# Chap 6. CORBA-based Architecture

# Part 6.2 CORBA-IDL

1. Rationale
2. IDL Overview
3. Basic IDL Constructs
4. IDL to Java Language Mapping

# 1. Rationale

-The main rationale for IDL is to solve the heterogeneity inherent in distributed architectures.

-Heterogeneity among programming languages may arise because, for instance, their constructs and features are different, or their machine code representations differ.

-CORBA standard supports a common object model and an interface definition language (IDL) that represents a key for resolving programming language heterogeneity.

÷This is based on defining ***bindings*** from available programming languages to the IDL.

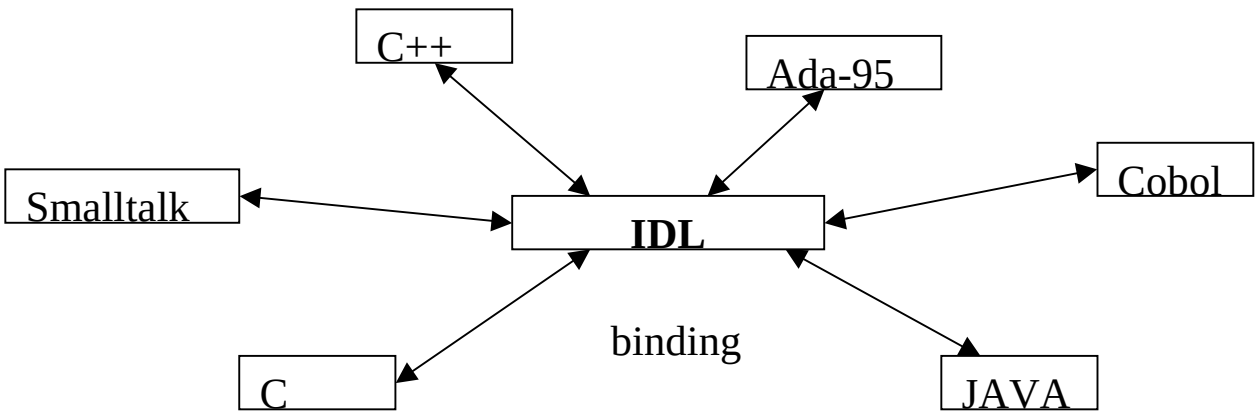
÷Defining a programming language binding consists of specifying how IDL constructs can be used in a client or server implementation, and vice-versa, regardless of which language they are written in or which platform they are running on.

-A language binding defines a one-to-one direct mapping between its constructs and the IDL constructs:

÷ Object types are mapped to client and server stubs.

÷ Server object references are encapsulated in client stub.

÷ Operations are mapped to procedures, operations or methods in the programming language.




-Vendors implement bindings by providing APIs that can be used both by client and servers, and also compilers that generate client and server's stubs.

# 2.IDL Overview

## *Example IDL Code*

The example deals with a store with point-of-sale (POS) terminals. The interface the POS terminal object uses to communicate with its barecode-reader object, Keypad object, ad receipt-printer object can be expressed in IDL:

```
//POS IDL Example
module POS {
        typedef string Barcode;

        interface InputMedia {
                typedef string OperatorCmd;
                void barcode_input (in media Barcode item) {
                void keypad_input(in OperatorCmd cmd);
        };

        interface OutputMedia {
                boolean output_text(in string string_to_print);
        };

        interface POSTerminal {
                void end_of_sale();
                void print_POS_sales_summary();
        }
};
```

-This file declares the interfaces for all the objects in our POS terminal, in a programming-language independent way.

-In our "store", other objects will invoke these objects on the POS Terminal computer through these interfaces.

# *IDL Basics*

-Although IDL interfaces are programming language-independent, the IDL language itself has the appearance (but not the semantics) of ANSI C++.

