# i219 Software Design Methodology
## 7. Information hiding and reuse

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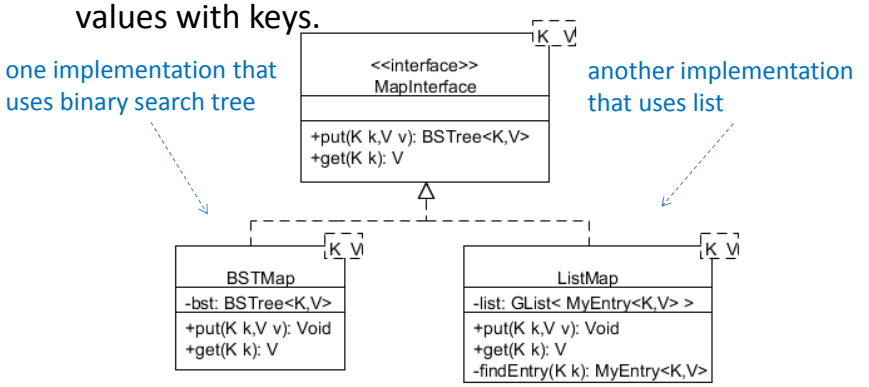
## Outline of lecture

- Information hiding
- Reuse
- Some examples for information hiding & reuse
  - Map
  - Parse tree for expression
  - Parse tree for assignment programs

# Information hiding

- Let us design a functionality (called map) that associates values with keys.




Both classes hide how to implement the functionality but just provide the functionality (the interface) – information hiding.



# Reuse

In the following program, BSTMap<K,V> is used. But, the only part that depends on the class is BSTMap:

```
MapInterface<String,Integer> map = new BSTMap<String,Integer>();
map.put("y",3);
map.put("x",4);
map.put("z",5);
map.put("x",6);
System.out.println(map.get("x"));
```

can be replaced with ListMap

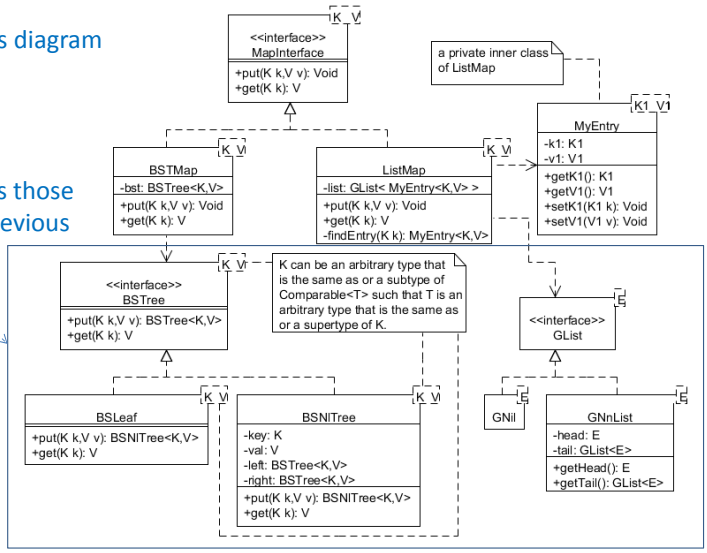
Use of implementations via an interface makes it possible to make dependent part local, increasing reusability.

If you want to use ListMap<K,V> instead of BSTMap<K,V>, all you have to do is to replace BSTMap with ListMap.

# Map (1)

a detailed class diagram on map

almost the same as those discussed in the previous lecture






# Map (2)

```
public class ListMap<K,V> implements MapInterface<K,V> {
  private class MyEntry<K1,V1> { … }
  private GList<MyEntry<K,V>> list;
  public ListMap() { list = new GNil<MyEntry<K,V>>(); }
  public void put(K k,V v) { … }
  public V get(K k) { … }
 private MyEntry<K,V> findEntry(K k) { … }
}
```

an inner class

list is initialized as nil (the empty list)

```
private K1 k1;  private V1 v1;
public MyEntry(K1 k1,V1 v1) { this.k1 = k1; this.v1 = v1; }
public K1 getK1() { return k1; }
public V1 getV1() { return v1; }
public void setK1(K1 k1) { this.k1 = k1; }
public void setV1(V1 v1) { this.v1 = v1; }
```

