

Programming Language Concepts: Lecture 7

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Java “generics”

```
public class Node<T> {  
    public T data;  
    public Node next;  
    ...  
}
```

I claimed we need to cast
the return value to `T` in a
generic `LinkedList`

```
public class LinkedList<T>{  
    private int size;  
    private Node first;  
  
    public T head(){  
        T returnval = null;  
        if (first != null){  
            returnval = first.data;  
            first = first.next;  
        }  
        return (T) returnval; // Cast!!  
    }  
}  
  
    public void insert(T newdata){  
        ...  
    }
```

Java “generics”

But this works OK!

```
public class Node<T> {  
    public T data;  
    public Node<T> next;  
    ...  
}
```

```
public class LinkedList<T>{  
    private int size;  
    private Node<T> first;  
  
    public T head(){  
        T returnval = null;  
        if (first != null){  
            returnval = first.data;  
            first = first.next;  
        }  
        return returnval; // No cast!!  
    }  
}  
  
    public void insert(T newdata){  
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- ▶ So we can declare variables of type `Node <T>` inside a generic class with parameter `T`

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- ▶ We cannot even have

```
LinkedList<Date>[] newarray;
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- ▶ `S` subtype of `T` means `S[]` is compatible with `T[]`

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- ▶ `S` subtype of `T` does not imply `LinkedList<S>` is compatible with `LinkedList<T>`

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- ▶ `S` subtype of `T` does not imply `LinkedList<S>` is compatible with `LinkedList<T>`

- ▶ This could create run time type errors

```
ETicket[] elecarr = new ETicket[10];  
Ticket[] ticketarr = elecarr;           // OK  
ticketarr[5] = new Ticket();            // Not OK!
```


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- ▶ ...but

```
T[] newarray;           // OK  
newarray = new T[100];  // Cannot create!
```

- ▶ An ugly workaround ...

```
T[] newarray;  
newarray = (T[]) new Object[100];
```

...that generates a compiler warning but works!

Exception handling

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Exception handling

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- ▶ Different levels of severity
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 - ▶ End of file on read
- ▶ Need to recover from exceptions
 - ▶ Take corrective action if possible
 - ▶ Abort only if no option left
- ▶ Identifying the cause of an exception
 - ▶ Need to go beyond rudimentary coding in terms of integer return values, as in C
 - ▶ Exceptions have types!

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- ▶ If an error occurs, an operation **throws** an exception
- ▶ Information about the exception is encapsulated as an object
- ▶ Program in which the offending operation occurred should **catch** the exception object ...
- ▶ ...and **handle** it
 - ▶ Analyze the object to determine the cause of the error
 - ▶ Take corrective action if possible

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 - ▶ Two subclasses, `Error` and `Exception`
 - ▶ `Error` — problems beyond program's control

An `Error` ... indicates serious problems that a reasonable application should not try to catch. Most such errors are abnormal conditions.
 - ▶ `Exception` — normally caught
 - ▶ `RuntimeException` — run time errors reported by JVM: divide-by-zero, array out-of-bounds ...

Exception handling in Java

`try-catch` structure to handle exceptions

```
try{
    ... // Code that might generate error
}
catch (ExceptionType1 e){...}
    // Corrective code for ExceptionType1

catch (ExceptionType2 e){...}
    // Corrective code for ExceptionType2
```

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- ▶ Error in `try` block generates exception object
- ▶ Exception object is sequentially checked against each `catch`
- ▶ What happens if first `catch` is

```
catch (Throwable e1){...}
```

Exception handling in Java

- ▶ If some `catch` condition matches, appropriate code is executed
- ▶ If no `catch` matches, abort and propagate exception object up one level, to calling class

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- ▶ May need to do some cleanup (deallocate resources etc)
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- ▶ Add a block labelled `finally`

```
try{
    ...
}

catch (ExceptionType1 e){...}

catch (ExceptionType2 e){...}

finally{
    ...
    // Always executed, whether try terminates normally
    // or exceptionally. Use for cleanup statements.
}
```

