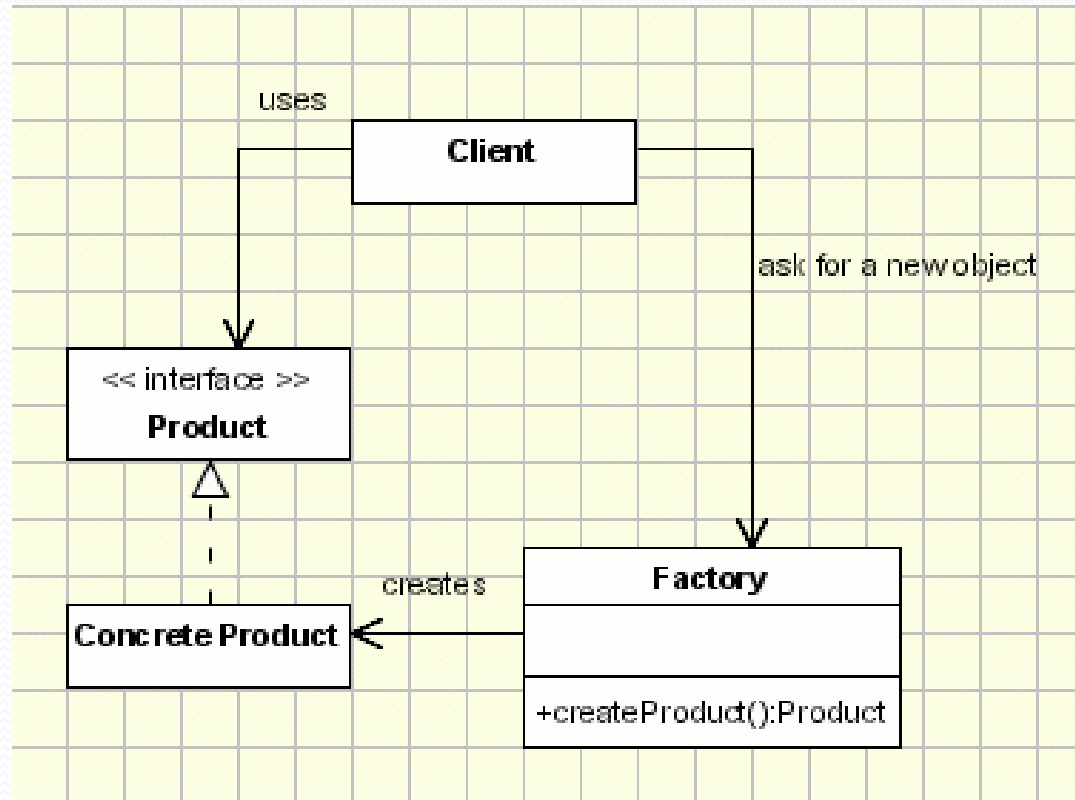
This is not allowed:

```
class Triangle {  
    Triangle(double s1, double s2, double s3) {  
        side1 = s1; side2 = s2; side3 = s3;  
    }  
    Triangle(double s1, double s2, double inclAngle){  
        side1 = s1; side2 = s2; angle3 = inclAngle;  
    }  
}
```

Issues When Using Static Factory Methods

- Classes without public, protected, or package-level constructors cannot be subclassed (when factory methods are used, usually the constructor is private)
- The factory method name must be distinguished from other static methods.
 - Use conventional naming
 - `getInstance` [often used to invoke a Singleton]
 - `newInstance` [used in Class to obtain an instance from a class]
 - `getType`
 - `newType`
 - `valueOf` [`BigInteger.valueOf(long)`]
 - `of` [`LocalDate.of(year, month, day)`]

Application of Interfaces: Factory Pattern



This pattern is an instance of the Factory design pattern.

Learn more at
<https://www.oodeesign.com/factory-pattern.html>

- creates objects without exposing the instantiation logic to the client.
- refers to the newly created object through a common interface

Factory Pattern

- The Factory Pattern provides a way of returning to a client an interface to a requested object. This decouples clients from objects they are requesting (which makes it possible to reuse those objects without any commitment to particular clients).
- **Advantages of Factory Pattern**
 - Can control access to instances. (See the `Student/GradeReport` and `DataAccess` examples, upcoming)
 - Unlike constructors, static factory method can return a subtype of the requested type, or an implementation of an interface type. (See `RuleSet` `getRuleSet()` in `Rules Framework`, upcoming)

Application: Controlling Access to Instances

Student/GradeReport Example. We wish to maintain a bidirectional 1:1 relationship between Student and GradeReport when data for these is read from a database. We wish to guarantee that instances of these classes are created in just the right way. After instances of each are created, we want to make sure that classes are read-only (i.e. immutable). To do this we:

1. Create instances using a static factory method
2. Keep all classes related to GradeReport and Student in the same package
3. Provide only package level access for all constructors and setters
4. Declare all classes in the package final

See `lesson5.lecture.factorymethods6`

Application: Controlling Access to Instances - continued

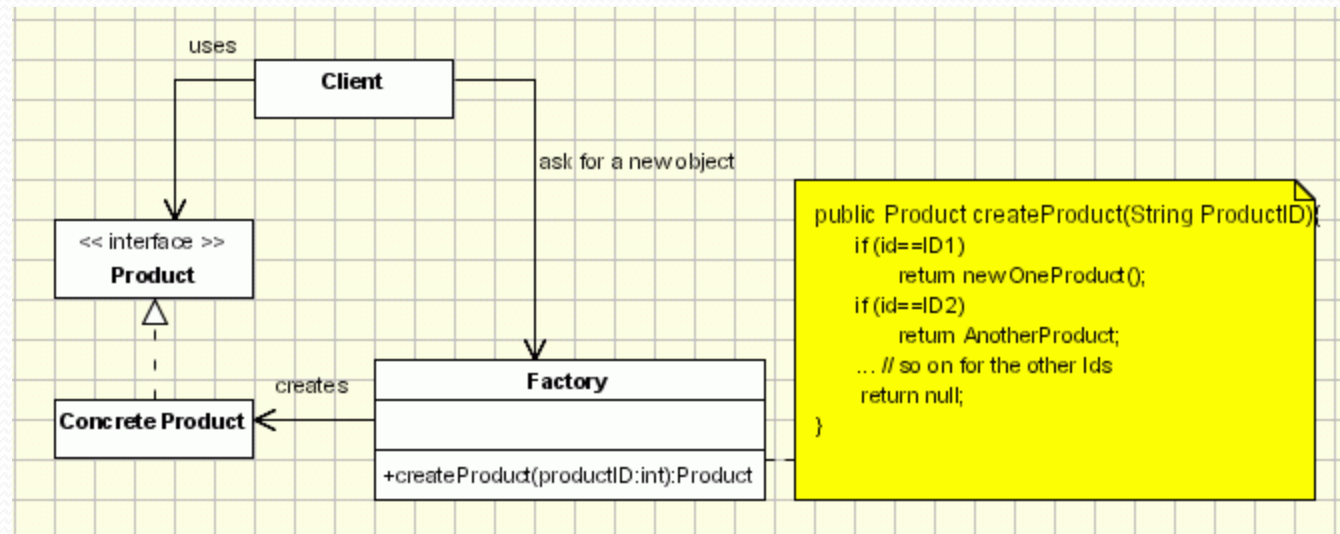
Data Access Example. We wish to provide restricted access to the database. Data access requests must come through a designated package. Special classes (called DAOs) will be allowed to send in data to be saved and to make requests for data. To accomplish this we

1. Designate a `dataaccess` package and a `dao` package of classes that know how to interact with the `dataaccess` package
2. Provide a factory to produce instances of the `DataAccessSystem`, typed as an interface `DataAccess`
3. Make all setters and constructors of classes in the `dataaccess` package have package level access
4. Require that entity classes like `Address` or `Person` make use of corresponding Dao classes, like `AddressDao`, `PersonDao` to communicate with the data access layer