# Map (3)

```
public void put(K k,V v) {  MyEntry<K,V> e = this.findEntry(k);
  if (e == null) {
    list = new GNnList<MyEntry<K,V>>(new MyEntry<K,V>(k,v),list);
  } else { e.setV1(v); }  }
```

```
public V get(K k) { MyEntry<K,V> e = this.findEntry(k);
  return e == null ? null : e.getV1();  }
```

```
private MyEntry<K,V> findEntry(K k) {
  for (GList<MyEntry<K,V>> l = list;
        !(l instanceof GNil); l = ((GNnList<MyEntry<K,V>>) l).getTail()) {
    MyEntry<K,V> e = ((GNnList<MyEntry<K,V>>) l).getHead();
    if (k.equals(e.getK1())) { return e; }  }
  return null;  }
```



# Map (4)

the same as BinarySearchTree<…> in the previous lecture

```
public class BSTMap<K extends Comparable<? super K>,V>
    implements MapInterface<K,V>  {
  private BSTree<K,V> bst;
  public BSTMap() { bst = new BSLeaf<K,V>(); }

  public void put(K k,V v) {
    bst = bst.put(k,v);
  }

  public V get(K k) {
    return bst.get(k);
  }
```

bst is initialized as leaf (the empty tree)

# Map (5)

Map is provided in Java libraries.

an interface provided by Java libraries

an implementation of Map provided by Java libraries

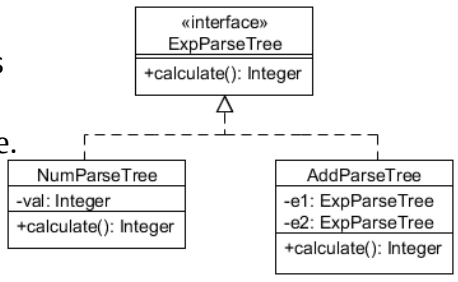
```
Map<String,Integer> map = new HashMap<String,Integer>();
map.put("y",3);
map.put("x",4);
map.put("z",5);
map.put("x",6);
System.out.println(map.get("x"));
```

Package java.util.* needs to be imported as “import java.util.*;”.



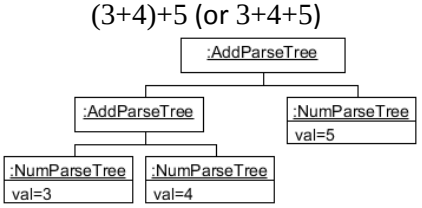
# Parse tree for expression (1)

Any expression that consists of integers, addition and parentheses can be represented as an instance of NumParseTree or AddParseTree.

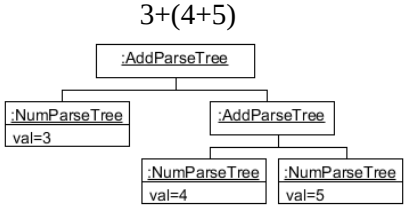



✓ val, e1 & e2 are private, and hidden.
✓ NumParseTree & AddParseTree can be used through ExpParseTree.

(3+4)+5 (or 3+4+5)




3+(4+5)



# Parse tree for expression (2)

```
public interface ExpParseTree { int calculate(); }

public class NumParseTree implements ExpParseTree {
  private int val;
  public NumParseTree(int x) { val = x; }
  public int calculate() { return val; }  }

public class AddParseTree implements ExpParseTree {
  private ExpParseTree ept1, ept2;
  public AddParseTree(ExpParseTree e1, ExpParseTree e2) {
     ept1 = e1; ept2 = e2; }
  public int calculate() {
    int n1 = ept1.calculate(); int n2 = ept2.calculate();
    return n1 + n2; }  }
```



