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6. Introduction

A class that is declared within another type declaration is called a nested class. Similarly,an interface or an enum type that is declared within another type declaration is called a nested interface or a nested enum type, respectively

Below are four categories of nested classes, defined by the context these nested

types are declared in:

* static member classes
* non-static member classes
* local classes
* anonymous classes

Below is nested enum types, defined by the context these nested

* static member enums

Below is nested interfaces defined by the context these nested

* static member interfaces

They differ from non-inner classes in one important aspect: that an instance of an inner class may be associated with an instance of the enclosing class

The instance of the enclosing class is called the immediately enclosing instance.

A static member class, enum, or interface

can be declared either at the top-level, or in a nested static type.

A static class can be instantiated like any ordinary top-level class, using its full name. No enclosing instance is required to instantiate a static member class

Non-static member classes

are defined as instance members of other classes, just as

fields and instance methods are defined in a class, An instance of a non-static memberclass always has an enclosing instance associated with it

Local classes can be defined in the

context of a block as in a method body

or a local block

anonymous classes can be defined as expressions and instantiated on the fly. An instance of a local (or an anonymous) class has an enclosing instance associated with it

A nested type cannot have the same name as any of its enclosing types.

Below table columns explain this -

* The Declaration Context column lists the lexical context in which a type can be declared.
* The Accessibility Modifiers column indicates what accessibility can be specified for the type.
* The Enclosing Instance column specifies whether an enclosing instance is associated with an instance of the type.
* The Direct Access to Enclosing Context column lists what is directly accessible in the enclosing context from within the type.
* The Declarations in Type Body column refers to what can be declared in the body of the type.

class TLC { // (1) Top level class

**// static inner class/interface/enum**

static class SMC {/\*...\*/} // (2) Static member class

interface SMI {/\*...\*/} // (3) Static member interface

enum SME {/\*...\*/} // (9) Static member enum

**// Non-static inner class**

class NSMC {/\*...\*/} // (4) Non-static member (inner) class

**// Local classes**

void nsm() {

class NSLC {/\*...\*/} // (5) Local (inner) class in non-static context

}

static void sm() {

class SLC {/\*...\*/} // (6) Local (inner) class in static context

}

**// Anonymous classes**

SMC nsf = new SMC() { // (7) Anonymous (inner) class in non-static context

/\*...\*/

};

static SMI sf = new SMI() { // (8) Anonymous (inner) class in static context

/\*...\*/

};

}

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Type** | **Declaration**  **Context** | **Accessibility**  **Modifiers** | **Enclosing**  **Instance** | **Direct Access**  **to Enclosing**  **Context** | **Declarations in**  **Type Body** |
| Top-level  Class, Enum,  or Interface | Package | public or  default | No | N/A | All that are  valid in a class,  enum, or  interface body,  respectively |
| Static Member  Class, Enum,  or Interface | As member  of a toplevel  type  or a nested  static type | All | No | Static members in  enclosing context | All that are  valid in a class,  enum, or  interface body,  respectively |
| Non-static  Member  Class | As  non-static  member of  enclosing  type | All | Yes | All members in  enclosing context | Only non-static  declarations  + final static  fields |
| Local Class | In block  with  non-static  context | None | Yes | All members in  enclosing context  + final local  variables | Only non-static  declarations  + final static  fields |
| In block  with static  context | None | No | Static members in  enclosing context  + final local  variables | Only non-static  declarations  + final static  fields |
| Anonymous  Class | As  expression  in nonstatic  context | None | Yes | All members in  enclosing context  + final local  variables | Only non-static  declarations  + final static  fields |
| As  expression  in static  context | None | No | Static members in  enclosing context  + final local  variables | Only non-static  declarations  + final static  fields |

1. Static Member Types

A static member class, enum type, or interface comprises the same declarations as

those allowed in an ordinary top-level class, enum type, or interface, respectively.

**A static member class** must be declared explicitly with the keyword static, as a static member of an enclosing type.

**Nested interfaces** are considered implicitly static, the keyword static can, therefore, be omitted.

**Nested enum types** are treated analogously to nested interface in this regard: they are static members.

The accessibility modifiers allowed for members in an enclosing type declaration

can naturally be used for nested types.

package smc;

public class ListPool { // (1) Top-level class

public static class MyLinkedList { // (2) Static member class

private interface ILink { } // (3) Static member interface

public static class BiNode implements IBiLink { } // (4) Static member class

}

interface IBiLink extends MyLinkedList.ILink { } // (5) Static member interface

}

//Filename: MyBiLinkedList.java

package smc;

public class MyBiLinkedList implements ListPool.IBiLink { // (6)

ListPool.MyLinkedList.BiNode objRef1 = new ListPool.MyLinkedList.BiNode(); // (7)

//ListPool.MyLinkedList.ILink ref; // (8) Compile-time error!

