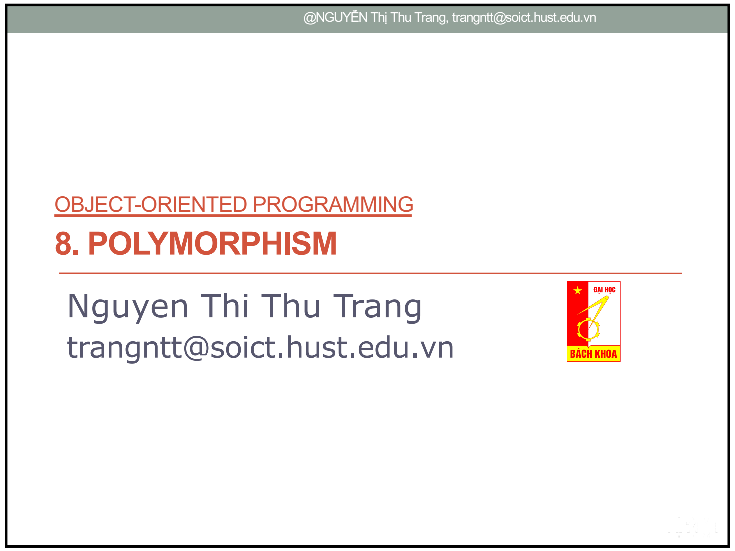

OBJECT-ORIENTED PROGRAMMING

8. POLYMORPHISM

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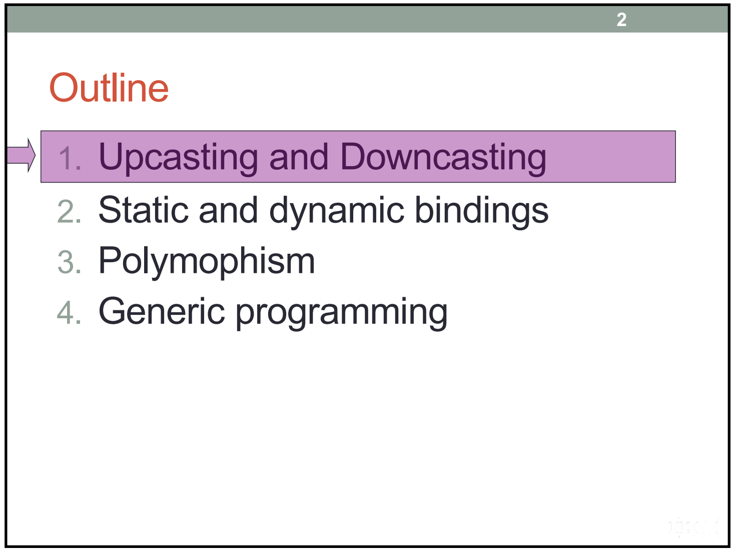
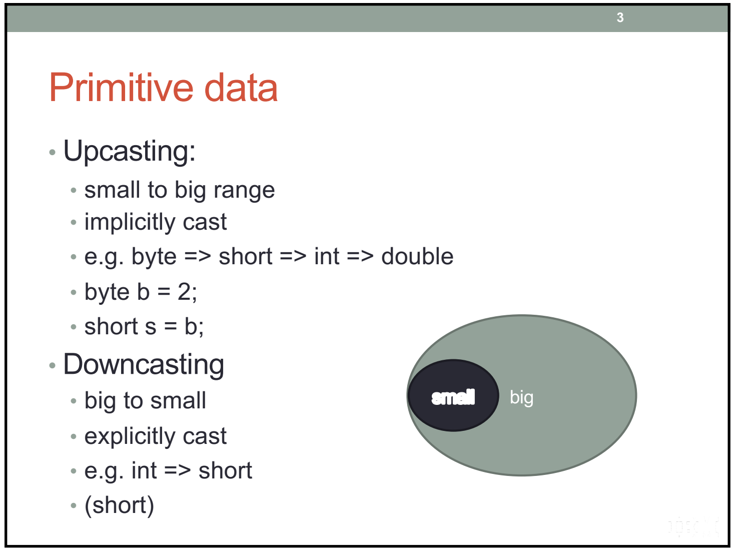
ĐẠI HỌC
BÁCH KHOA



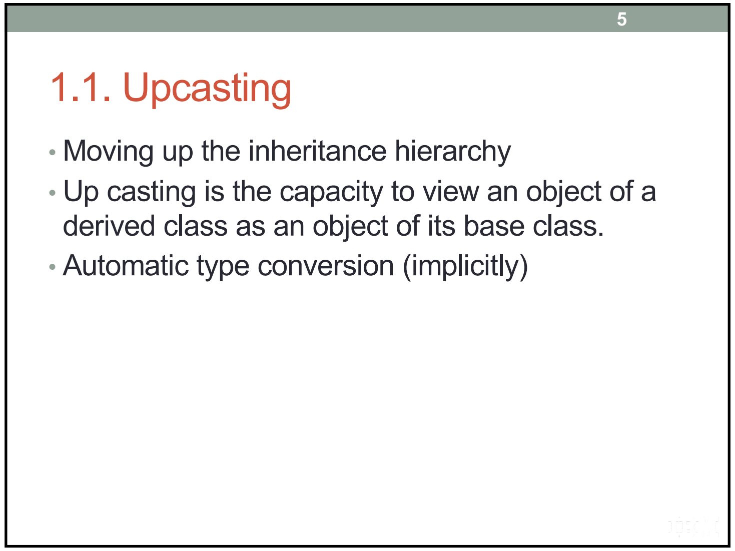
Outline

1. Upcasting and Downcasting
2. Static and dynamic bindings
3. Polymophism
4. Generic programming



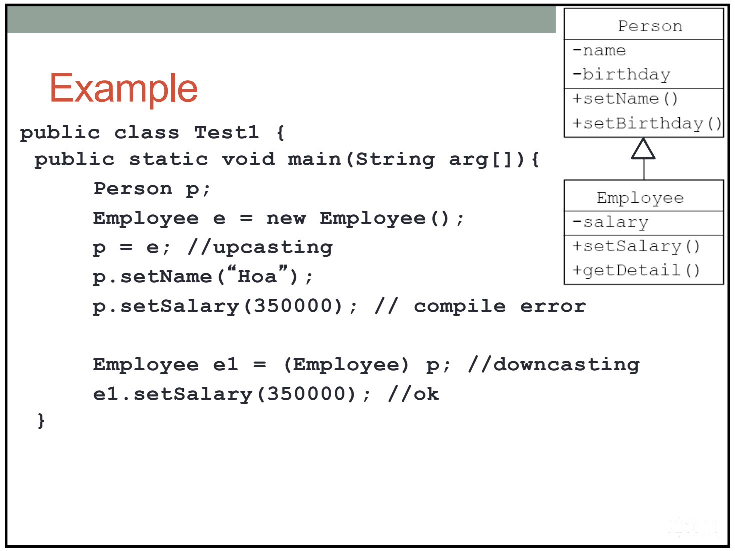
Primitive data

- Upcasting:
  - small to big range
  - implicitly cast
  - e.g. byte => short => int => double
  - byte b = 2;
  - short s = b;
- Downcasting
  - big to small
  - explicitly cast
  - e.g. int => short
  - (short)



1.1. Upcasting

- Moving up the inheritance hierarchy
- Up casting is the capacity to view an object of a derived class as an object of its base class.
- Automatic type conversion (implicitly)