See `lesson5.lecture.factorymethods3.dataaccess`

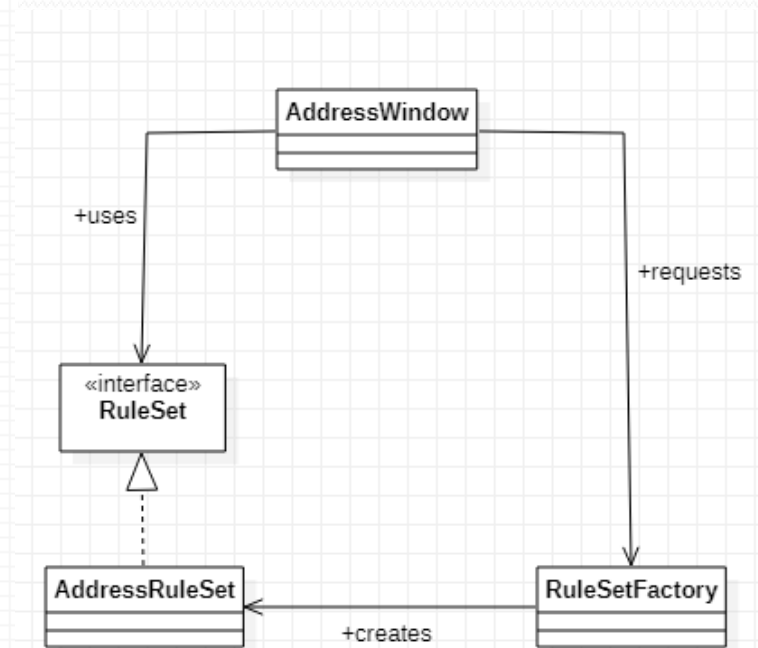
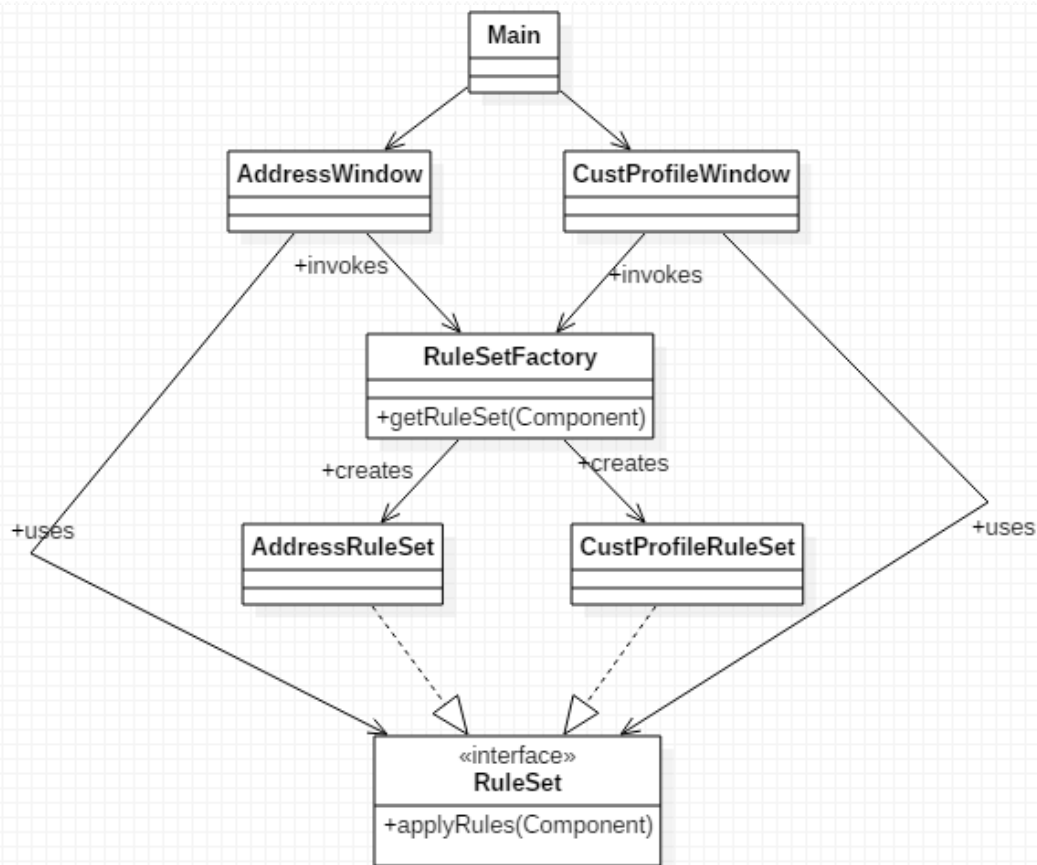
Parametrized Factories

- Parameterized factories are a design pattern variation where factory can create different types of objects of an interface based on input parameters.



Example of Parametrized Factories

- Example: Rules Framework – see `lesson5.lecture.factorymethods2`



Interfaces as *Types*

- Primitives (int, float, etc) are examples of simple types
- Classes provide an ‘interface’ and an implementation
 - In this context the interface is ‘The publicly exposed methods’ – the services provided by the class.
 - This ‘interface’ is therefore a way of specifying the type
- A Java Interface provides a pure ‘type’ – an abstraction of a class.
 - Just specifies what you can do with an implementer of the interface

Interfaces and Polymorphism

- Since interfaces are types like classes, they can be used in the same polymorphic ways that classes can be used. [For these examples, recall that `List` is an interface in the Java collections library]

- As variable type:

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

- As argument type:

```
public void createTranscripts(List<Student> students)
```