# Parse tree for expression (3)

An expression can be calculated by sending the message calculate() to an instance of NumParseTree or AddParseTree that represents the expression.

```
ExpParseTree three = new NumParseTree(3);
ExpParseTree four = new NumParseTree(4);
ExpParseTree five = new NumParseTree(5);
ExpParseTree e1 = new AddParseTree(three,four);
ExpParseTree e2 = new AddParseTree(four,five);
ExpParseTree e3 = new AddParseTree(e1,five);
ExpParseTree e4 = new AddParseTree(three,e2);
System.out.println(e3.calculate());
System.out.println(e4.calculate());
```

3+4

4+5

(3+4)+5

3+(4+5)

(3+4)+5 & 3+(4+5) are calculated by sending calculate() to e3 & e4

# Parse tree for expression (4)

What if we want to use more operators such as multiplication in addition to addition?
All we have to do is basically to make a new class that implements ExpParseTree because of the modularity of the parse tree design.

```
public class MulParseTree implements ExpParseTree {
  private ExpParseTree ept1, ept2;
  public MulParseTree(ExpParseTree e1, ExpParseTree e2) {
     ept1 = e1; ept2 = e2; }
  public int calculate() {
    int n1 = ept1.calculate(); int n2 = ept2.calculate();
    return n1 * n2; }  }
```

AddParseTree can also be used to write MulParaeTree; these are the only difference between them



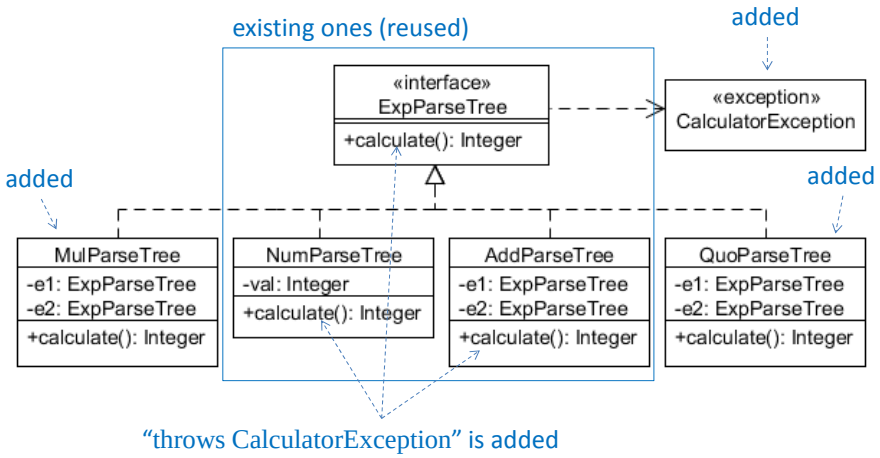
# Parse tree for expression (5)

Division (quotient) makes us do some more because “divided by zero” exception may occur, but existing classes & interface can be essentially reused.
Necessary to add “throws CalculatorException” to the method calculate() in ExpParseTree & all existing classes that implements ExpParseTree except for NumParseTree.

```
public class QuoParseTree implements ExpParseTree {
  private ExpParseTree ept1, ept2;
  public QuoParseTree(ExpParseTree e1, ExpParseTree e2) {
     ept1 = e1; ept2 = e2; }
  public int calculate() throws CalculatorException {
    int n1 = ept1.calculate(); int n2 = ept2.calculate();
    if (n2 == 0) { throw new CalculatorException(); }
    return n1 / n2; }  }
```

an exception is thrown

# Parse tree for expression (6)






# Parse tree for assignment programs (1)

Let us design parse trees for assignment programs; an assignment program is a sequence of assignment statements.
An example of assignment programs is as follows:

variable ⇢

```
x := 2;
x := x*x;
x := x*x;
x := x*x;
```

the program consists of four assignments

After the execution of the 4th assignment, x should be 256.

But, how to deal with variables?

# Parse tree for assignment programs (2)

A map can be used to deal with variables.
Such a map is called an environment or a store.