Example

```
Person
-name
-birthday
+setName()
+setBirthday()

Employee
-salary
+setSalary()
+getDetail()
```

```
public class Test1 {
 public static void main(String arg[]){
     Person p;
     Employee e = new Employee();
     p = e; //upcasting
     p.setName("Hoa");
     p.setSalary(350000); // compile error

     Employee e1 = (Employee) p; //downcasting
     e1.setSalary(350000); //ok
 }
```

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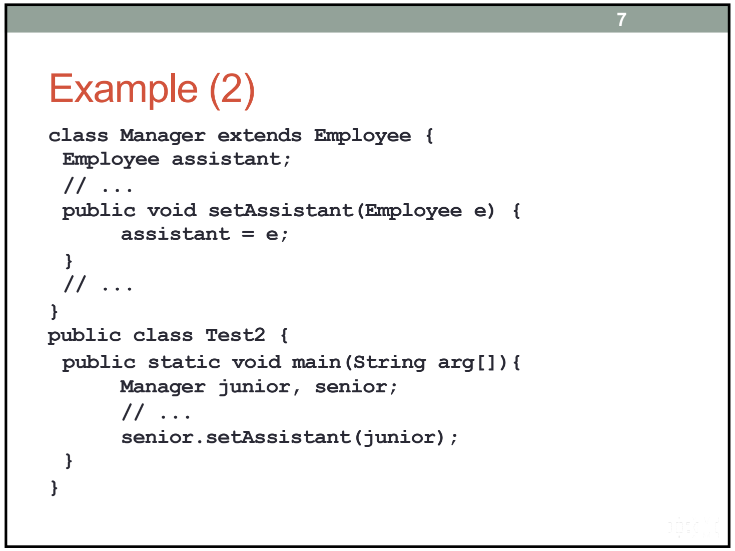

Example (2)

```
class Manager extends Employee {
 Employee assistant;
 // ...
 public void setAssistant(Employee e) {
     assistant = e;
 }
 // ...
}
public class Test2 {
 public static void main(String arg[]){
     Manager junior, senior;
     // ...
     senior.setAssistant(junior);
 }
}
```

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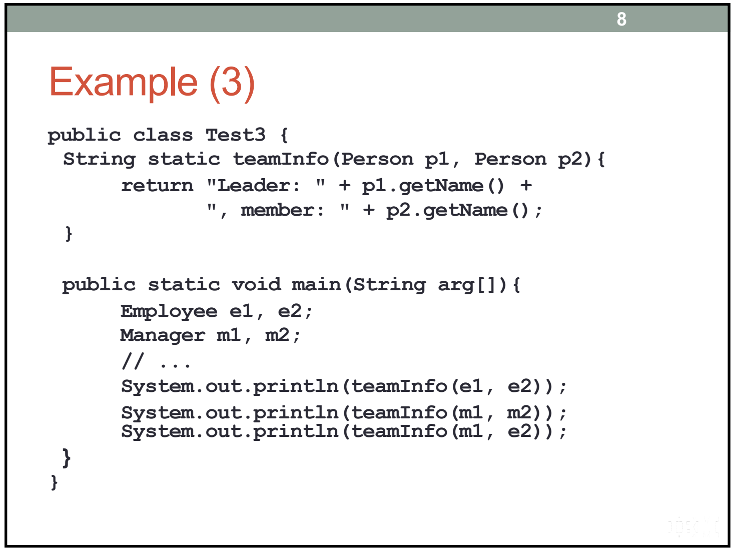

Example (3)

```
public class Test3 {
 String static teamInfo(Person p1, Person p2){
     return "Leader: " + p1.getName() +
            ", member: " + p2.getName();
 }

 public static void main(String arg[]){
     Employee e1, e2;
     Manager m1, m2;
     // ...
     System.out.println(teamInfo(e1, e2));
     System.out.println(teamInfo(m1, m2));
     System.out.println(teamInfo(m1, e2));
 }
}
```

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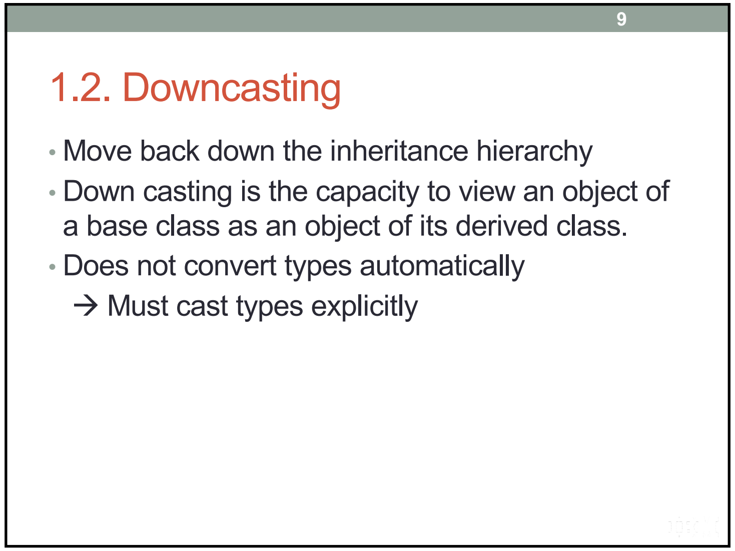

1.2. Downcasting

- Move back down the inheritance hierarchy
- Down casting is the capacity to view an object of a base class as an object of its derived class.
- Does not convert types automatically
  → Must cast types explicitly

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Example

```
public class Test2 {
 public static void main(String arg[]){
     Employee e = new Employee();
     Person p = e; // up casting
     Employee ee = (Employee) p; // down casting
     Manager m = (Manager) ee; // run-time error

     Person p2 = new Manager();
     Employee e2 = (Employee) p2;
 }
}
```

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Operator instanceof

```
public class Employee extends Person {}
public class Student extends Person {}

public class Test{
  public doSomething(Person e) {
   if (e instanceof Employee) {...
   } else if (e instanceof Student) {... ){
   } else {...}
  }
}
```

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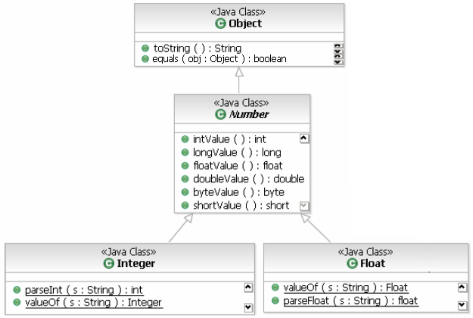
Exercise

- Re-write method **equals** for the class **MyValue** (this method is inherited from the class Object)



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Outline

1. Upcasting and Downcasting
2. Static and dynamic bindings
3. Polymophism
4. Generic programming

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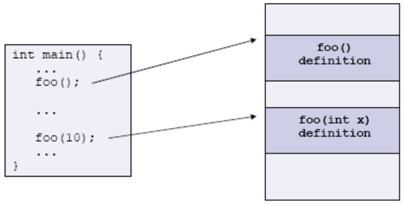
Function call binding

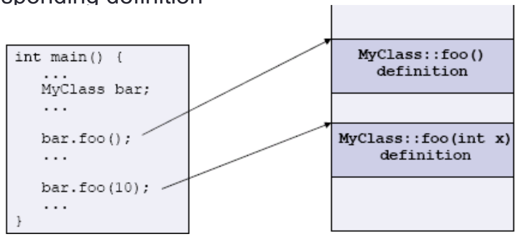
- Function call binding is a procedure to **specify the piece of code that need to be executed** when calling a function
- E.g. C language: a function has a unique name



```
int main() {
    ...
    foo();

    ...
    foo(10);
    ...
}
```