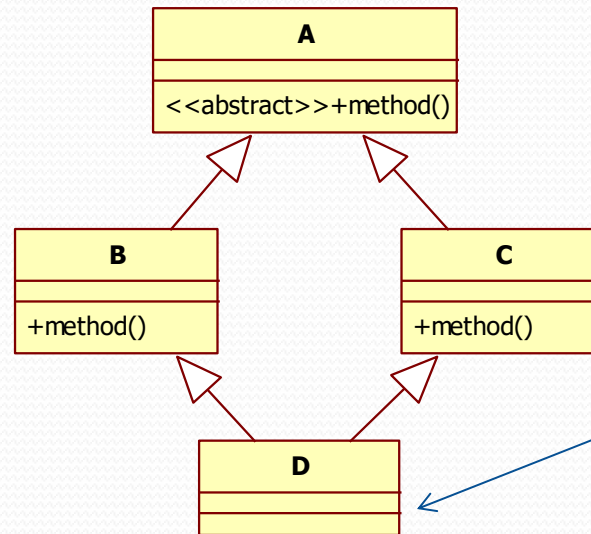
- As return value type:

```
public List<Student> findStudents(String country)
```

See Demos in `lesson5.lecture.interfaces1`, `lesson5.lecture.interfaces2`

Multiple Inheritance in Other Languages (like C++)

- Diamond Problem
 - Which (conflicting) implementation do we use?



Which version of `method()` does D inherit?

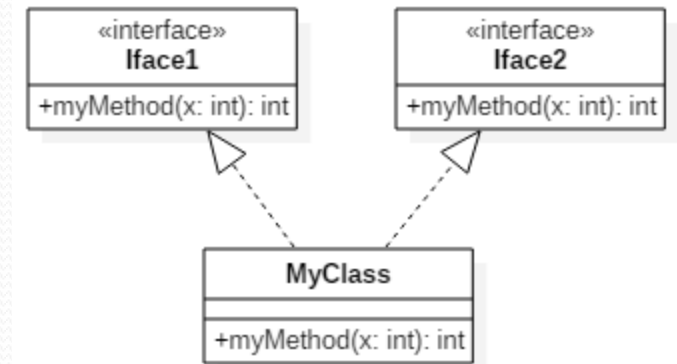
- Note there is no conflict if A, B, C are understood to be interfaces

Exercise 5.2

Does the following code compile and run? Explain

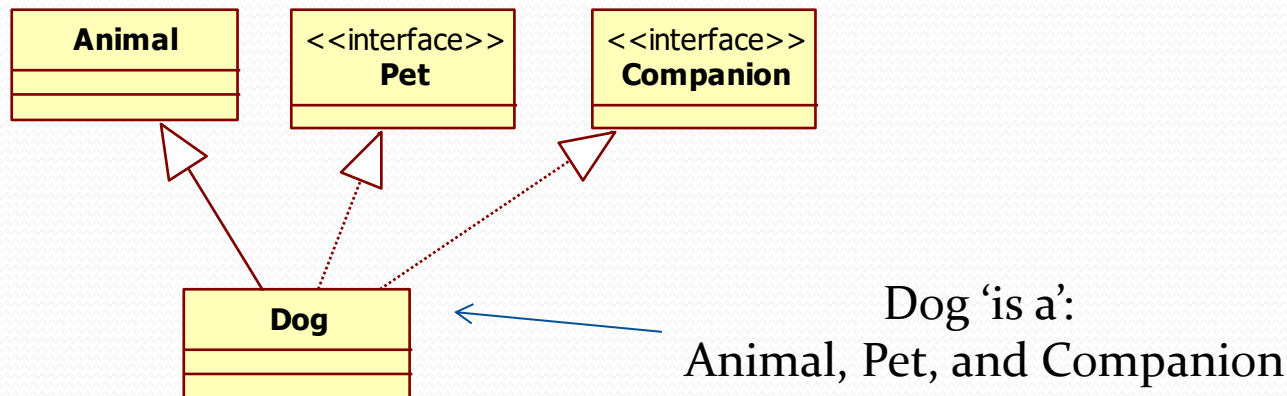
```
public interface Iface1 {  
    int myMethod(int x);  
}  
  
public interface Iface2 {  
    int myMethod(int x);  
}
```

```
public class MyClass implements Iface1, Iface2 {  
    public int myMethod(int x) {  
        return x + 1;  
    }  
}
```