}

* Static variables and methods belong to a class, and not to instances of the class. The same is true for static member classes and interfaces.
* Within the scope of its top-level class or interface, a member class or interface can be referenced regardless of its accessibility modifier and lexical nesting,
* Its accessibility modifier (and that of the types making up its full name) comes into play when it is referenced by an external client.
* Above Example will not compile because the member interface ListPool.MyLinkedList.ILink **has private** accessibility.
* A static member class can be instantiated without any reference to any instance of the enclosing context, as is the case for instantiating top-level classes
* There is seldom any reason to import nested types from packages. It would undermine the encapsulation achieved by such types.
* However, a compilation unit can use the import facility to provide a shortcut for the names of member classes and interfaces. Note that type import and static import of nested static types is equivalent: in both cases, a type name is imported.

//Filename: Client1.java

import smc.ListPool.MyLinkedList; // (1**) Type import**

public class Client1 {

MyLinkedList.BiNode objRef1 = new MyLinkedList.BiNode();// (2)

}

//Filename: Client2.java

import static smc.ListPool.MyLinkedList.BiNode; // **(3) Static import**

public class Client2 {

BiNode objRef2 = new BiNode(); // (4)

}

class BiListPool implements smc.ListPool.IBiLink { } // (5) Not accessible because of package level acceisbility!

* 1. **Accessing Members in Enclosing Context**

Static code does not have a “*this”* reference and can, therefore, only directly access

other members that are declared static within the same class. **But not instance members**, in its enclosing context.

Note that a static member class **can define both static and instance members**, like

any other top-level class. **However, its code can only directly access static members**

**in its enclosing context.**

A static member class, being a member of the enclosing class or interface, can have

any accessibility (public, protected, package/default, private), like any other member

of a class.

//Filename: ListPool.java

public class ListPool { // Top-level class

public void messageInListPool() { // Instance method

System.out.println("This is a ListPool object.");

}

**private static class MyLinkedList { // (1) Static class**

private static int maxNumOfLists = 100; // Static variable

private int currentNumOfLists; // Instance variable

**public static void messageInLinkedList() { // Static method**

System.out.println("This is MyLinkedList class.");

}

interface ILink { int MAX\_NUM\_OF\_NODES = 2000; } // (2) Static interface

**protected static class Node implements ILink { // (3) Static class**

private int max = MAX\_NUM\_OF\_NODES; // (4) Instance variable

public void messageInNode() { // Instance method

// int currentLists = currentNumOfLists; // (5) Not OK.

int maxLists = maxNumOfLists;

int maxNodes = max;

// messageInListPool(); // (6) Not OK.

**messageInLinkedList(); // (7) Call static method**

}

public static void main (String[] args) {

int maxLists = maxNumOfLists; // (8)

// int maxNodes = max; // (9) Not OK.

**messageInLinkedList(); // (10) Call static method**

}

} // Node

} // MyLinkedList

} // ListPool

1. Non-Static Member Classes

Non-static member classes are inner classes that are defined without the keyword

static as members of an enclosing class or interface. Non-static member classes are

on par with other non-static members defined in a class. The following aspects

about non-static member classes should be noted:

* An instance of a non-static member class can **only exist with an instance of its**

**enclosing class**.

* + This means that an instance of a non-static member class **must be created in the context of an instance** of the enclosing class.
  + This also means that a **non-static member class cannot have static members**. In other words,
  + Directly the non-static member **class does not provide any services, only instances of the**

**class do**

* + However, final static variables are allowed, as these are constants.
* Code in a non-static member class can directly refer to any member (including

nested) of any enclosing class or interface, including private members. No fully

qualified reference is required.

* Since a non-static member class is a member of an enclosing class, it can have

any accessibility: public, package/default, protected, or private

A typical application of non-static member classes **is implementing data structures.**

For example, a class **for linked lists could define the nodes** in the list with the

help of a non-static member class which could be declared private so that it was

not accessible outside of the top-level class. **Nesting promotes encapsulation, and**

**the close proximity** allows classes to exploit each other’s capabilities.

* 1. Instantiating Non-Static Member Classes

In the below Example, the declaration of a static variable at (6) in class Node is flagged as a compile-time error, but defining a final static variable at (7) is allowed.