OOP languages (method call binding)

- For independent classes (are not in any inheritance tree), the procedure is almost the same as function call binding
  - Compare function name, argument list to find the corresponding definition



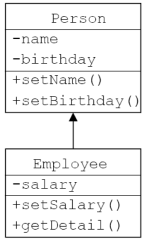
```
int main() {
    ...
    MyClass bar;
    ...

    bar.foo();
    ...

    bar.foo(10);
    ...
}
```

2.1. Static Binding

- Binding at the compiling time
  - Early Binding/Compile-time Binding
  - Function call is done when compiling, hence there is only one instance of the function
  - Any error will cause a compiling error
  - Advantage of speed
- C/C++ function call binding, and C++ method binding are basically examples of static function call binding

Example

```
public class Test {
 public static void main(String arg[]){
     Person p = new Person();
     p.setName("Hoa");
     p.setSalary(350000); //compile-time error
 }
}
```



2.2. Dynamic binding

- The method call is done at run-time
  - Late binding/Run-time binding
  - Instance of method is suitable for called object.
  - Java uses dynamic binding by default

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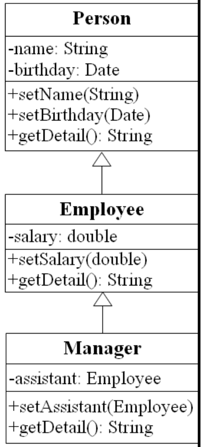
Example

```
public class Test {
  public static void main(String arg[]){
    Person p = new Person();
     // ...
    Employee e = new Employee();
    // ...
    Manager m = new Manager();
     // ...
    Person pArr[] = {p, e, m};//upcasting
    for (int i=0; i< pArr.length; i++){
      System.out.println(
             pArr[i].getDetail());
    }
  }
}
```



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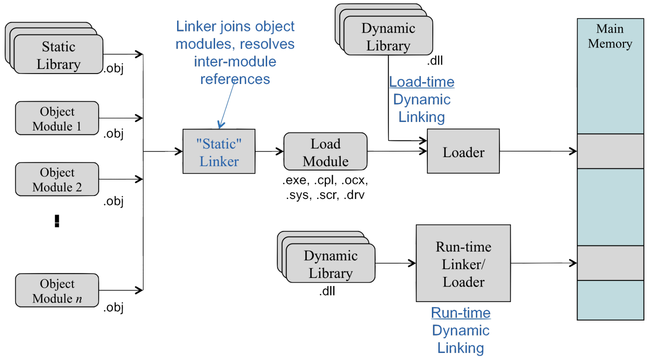
Linker and Loader



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Outline

1. Upcasting and Downcasting
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3. Polymorphism

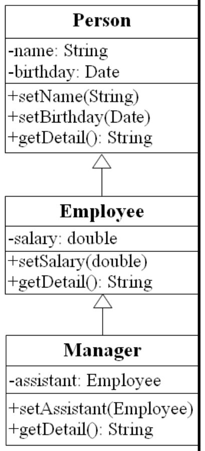
- Polymorphism: multiple ways of performance, of existance
- Polymorphism in OOP
  - Method polymorphism:
    - Methods with the same name, only difference in argument lists => method overloading
  - Object polymorphism
    - **Multiple types:** A single object to represent multiple different types (upcasting and downcasting)
    - **Multiple implementations/behaviors:** A single interface to objects of different types (upcasting+overriding – dynamic binding)

3. Polymophism (2)

- A single symbol to represent multiple different types
  → Upcasting and Downcasting

```
public class Test3 {
  public static void main(String args[]){
    Person p1 = new Employee();
    Person p2 = new Manager();

    Employee e = (Employee) p1;
    Manager m = (Manager) p2;
  }
}
```



3. Polymorphism (5)

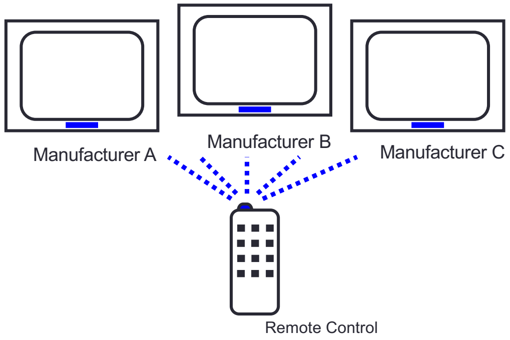
- A single interface to entities of different types
  →Dynamic binding (Java)

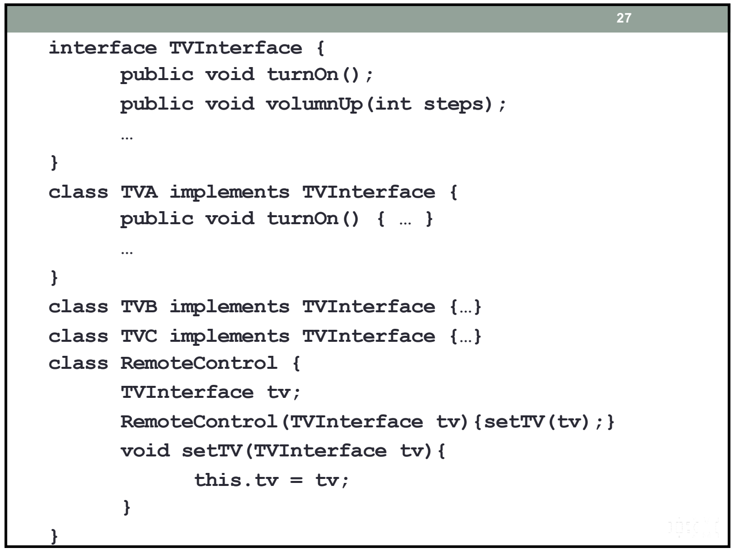
- Example:

```
Person p1 = new Person();
Person p2 = new Employee();
Person p3 = new Manager();
// ...
System.out.println(p1.getDetail());
System.out.println(p2.getDetail());
System.out.println(p3.getDetail());
```

Why Polymorphism?

- The ability to hide many different implementations behind a single interface





```
interface TVInterface {
      public void turnOn();
      public void volumnUp(int steps);
      …
}
class TVA implements TVInterface {
      public void turnOn() { … }
      …
}
class TVB implements TVInterface {…}
class TVC implements TVInterface {…}
class RemoteControl {
      TVInterface tv;
      RemoteControl(TVInterface tv){setTV(tv);}
      void setTV(TVInterface tv){
            this.tv = tv;
      }
}
```

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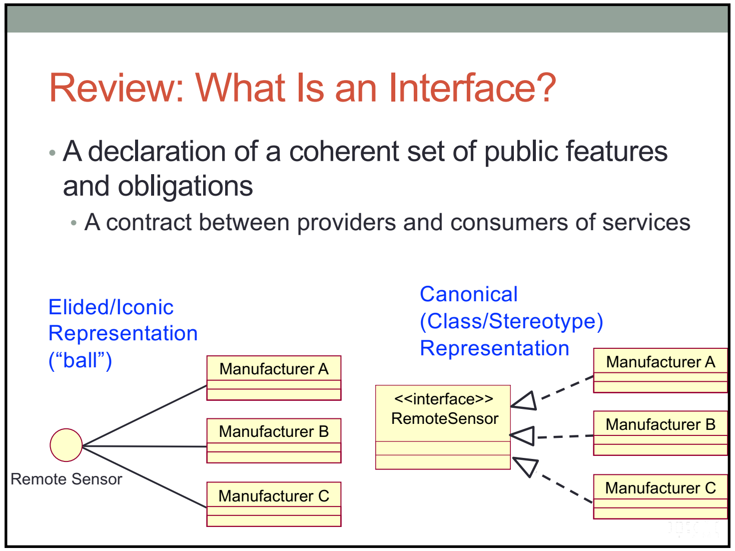

Review: What Is an Interface?