Customized exceptions

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Customized exceptions

- ▶ Don't want negative values in a `LinkedList`
- ▶ Define a new class extending `Exception`

```
class NegativeException extends Exception{

    private int error_value;
    // Stores negative value that generated exception

    public NegativeException(String message, int i){
        super(message); // Appeal to superclass
        error_value = i; // constructor to set message
    }

    public int report_error_value(){
        return error_value;
    }
}
```


Customized exceptions

Inside `LinkedList`

```
class LinkedList{  
    ...  
    public add(int i){  
        ...  
        if (i < 0){  
            throw new NegativeException("Negative input",i);  
        }  
        ...  
    }  
}
```

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- ▶ Exception should be advertized by `LinkedList`

```
class LinkedList{  
    ...  
    public add(int i) throws NegativeException{  
        ...  
    }  
    ...  
}
```

Customized exceptions

- ▶ A program using `LinkedList` should be aware that `LinkedList.add()` can result in such an exception
- ▶ Exception should be advertized by `LinkedList`

```
class LinkedList{  
    ...  
    public add(int i) throws NegativeException{  
        ...  
    }  
    ...  
}
```

- ▶ Need not advertize exceptions of type `Error` or `RuntimeException`

Customized exceptions

Using `LinkedList.add()` with customized exception

```
LinkedList l = new LinkedList();  
...  
try{  
    ...  
    l.add(i);  
    ...  
}  
catch (NegativeException ne){  
    System.out.print("Negative input supplied was ");  
    System.out.print(ne.report_error_value);  
}  
...
```

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 - ▶ No way to write a function to swap two `ints`
- ▶ Objects are passed by reference
- ▶ How do we swap two objects?

```
class Myclass{  
    ...  
    public void swap(Myclass p){ // Swap "this" with p  
        Myclass tmp;  
        tmp = p;  
        p = this;  
        this = tmp;  
    }  
}
```

- ▶ Will not work!

Parameter passing

- Instead, we must write something like:

```
class MyClass{
    ...
    public void swap(Myclass p){
        MyClass tmp = new MyClass(...); // Make a new tmp ob
        ... // Copy contents of p into tmp
        ... // Copy contents of this into p
        ... // Copy contents of tmp back into this
    }
}
```

Parameter passing

- ▶ Return values?
- ▶ Suppose we add a function to `Employee`

```
class Employee{  
    ...  
    // "accessor" methods  
    public Date get_joindate(){ return joindate; }  
    ...  
}
```

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- ▶ Now we write

```
Employee e = new Employee(...);  
Date d = e.get_joindate();  
d.advance(100); // e loses 100 days seniority!
```

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Date d = e.get_joindate();  
d.advance(100); // e loses 100 days seniority!
```

- ▶ Get public access to a private field of `Employee`
- ▶ Should make a copy of `joindate` before returning it

Cloning

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- ▶ To use `clone`, must implement `Cloneable`

```
class Employee implements Cloneable{  
    ...  
}
```

- ▶ `Marker` interface — empty!

Cloning

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 - ▶ Nested objects will not be cloned automatically!
- ▶ To use `clone`, must implement `Cloneable`

```
class Employee implements Cloneable{  
    ...  
}
```

- ▶ `Marker` interface — empty!
- ▶ Inside `clone()`, expect a check such as

```
Object clone(Object o){  
    if (o instanceof Cloneable){  
        ... // go ahead and clone  
    }else{  
        ... // complain and quit  
    }  
}
```

Packages

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 - ▶ If neither `public` nor `private` is specified, visibility is with respect to `package`

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- ▶ Java has an organizational unit called `package`
 - ▶ By default, all classes in a directory belong to a package
 - ▶ If neither `public` nor `private` is specified, visibility is with respect to `package`
- ▶ Can use `import` to use packages directly

```
import java.math.BigDecimal
```

or

```
import java.math.*
```

- ▶ All classes in `.../java/math`
- ▶ Note that `*` is not recursive

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- ▶ Normally, a subclass cannot change visibility of a function
- ▶ However, `protected` can be made `public`
- ▶ `clone()` is defined as `protected`