A special form of the new operator is used to instantiate a non-static member class:

*<enclosing object reference>.****new*** *<non-static member class constructor call>*

A new instance of the non-static member class is created and associated with the indicated instance of the enclosing class.

Note that the **expression returns a reference value** that denotes a new instance of the non-static member class.

It is **illegal to specify the full name of the non-static member class in the constructor**

**call**, as the enclosing context is already given by the <enclosing object reference>.

The non-static method makeInstance() at (3) in the class MyLinkedList creates an

instance of the Node using the new operator, as shown at (4):

return new Node(info, next);

This inner object is denoted by the reference node1. This reference can then be used in the normal way to access members of the inner object.

An attempt to create an instance of the non-static member class without an outer instance, using the new operator with the full name of the inner class, as shown at (16), results in a compile-time error.

The special form of the new operator is also used in the object creation expression

at (17).

MyLinkedList.Node node2 = list.new Node("node2", node1);

class MyLinkedList { // (1)

private String message = "Shine the light"; // (2)

public Node makeInstance(String info, Node next) { // (3)

return new Node(info, next); // (4)

}

public class Node { // (5) NSMC

// static int maxNumOfNodes = 100; // (6) Not OK.

final static int maxNumOfNodes = 100; // (7) OK.

private String nodeInfo; // (8)

private Node next;

public Node(String nodeInfo, Node next) { // (9)

this.nodeInfo = nodeInfo;

this.next = next;

}

public String toString() {

return message + " in " + nodeInfo + " (" + maxNumOfNodes + ")"; // (10)

}

}

}

public class ListClient { // (11)

public static void main(String[] args) { // (12)

MyLinkedList list = new MyLinkedList(); // (13)

MyLinkedList.Node node1 = list.makeInstance("node1", null); // (14)

System.out.println(node1); // (15)

// MyLinkedList.Node nodeX

// = new MyLinkedList.Node("nodeX", node1); // (16) Not OK.

MyLinkedList.Node node2 = list.new Node("node2", node1); // (17)

System.out.println(node2); // (18)

}

}

* 1. Instantiating Non-Static Member Classes

An implicit reference to the enclosing object is always available in every method

and constructor of a non-static member class.

A method can explicitly use this reference with a special form of the this construct. From within a non-static member class, it is possible to refer to all members in the enclosing class directly.

return **MyLinkedList.*this*.message** + " in " + this.nodeInfo + " (" + this.maxNumOfNodes + ")";

The below expression evaluates to a reference that denotes the enclosing object (of the class <enclosing class name>) of the current instance of a non-static member class.

***<enclosing class name>.this***

* + 1. *Accessing Hidden Members*

//Filename: Client2.java

class TLClass { // (1) TLC

private String id = "TLClass "; // (2)

public TLClass(String objId) { id = id + objId; } // (3)

public void printId() { // (4)

System.out.println(id);

}

class InnerB { // (5) NSMC

private String id = "InnerB "; // (6)

public InnerB(String objId) { id = id + objId; } // (7)

public void printId() { // (8)

System.out.print(TLClass.this.id + " : "); // (9) Refers to (2)

System.out.println(id); // (10) Refers to (6)

}

class InnerC { // (11) NSMC

private String id = "InnerC "; // (12)

public InnerC(String objId) { id = id + objId; } // (13)

public void printId() { // (14)

System.out.print(TLClass.this.id + " : "); // (15) Refers to (2)

System.out.print(InnerB.this.id + " : "); // (16) Refers to (6)

System.out.println(id); // (17) Refers to (12)

}

public void printIndividualIds() { // (18)

TLClass.this.printId(); // (19) Calls (4)

InnerB.this.printId(); // (20) Calls (8)

printId(); // (21) Calls (14)

}

} // InnerC

} // InnerB

} // TLClass

public class OuterInstances { // (22)

public static void main(String[] args) { // (23)

TLClass a = new TLClass("a"); // (24)

TLClass.InnerB b = a.new InnerB("b"); // (25)

TLClass.InnerB.InnerC c1 = b.new InnerC("c1"); // (26)

TLClass.InnerB.InnerC c2 = b.new InnerC("c2"); // (27)

b.printId(); // (28)

c1.printId(); // (29)

c2.printId(); // (30)

TLClass.InnerB bb = new TLClass("aa").new InnerB("bb"); // (31)

TLClass.InnerB.InnerC cc = bb.new InnerC("cc"); // (32)

bb.printId(); // (33)

cc.printId(); // (34)