- A declaration of a coherent set of public features and obligations
  - A contract between providers and consumers of services

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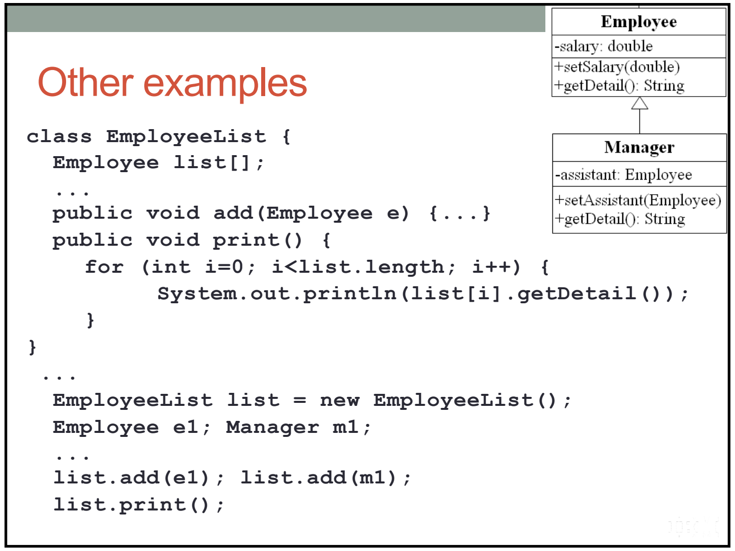

Other examples

Employee
-salary: double
+setSalary(double)
+getDetail(): String
Manager
-assistant: Employee
+setAssistant(Employee)
+getDetail(): String

```
class EmployeeList {
  Employee list[];
  ...
  public void add(Employee e) {...}
  public void print() {
     for (int i=0; i<list.length; i++) {
          System.out.println(list[i].getDetail());
     }
}
 ...
  EmployeeList list = new EmployeeList();
  Employee e1; Manager m1;
  ...
  list.add(e1); list.add(m1);
  list.print();
```

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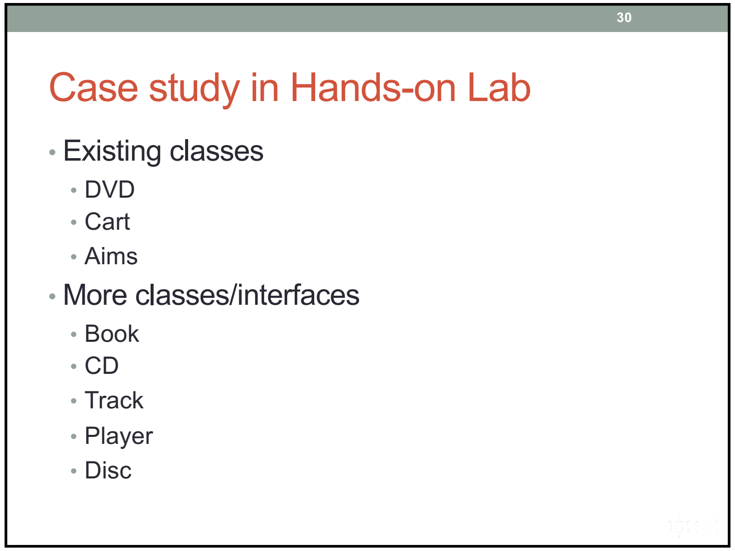

Case study in Hands-on Lab

- Existing classes
  - DVD
  - Cart
  - Aims
- More classes/interfaces
  - Book
  - CD
  - Track
  - Player
  - Disc

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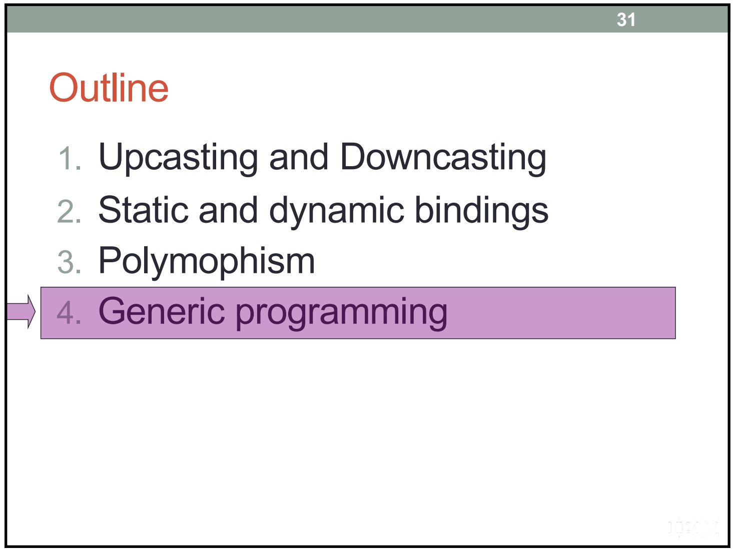

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Outline

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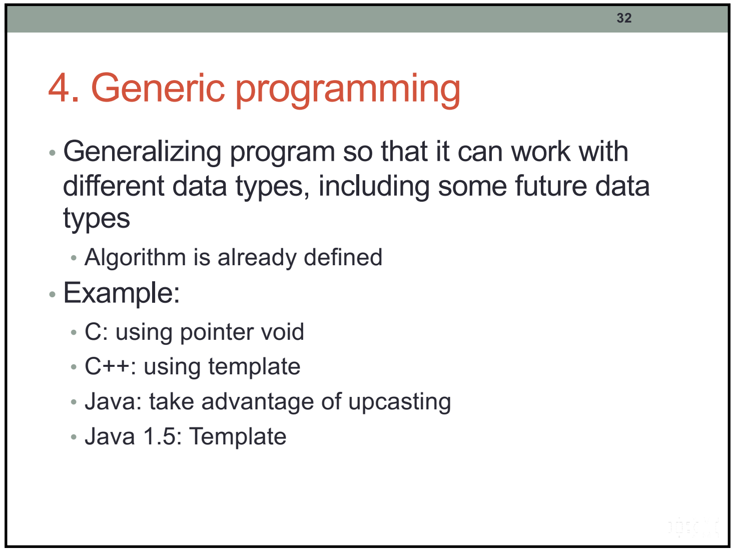

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4. Generic programming

- Generalizing program so that it can work with different data types, including some future data types
  - Algorithm is already defined
- Example:
  - C: using pointer void
  - C++: using template
  - Java: take advantage of upcasting
  - Java 1.5: Template