The value of *y* is the one most recently associated with *y* in the current environment.

$$x := \ldots y \ldots ;$$

Let *v* be the value of evaluating (or calculating) the right-hand side expression of the assignment. The assignment to *x* is to associate *v* with *x*, modifying the current environment.



# Parse tree for assignment programs (3)

Let env be the empty map.

```
x := 2;
x := x*x;
x := x*x;
x := x*x;
```

env.put(x,2) associating 2 with x

env.get(x) is 2 & x*x is 4.
env.put(x,4) associating 4 with x

env.get(x) is 4 & x*x is 16.
env.put(x,16) associating 16 with x

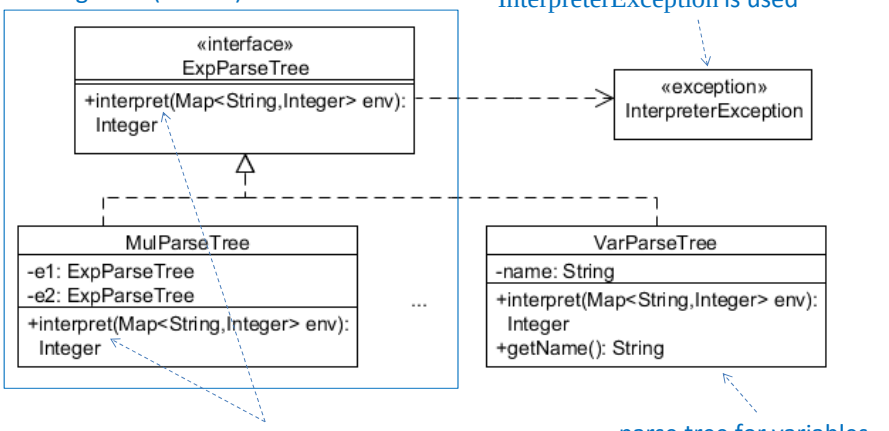
env.get(x) is 16 & x*x is 256.
env.put(x,256) associating 256 with x

After the execution of the 4th assignment, env.get(x) is 256.

# Parse tree for assignment programs (4)

existing ones (reused)

Instead of CalculatorException, InterpreterException is used




interpret(…) is the same as calculate() except that the former has a map env as its parameter

parse tree for variables appearing in expressions



# Parse tree for assignment programs (5)

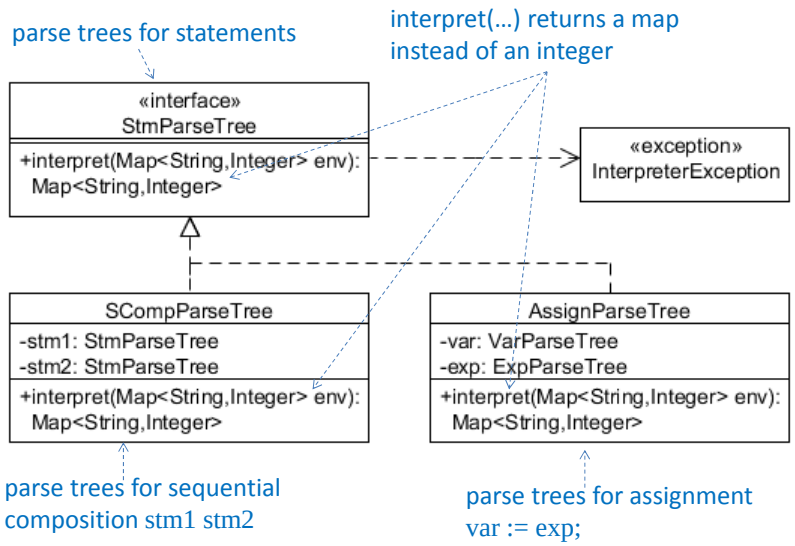
```
public class VarParseTree implements ExpParseTree {
  private String name;
  public VarParseTree(String s) { name = s; }
  public String getName() { return name; }

  public int interpret(Map<String,Integer> env)
      throws InterpreterException {
    try { return env.get(name); }
    catch (NullPointerException e) {
      throw new InterpreterException(name); } } }
```

the name of the variable

the value of the variable

env.get(name) throws an exception NullPointerException if no value is associated with name; such an exception is caught here and then another exception InterpreterException is thrown