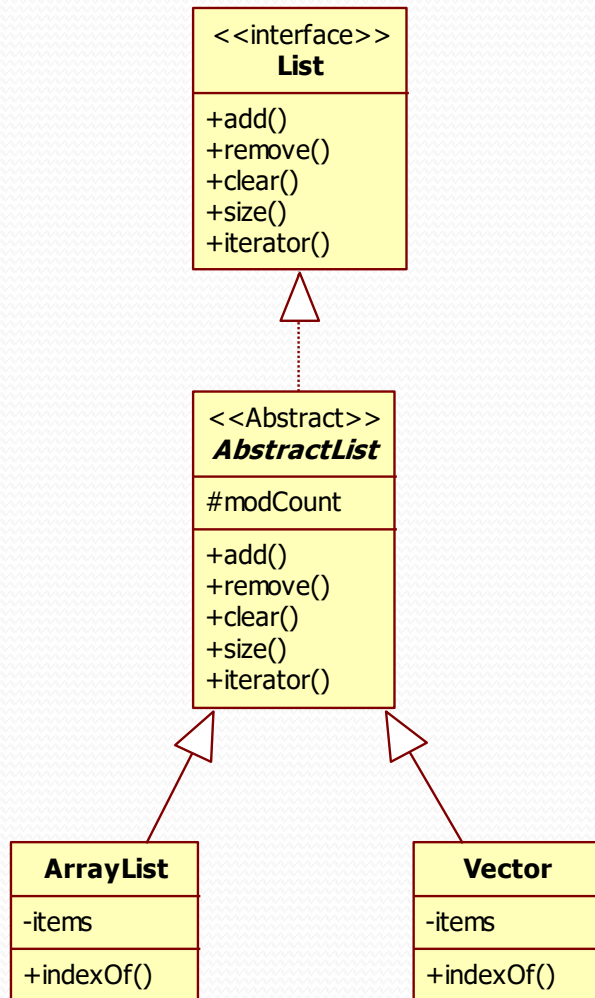


"Multiple Inheritance" Before Java SE 8)

- *Implementation* can be 'inherited' / extended *only once*
- *Types* can be 'inherited' / implemented *multiple times*
 - No limit on the number of interfaces you can implement
 - A single interface can extend other interfaces



Interface vs. Abstract Class: Pre-Java 8



Interface has no implementation

- Important types should always be interfaces to allow for 'multiple' inheritance

Interface takes abstraction one step further.

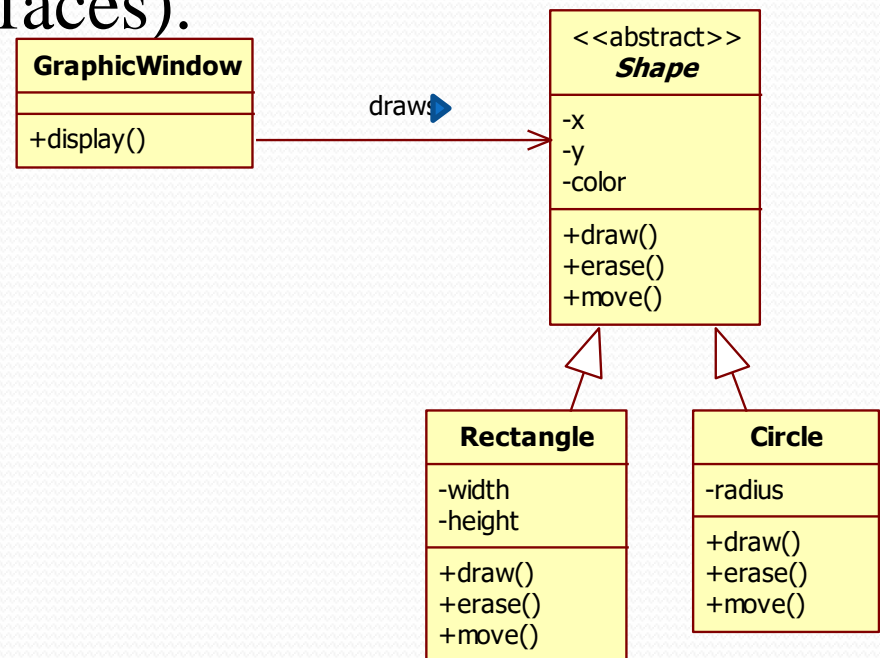
- Abstract class is an abstraction of its subclasses – provide common implementation.
- Interface is an abstraction of its subclasses (can be abstract classes) – provides common type.

Some Advantages of Interfaces

- They support the safe part of multiple inheritance
- They enforce information hiding and encapsulation.
 - Remember encapsulation is about grouping data and methods together for ease of use. Information hiding hides the implementation from the public 'interface'.
- They support change – implementation can be changed behind the interface
- They support development of code in parallel – each team can rely on other teams interfaces even before they are implemented.