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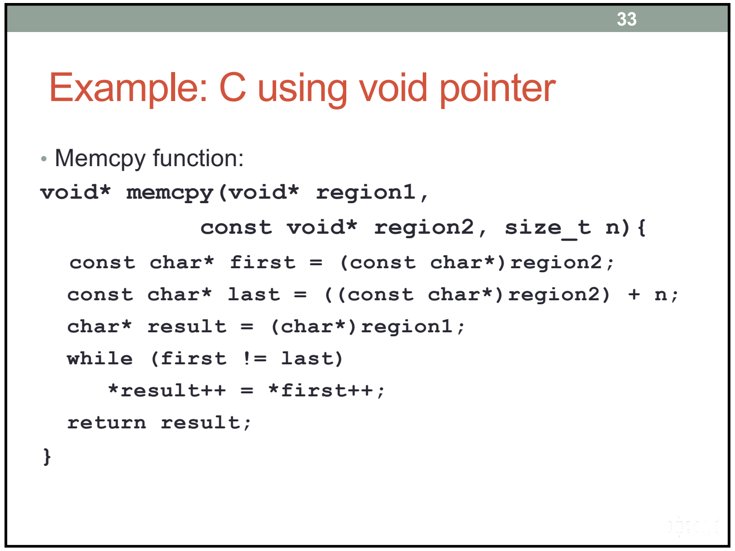

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Example: C using void pointer

- Memcpy function:

```
void* memcpy(void* region1,
             const void* region2, size_t n){
  const char* first = (const char*)region2;
  const char* last = ((const char*)region2) + n;
  char* result = (char*)region1;
  while (first != last)
     *result++ = *first++;
  return result;
}
```

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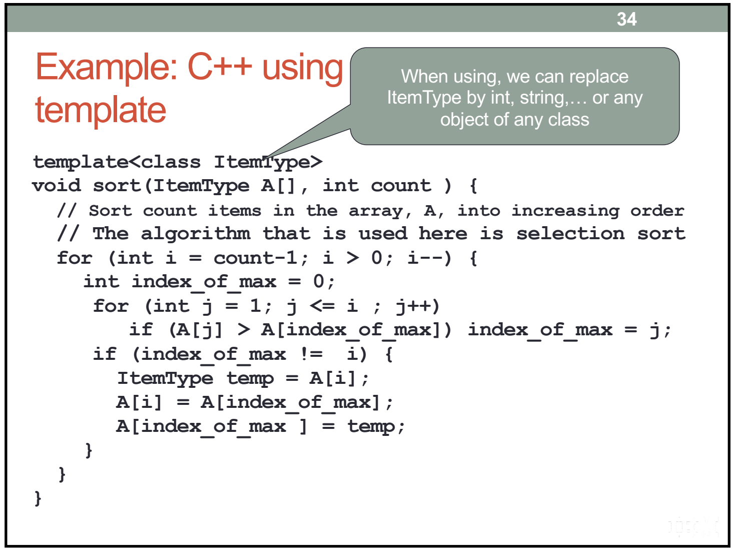

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Example: C++ using template

When using, we can replace ItemType by int, string,… or any object of any class

```
template<class ItemType>
void sort(ItemType A[], int count ) {
  // Sort count items in the array, A, into increasing order
  // The algorithm that is used here is selection sort
  for (int i = count-1; i > 0; i--) {
    int index_of_max = 0;
     for (int j = 1; j <= i ; j++)
        if (A[j] > A[index_of_max]) index_of_max = j;
     if (index_of_max !=  i) {
       ItemType temp = A[i];
       A[i] = A[index_of_max];
       A[index_of_max ] = temp;
     }
  }
}
```

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Example: Java using upcasting and Object

```
class MyStack {
  ...
 public void push(Object obj) {...}
 public Object pop() {...}
}
public class TestStack{
 MyStack s = new MyStack();
 Point p = new Point();
 Circle c = new Circle();
 s.push(p); s.push(c); //upcasting
 Circle c1 = (Circle) s.pop(); //downcasting
 Point p1 = (Point) s.pop(); //downcasting
}
```

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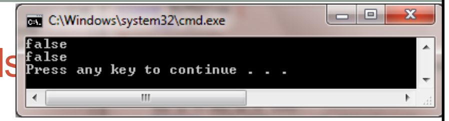
Recall – equals



```
false
false
Press any key to continue . . .
```

```
class MyValue {
 private int number;
 public MyValue(int number){this.number = number;}
 public boolean equals(Object obj){

 }
 public int getNumber(){return number;}
}
public class EqualsMethod2 {
 public static void main(String[] args) {
   MyValue v1 = new MyValue(100);
   MyValue v2 = new MyValue(100);
   System.out.println(v1.equals(v2));
   System.out.println(v1==v2);
 }
}
```

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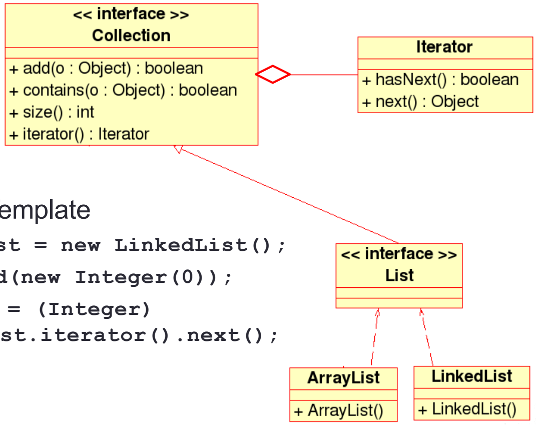
Example: Java 1.5: Template



- Without Template

```
List myList = new LinkedList();
myList.add(new Integer(0));
Integer x = (Integer)
      myList.iterator().next();
```

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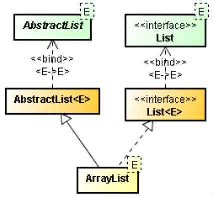
Example: Java 1.5: Template (2)

- Using Template:

```
List<Integer> myList = new LinkedList<Integer>();
myList.add(new Integer(0));
Integer x = myList.iterator().next();

//myList.add(new Long(0)); → Compile error
```



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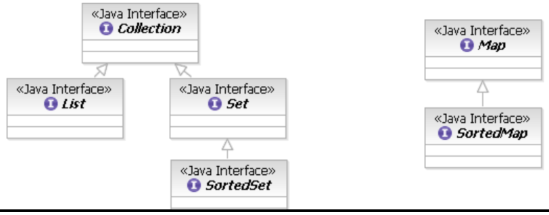
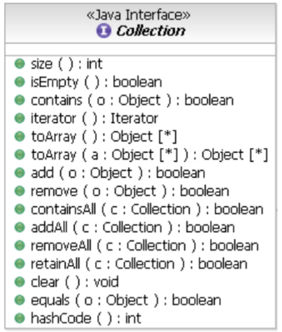
4.1. Java generic data structure

- Collection: a collection of objects
  - List: a collection of objects that are sequential, consecutive and repeatable
  - Set: a collection of objects that are not repeatable
- Map: Collection of key-value pairs (key is unique)
  - Linking objects in this set to other sets as a dictionary/a telephone book.