TLClass.InnerB.InnerC ccc = new TLClass("aaa").new InnerB("bbb").new InnerC("ccc");// (35)

ccc.printId(); // (36)

System.out.println("------------");

ccc.printIndividualIds(); // (37)

}

}

Output from the program:

TLClass a : InnerB b

TLClass a : InnerB b : InnerC c1

TLClass a : InnerB b : InnerC c2

TLClass aa : InnerB bb

TLClass aa : InnerB bb : InnerC cc

TLClass aaa : InnerB bbb : InnerC ccc

------------

TLClass aaa

TLClass aaa : InnerB bbb

TLClass aaa : InnerB bbb : InnerC ccc

**Fields and methods in the enclosing context** can be **hidden by** **fields and methods with the same names in the non-static member** class. The special form of ***this*** syntax can be used to access members in the enclosing context, somewhat analogous to using the keyword super in subclasses to access hidden superclass members.

All three classes have a private non-static String field named id and a non-static method named printId. The member name in the nested class hides the name in the enclosing context. **These members are not overridden in the nested classes because no inheritance is involved.** In order to refer to the hidden members, the nested class can use the special this construct

* + 1. *Inheritance Hierarchy and Enclosing Context*

Inner classes can extend other classes, and vice versa.

An inherited field (or method) in an inner subclass can hide a field (or method) with the same name in the enclosing context.

**Using the simple name to access this member will access the inherited member, not the one in the enclosing context.**

class Superclass {

protected double x = 3.0e+8;

}

//\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

class TopLevelClass { // (1) Top-level Class

private double x = 3.14;

class Inner extends Superclass { // (2) Non-static member Class

public void printHidden() { // (3)

// (4) x from superclass:

System.out.println("this.x: " + this.x);

// (5) x from enclosing context:

System.out.println("TopLevelClass.this.x: " + TopLevelClass.this.x);

}

} // Inner

} // TopLevelClass

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

public class HiddenAndInheritedAccess {

public static void main(String[] args) {

TopLevelClass.Inner ref = new TopLevelClass().new Inner();

ref.printHidden();

}

}

***extending an inner class***

Note that *SubclassC and the class OuterA are not related in any way*, and that the subclass OuterB inherits the class InnerA from its superclass OuterA.

An instance of SubclassC is created at (8).

An instance of the class OuterA is explicitly passed as argument in the constructor call to SubclassC.

The constructor at (4) for SubclassC has a special super() call in its body at (5).

This call ensures that the constructor of the superclass InnerA has an outer object (denoted by the reference outerRef) to bind to.

The non-default constructor at (4) **and the outerRef.super() expression at (5) are mandatory** to set up the proper relationships between the objects involved.

class OuterA { // (1)

class InnerA { } // (2)

}

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

class SubclassC extends OuterA.InnerA { // (3) Extends NSMC at (2)

// (4) Mandatory non-default constructor:

SubclassC(OuterA outerRef) {

**outerRef.super();** // (5) Explicit super() call

}

}

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

class OuterB extends OuterA { // (6) Extends class at (1)

class InnerB extends OuterB.InnerA { } // (7) Extends NSMC at (2)

}

//\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

public class Extending {

public static void main(String[] args) {

// (8) Outer instance passed explicitly in constructor call:

new **SubclassC(new OuterA());**

// (9) No outer instance passed explicitly in constructor call to InnerB:

new **OuterB().new InnerB();**

}

}

1. Local Classes

A local class is an inner class that is defined in a block. This could be a method

body, a constructor body, a local block, a static initializer, or an instance initializer.

Blocks in a non-static context have a this reference available, which refers to an

instance of the class containing the block. An instance of a local class, which is

declared in such a non-static block, has an instance of the enclosing class associated

with it. This gives such a non-static local class much of the same capability as a

non-static member class.

However, if the block containing a local class declaration is defined in a static context

(that is, a static method or a static initializer), the local class is implicitly static

in the sense that its instantiation does not require any outer object. This aspect of

local classes is reminiscent of static member classes. However, note that a local

class cannot be specified with the keyword static.

Some restrictions that apply to local classes are

* Local classes cannot have static members, as they cannot provide class-specific

services. However, final static fields are allowed, as these are constants. This is

illustrated in Example 8.9 at (1) and (2) in the NonStaticLocal class, and also by

the StaticLocal class at (11) and (12).

* Local classes cannot have any accessibility modifier. The declaration of the

class is only accessible in the context of the block in which it is defined, subject to the same scope rules as for local variable declarations.

1. Anonymous Classes