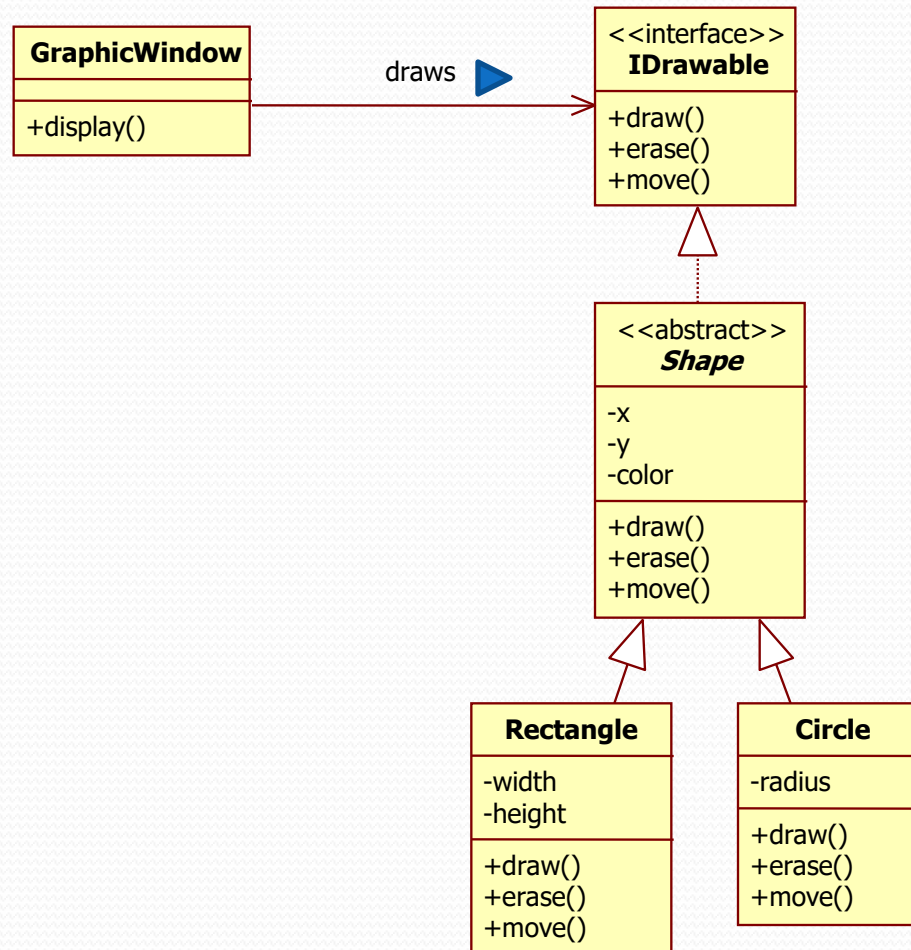
Flexibility of Interfaces

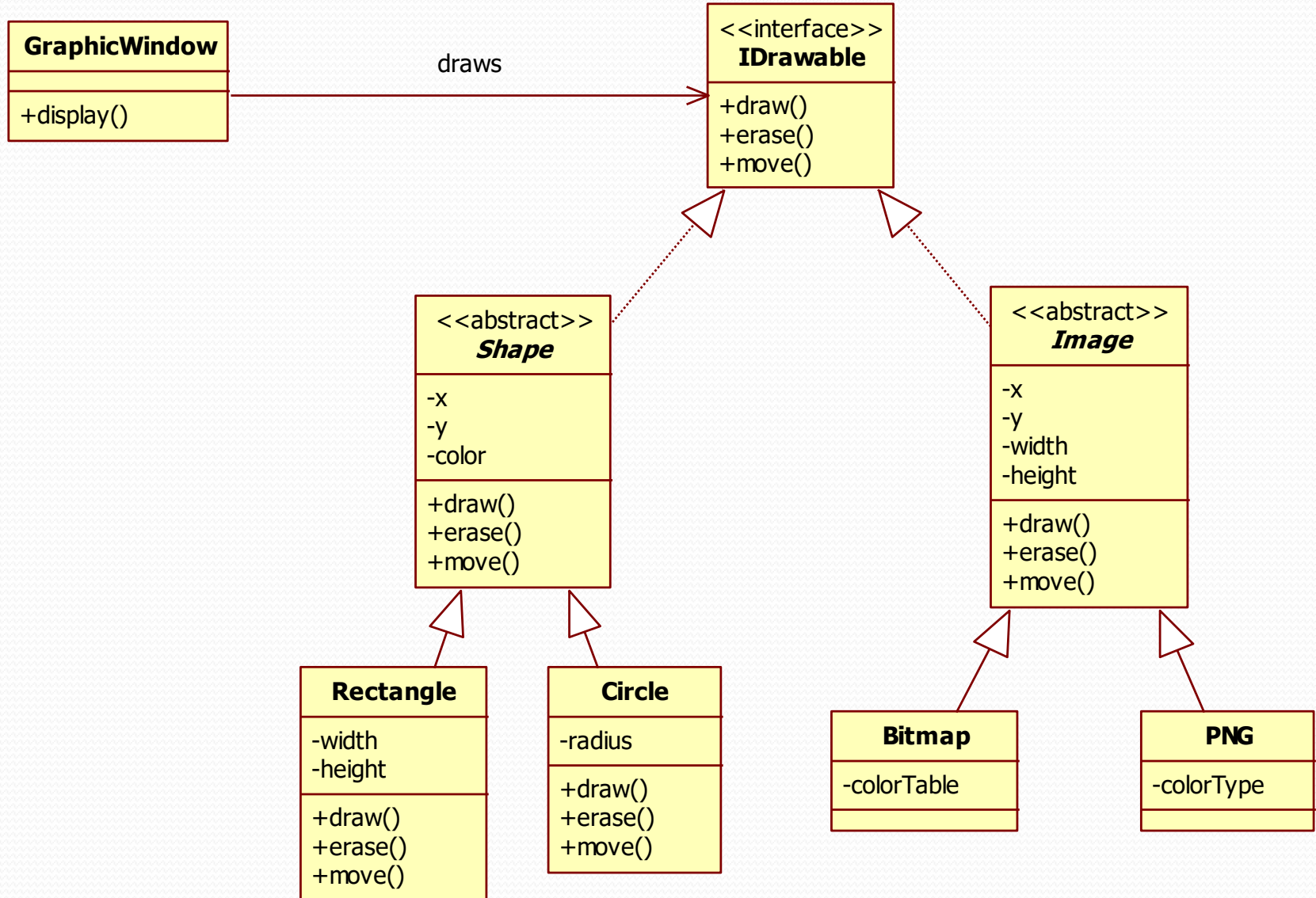
- Interfaces let you take greater advantage of polymorphism in your designs, which in turn helps you make your software more flexible.
- How to modify this class hierarchy so it supports display of images (like bitmaps and png's)? (you can add more classes or interfaces).