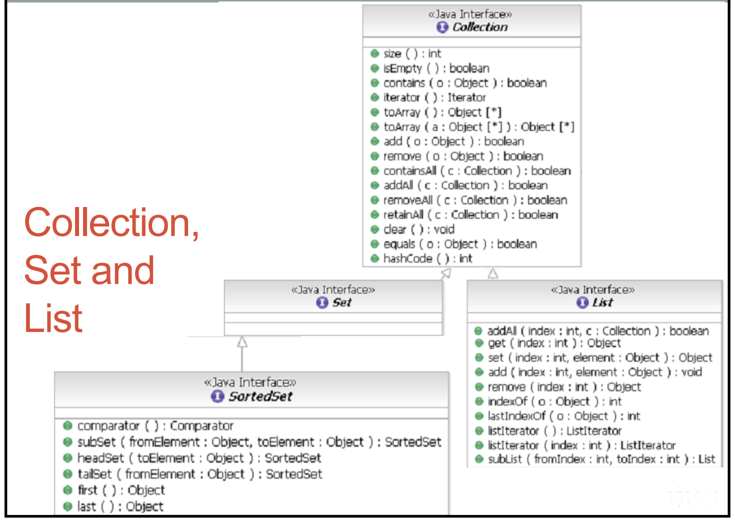


a. Interface of Collection

- Specifies basic interface for manipulating a set of objects
  - Add to collection
  - Remove from collection
  - Check if existing
- Contains methods to manipulate individual objects or a set of objects
- Provide methods to traverse objects in a repeatable collection and convert a collection to an array

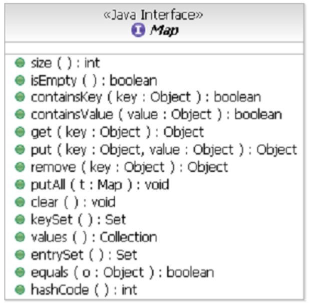

«Java Interface»
Collection
size ( ) : int
isEmpty ( ) : boolean
contains (o : Object) : boolean
iterator ( ) : Iterator
toArray ( ) : Object [*]
toArray (a : Object [*]) : Object [*]
add (o : Object) : boolean
remove (o : Object) : boolean
containsAll (c : Collection) : boolean
addAll (c : Collection) : boolean
removeAll (c : Collection) : boolean
retainAll (c : Collection) : boolean
clear ( ) : void
equals (o : Object) : boolean
hashCode ( ) : int

Collection, Set and List


«Java Interface»
Collection
size ( ) : int
isEmpty ( ) : boolean
contains (o : Object) : boolean
iterator ( ) : Iterator
toArray ( ) : Object [*]
toArray (a : Object [*]) : Object [*]
add (o : Object) : boolean
remove (o : Object) : boolean
containsAll (c : Collection) : boolean
addAll (c : Collection) : boolean
removeAll (c : Collection) : boolean
retainAll (c : Collection) : boolean
clear ( ) : void
equals (o : Object) : boolean
hashCode ( ) : int
«Java Interface»
Set
«Java Interface»
List
addAll (index : int, c : Collection) : boolean
get (index : int) : Object
set (index : int, element : Object) : Object
add (index : int, element : Object) : void
remove (index : int) : Object
indexOf (o : Object) : int
lastIndexOf (o : Object) : int
listIterator ( ) : ListIterator
listIterator (index : int) : ListIterator
subList (fromIndex : int, toIndex : int) : List
«Java Interface»
SortedSet
comparator ( ) : Comparator
subSet (fromElement : Object, toElement : Object) : SortedSet
headSet (toElement : Object) : SortedSet
tailSet (fromElement : Object) : SortedSet
first ( ) : Object
last ( ) : Object

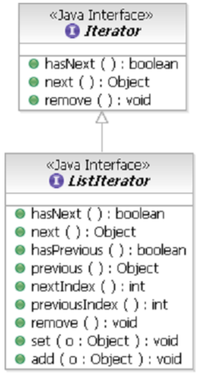
b. Interface of Map

- A basic interface for manipulating a set of pairs key-value
  - Add a pair key-value
  - Remove a pair key-value
  - Get a value of a given key
  - Check if existing (key or value)
- 3 views for the content of collections:
  - Key collection
  - Value collection
  - Mapping collection of key-value


«Java Interface»
Map
size ( ) : int
isEmpty ( ) : boolean
containsKey (key : Object) : boolean
containsValue (value : Object) : boolean
get (key : Object) : Object
put (key : Object, value : Object) : Object
remove (key : Object) : Object
putAll (t : Map) : void
clear ( ) : void
keySet ( ) : Set
values ( ) : Collection
entrySet ( ) : Set
equals (o : Object) : boolean
hashCode ( ) : int

c. Iterator

- Provide a mechanism to visit (repeat) all the members of a collection
  - Similar to SQL cursor
- ListIterator has methods to show the sequential attribute of the basic list
- Iterator of a sorted collection will visit in the sorting order



«Java Interface»
Iterator

- hasNext ( ) : boolean
- next ( ) : Object
- remove ( ) : void

«Java Interface»
ListIterator

- hasNext ( ) : boolean
- next ( ) : Object
- hasPrevious ( ) : boolean
- previous ( ) : Object
- nextIndex ( ) : int
- previousIndex ( ) : int
- remove ( ) : void
- set (o : Object) : void
- add (o : Object) : void

Source code for Iterator

```
Collection c;
// Some code to build the collection

Iterator i = c.iterator();
while (i.hasNext()) {
 Object o = i.next();
 // Process this object
}
```

Interface and Implementation

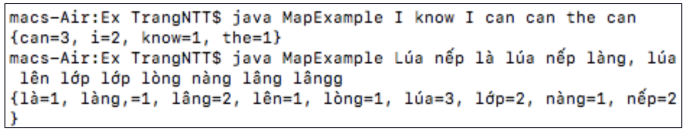
Set<String> mySet = new TreeSet<String>();

Map<String,Integer> myMap = new HashMap<String,Integer>();

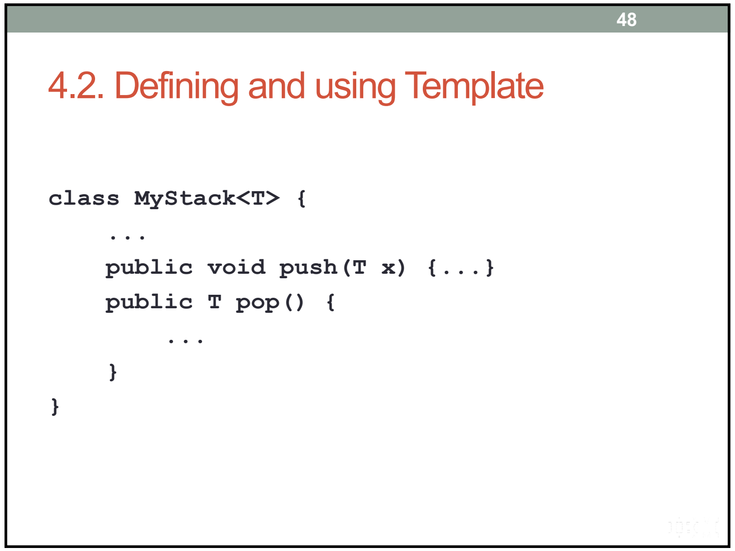
		IMPLEMENTATIONS				
		Hash Table	Resizable Array	Balanced Tree	Linked List	Legacy
INTERFACES	Set	HashSet		TreeSet		
	List		ArrayList		LinkedList	Vector, Stack
	Map	HashMap		TreeMap		HashTable, Properties

Exercise

- Write a program that get the parameters from command line as a string,
- Then calculate the frequency of each token in that string,
- Finally show the screen with the token and its frequency. The token should be sorted from a-z.



```
macs-Air:Ex TrangNTT$ java MapExample I know I can can the can
{can=3, i=2, know=1, the=1}
macs-Air:Ex TrangNTT$ java MapExample Lúa nếp là lúa nếp làng, lúa
 lên lớp lớp lòng nàng lâng lângg
{là=1, làng,=1, lâng=2, lên=1, lòng=1, lúa=3, lớp=2, nàng=1, nếp=2
}
```