# Parse tree for assignment programs (6)






# Parse tree for assignment programs (7)

```
public interface StmParseTree {
  public Map<String,Integer> interpret(Map<String,Integer> env)
    throws InterpreterException;  }
                              var := exp;
public class AssignParseTree implements StmParseTree {
  private VarParseTree var;  private ExpParseTree exp;
  public AssignParseTree(VarParseTree v, ExpParseTree e) {
    var = v;  exp = e;  }
  public Map<String,Integer> interpret(Map<String,Integer> env)
      throws InterpreterException {
    int n = exp.interpret(env);  <-- evaluating  the expression exp
    env.put(var.getName(), n);  <-- associating n with the variable var
    return env;  }  }
```

# Parse tree for assignment programs (8)

stm1 stm2

```
public class SCompParseTree implements StmParseTree {
  private StmParseTree stm1, stm2;
  public SCompParseTree(StmParseTree s1, StmParseTree s2) {
    stm1 = s1;  stm2 = s2;  }
  public Map<String,Integer> interpret(Map<String,Integer> env)
      throws InterpreterException {
    Map<String,Integer> env1 = stm1.interpret(env);
    Map<String,Integer> env2 = stm2.interpret(env1);
    return env2;  }
```

executing (interpreting) stm1 using env, which may modify env; let env1 be the new environment

finally, env2 is returned

then, executing (interpreting) stm2 using env1, which may modify env1; let env2 be the new environment



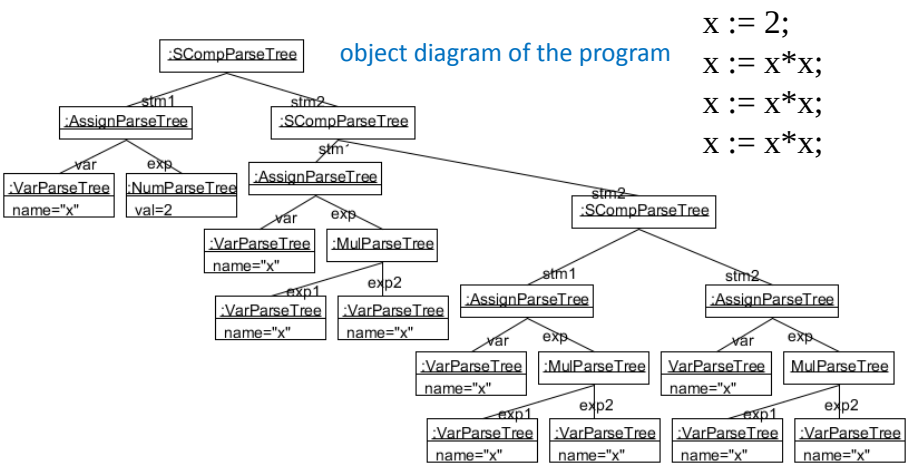
# Parse tree for assignment programs (9)

```
Map<String,Integer> env = new HashMap<String,Integer>();
ExpParseTree two = new NumParseTree(2);
VarParseTree x = new VarParseTree("x");
ExpParseTree e = new MulParseTree(x,x);
StmParseTree a0 = new AssignParseTree(x,two);
StmParseTree a = new AssignParseTree(x,e);
StmParseTree s = new SCompParseTree(a,a);
s = new SCompParseTree(a,s);
s = new SCompParseTree(a0,s);
System.out.println(s.interpret(env));
```

the parse tree for the program

```
x := 2;
x := x*x;
x := x*x;
x := x*x;
```

# Parse tree for assignment programs (10)






# Summary

- Information hiding
- Reuse
- Some examples for information hiding & reuse
  - Map
  - Parse tree for expression
  - Parse tree for assignment programs