(continued)

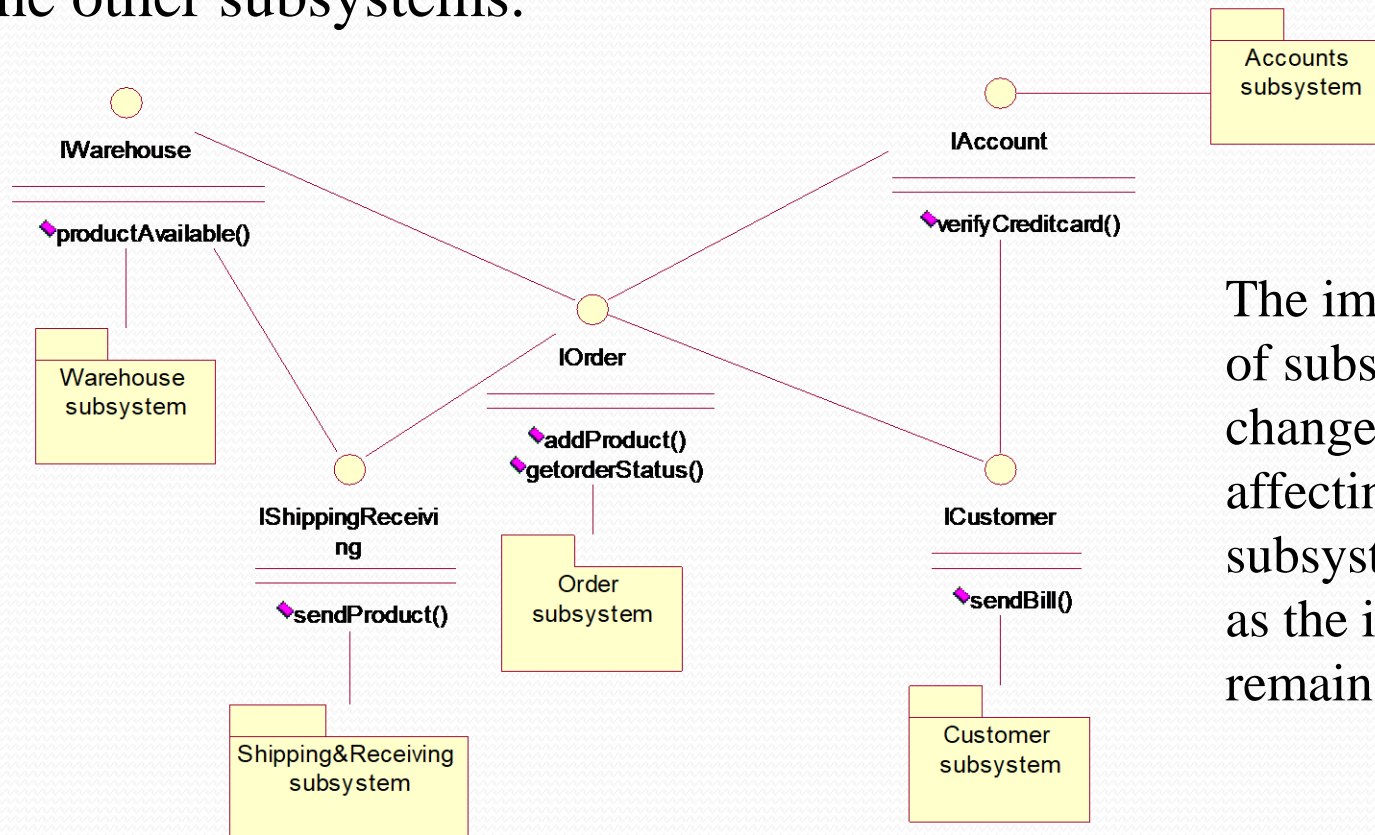
- With an interface, we can easily add a new class hierarchy