4.2. Defining and using Template

```
class MyStack<T> {
    ...
    public void push(T x) {...}
    public T pop() {
        ...
    }
}
```

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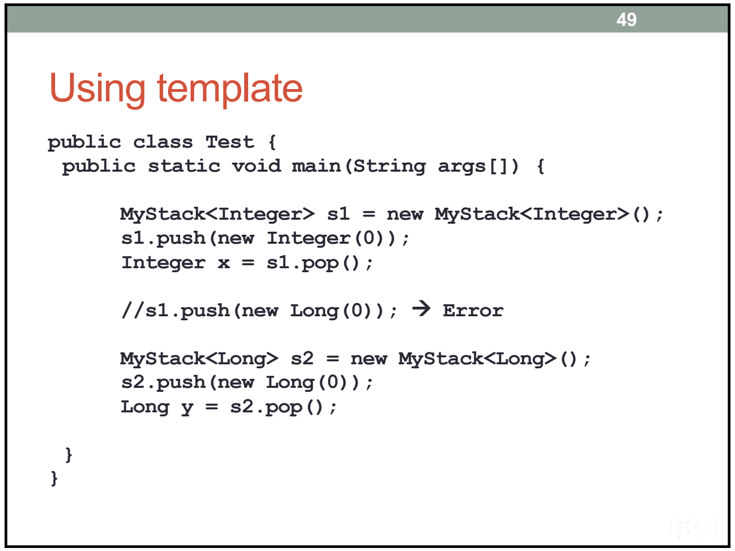

Using template

```
public class Test {
 public static void main(String args[]) {

     MyStack<Integer> s1 = new MyStack<Integer>();
     s1.push(new Integer(0));
     Integer x = s1.pop();

     //s1.push(new Long(0)); → Error

     MyStack<Long> s2 = new MyStack<Long>();
     s2.push(new Long(0));
     Long y = s2.pop();

  }
}
```

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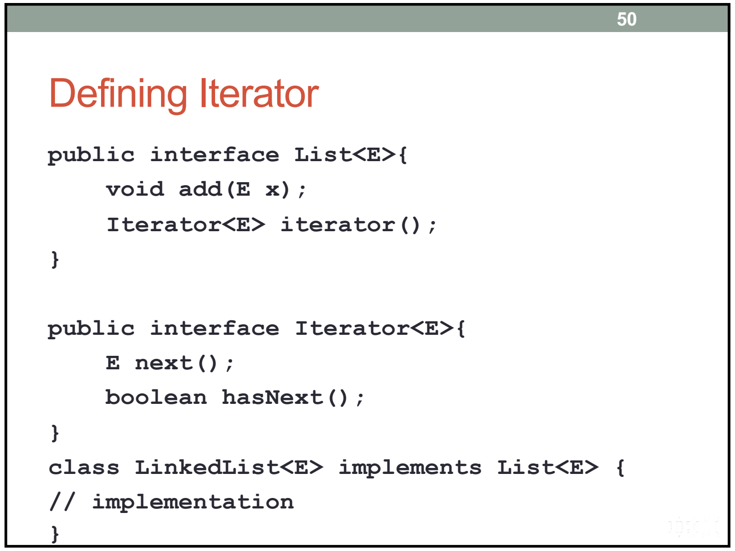

Defining Iterator

```
public interface List<E>{
    void add(E x);
    Iterator<E> iterator();
}

public interface Iterator<E>{
    E next();
    boolean hasNext();
}
class LinkedList<E> implements List<E> {
// implementation
}
```

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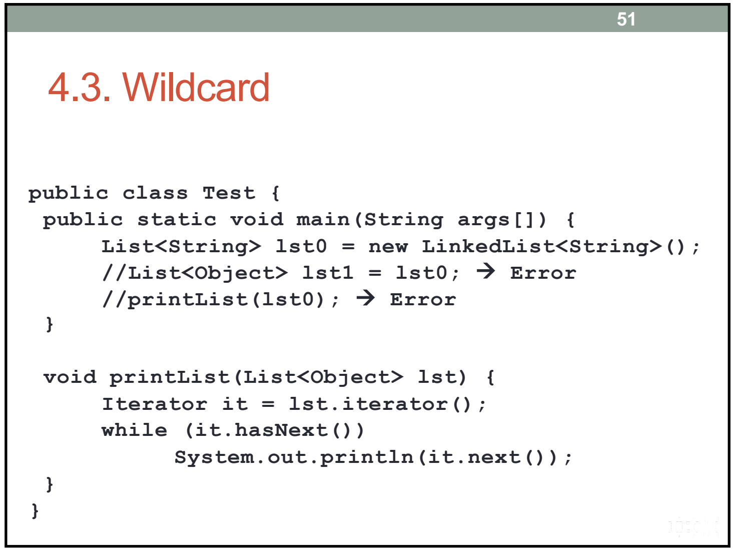

4.3. Wildcard

```
public class Test {
 public static void main(String args[]) {
     List<String> lst0 = new LinkedList<String>();
     //List<Object> lst1 = lst0; → Error
     //printList(lst0); → Error
 }

 void printList(List<Object> lst) {
     Iterator it = lst.iterator();
     while (it.hasNext())
           System.out.println(it.next());
 }
}
```

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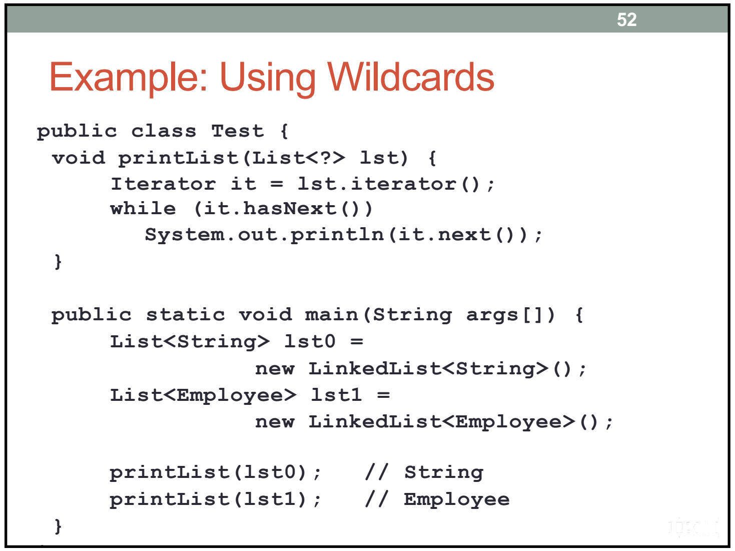

Example: Using Wildcards

```
public class Test {
 void printList(List<?> lst) {
     Iterator it = lst.iterator();
     while (it.hasNext())
        System.out.println(it.next());
 }

 public static void main(String args[]) {
     List<String> lst0 =
                 new LinkedList<String>();
     List<Employee> lst1 =
                 new LinkedList<Employee>();

     printList(lst0);   // String
     printList(lst1);   // Employee
 }
```