Interfaces Support Team Development

First define the interfaces for all subsystems, then every programmer can program one subsystem by using the interfaces of the other subsystems.



The implementation of subsystems may change without affecting all other subsystems, as long as the interfaces remain the same.

Interfaces in System Development

If you have a subsystem that represents an abstraction that may have multiple implementations, whether the subsystem is a single object, a group of objects, an entire application, you should define Java interfaces through which the rest of the world communicates with that subsystem.

When you use interfaces in this way, you decouple the parts of your system from each other and generate code that is more flexible: more easily changed, extended, and customized (encapsulation and abstraction).

Program to Interface (P2I), rather than implementation.

Best Practices: When to Use Interfaces?

1. Always use interfaces for subsystem development
2. Prefer interfaces over multiple levels of abstract classes
3. If an abstract class will provide all the abstraction you need, then do not add an interface.
4. Code will be read many more hours than it will take to write it. Make it as simple, elegant, and clear as possible.

“as simple as possible, but no simpler” (Einstein)

The Evolving API Problem

Problem: You have created a library of Java classes and you have a substantial clientele who make use of your library. Your library contains numerous interfaces, for which you have implementations (in some cases, multiple implementations) in your library code.

Suppose you now want to add new functionality to your library. In many cases, you will need to add new methods to some of your interfaces. You think “I have to be careful not to change the signature of my interface methods, but adding new methods should not create a problem for my users.” You add some methods, and distribute a new release.

A few days later you get hundreds of complaints that your new code has broken the code of your clients who were using your library. What went wrong?

Explanation:

Clients created their own implementations of your interfaces, in earlier versions of your code. When you add new methods to those interfaces, their code breaks because they do not have implementations of the new methods.

New features of interfaces in Java 8 provide a solution to this and other issues concerning interfaces.

Main Point

Abstract classes and interfaces are both strongly related to the concept of Inheritance.

The interface is the most abstract entity in the class diagram, and by pro-gramming to interfaces, we generate more flexible code.

Greater abstraction holds the possibility of greater potential; this principle is especially evident in the case of the unified field.

Summary

Today we looked at modeling abstractions through Inheritance, abstract classes and interfaces. We also looked at the design decisions that go along with using them:

- Abstract classes and interfaces contain less and less implementation details, and instead focus more on general abstract parts (like types)
- With Java it is important to always “Program to Interface”.
- Use interfaces for ‘multiple’ inheritance, encapsulation, flexibility, and parallel development.

CONNECTING THE PARTS OF KNOWLEDGE WITH THE WHOLENESS OF KNOWLEDGE

ABSTRACTION IN THE FORM OF ABSTRACT CLASSES AND INTERFACES

1. A concrete class embodies a set of concrete behaviors on a set of data whereas an abstract class embodies some concrete behaviors and at the same time gives expression to new, unimplemented behaviors in the form of *abstract methods*.
 2. Interfaces (in pre-Java 8) give expression to abstract “unmanifest” behaviors, “pure possibilities,” which can be realized in an endless number of ways by implementing classes.
-
3. *Transcendental Consciousness* is a field of all possibilities.
 4. *Impulses Within the Transcendental Field*. Pure consciousness, as it prepares to manifest, is a “wide angle lens” making use of every possibility for creative ends.
 5. *Wholeness Moving Within Itself*. In Unity Consciousness, awareness is flexible enough to give expression to any possibility that is needed at the time.