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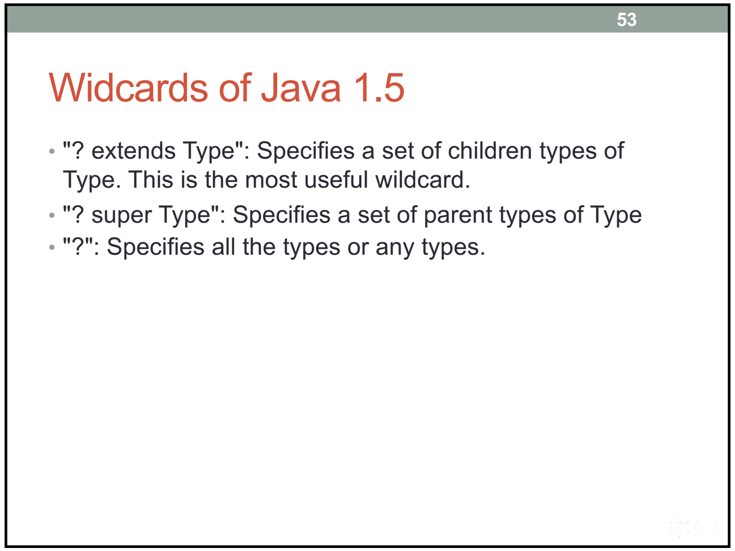

Widcards of Java 1.5

- "? extends Type": Specifies a set of children types of Type. This is the most useful wildcard.
- "? super Type": Specifies a set of parent types of Type
- "?": Specifies all the types or any types.

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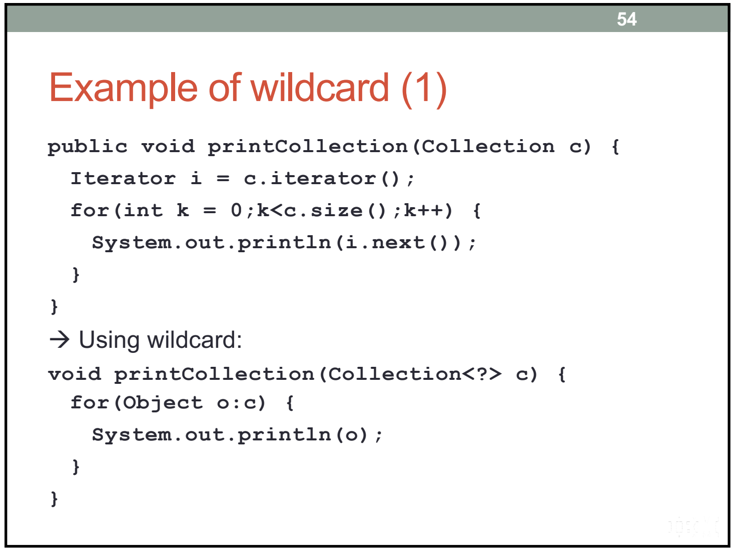

Example of wildcard (1)

```
public void printCollection(Collection c) {
  Iterator i = c.iterator();
  for(int k = 0;k<c.size();k++) {
    System.out.println(i.next());
  }
}
```

→ Using wildcard:

```
void printCollection(Collection<?> c) {
  for(Object o:c) {
    System.out.println(o);
  }
}
```

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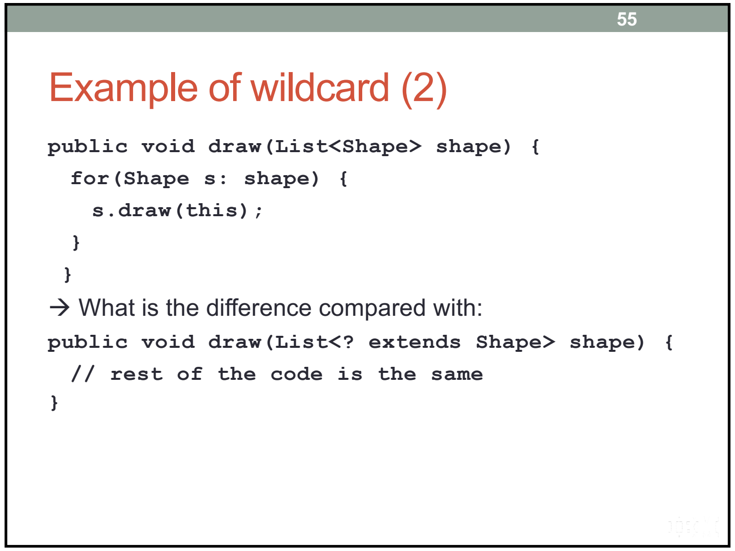

Example of wildcard (2)

```
public void draw(List<Shape> shape) {
  for(Shape s: shape) {
    s.draw(this);
  }
 }
```

→ What is the difference compared with:

```
public void draw(List<? extends Shape> shape) {
  // rest of the code is the same
}
```

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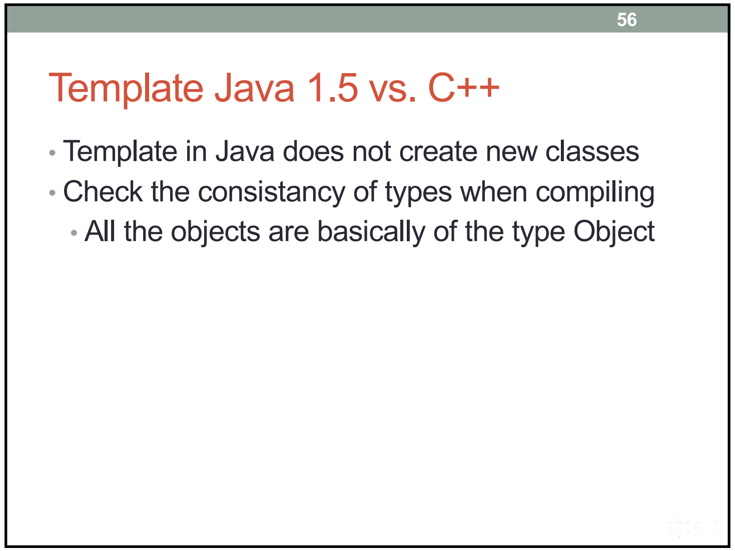

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Template Java 1.5 vs. C++

- Template in Java does not create new classes
- Check the consistancy of types when compiling
  - All the objects are basically of the type Object

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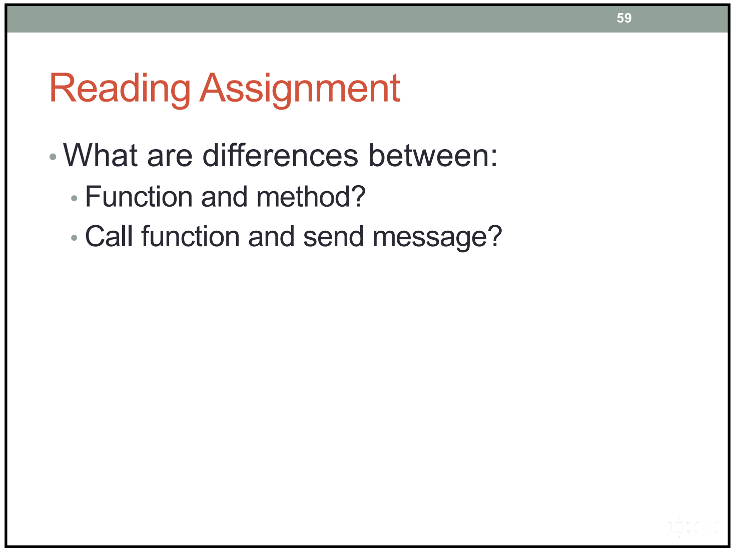

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Reading Assignment

- What are differences between:
  - Function and method?
  - Call function and send message?

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