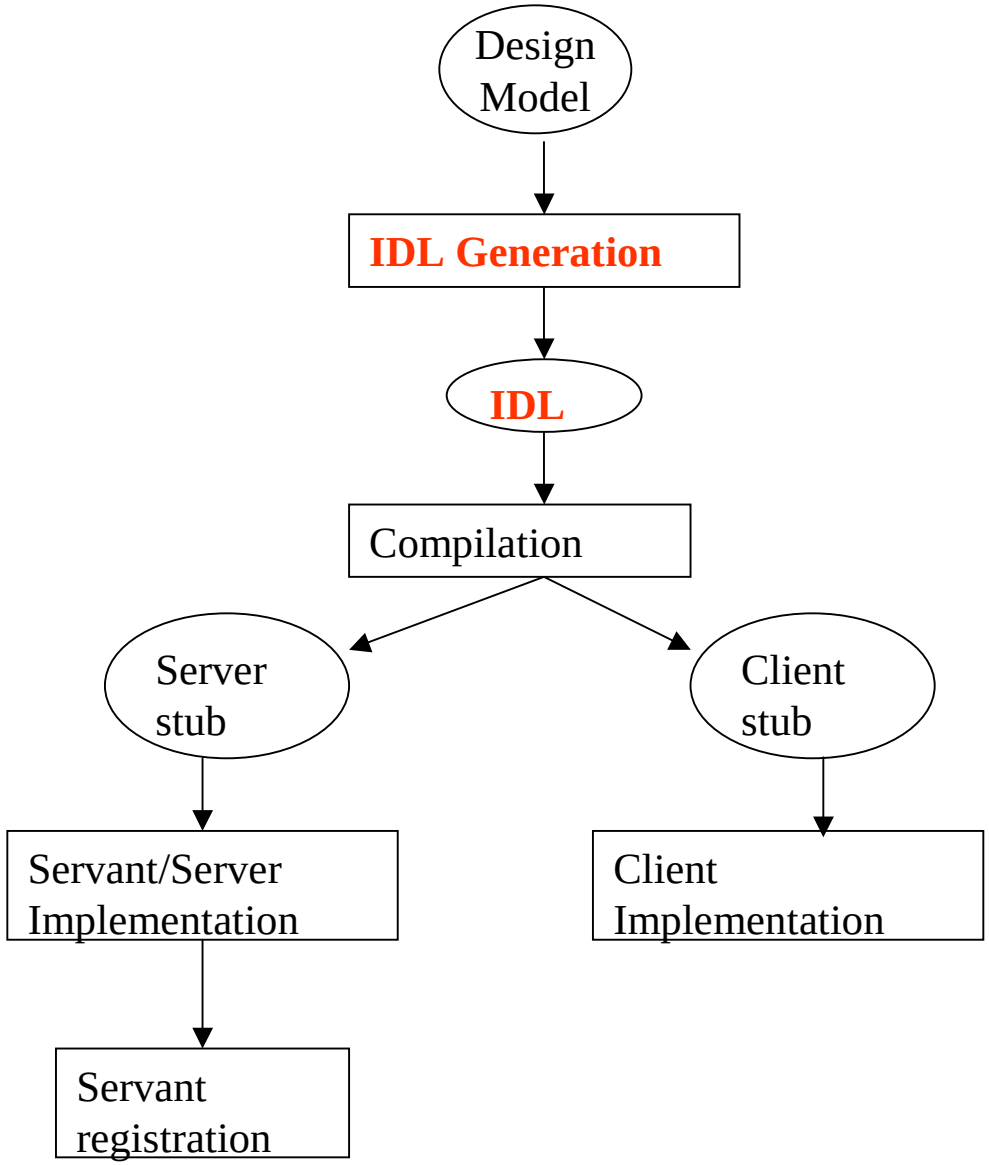
÷Notable resemblances include:

- C++ -like preprocessing
- Lexical rules (with new keywords for distribution concepts)
- Grammar, which is a subset of C++ and incorporates syntax for constant, type, and operation declarations; but lacks algorithmic structures and variables.

÷Differences include:

- Function return type is required (but may be void)
- Each formal parameter in an operation declaration must have a name
- and others

# *Generating IDL*



# 3. Basic IDL

-Basic IDL includes constructs such as module, interface, simple and complex data types, and exception.

## *Modules*

- Create separate name spaces for IDL definitions by defining scopes
- Used to define the enclosing scope of a group of IDL interfaces.
- Can contain one or more interfaces and can nest other module constructs
- Modules do not inherit from other modules, but can be nested.
- Only IDL interfaces are capable of inheriting specifications

- Example:

```
module Assembly {
    typedef string Widget;
};
```

# *Interfaces*

- Specify a software boundary between a service implementation and its clients.
- IDL interfaces can inherit from other interfaces
- IDL interfaces may involve *attributes*, *operations* and *types* definitions

- Example:

```
interface Account {
  //Account definitions
 };

interface Savings: Account {
 //Inherits all Account definitions
 //then adds Savings definitions
};
```

***Attributes***

- Attributes define general characteristics for an interface
- If an attribute or operation is private, it should not appear in a public IDL definition
- By default, all IDL definitions (known by the ORB) are public
- Attributes may be *read-only* or *read-write*

- Example

```
interface Account {

    attribute string balance;
    readonly attribute long ssn;

 };
```

- For read-write attributes, the compiler generates a *set* and a *get* functions for each attribute.
- For read-only attributes, only a *get* function is generated.

## *IDL Forward*

- Statement used to declare an interface before its complete definition appears in the IDL file.
- Can also be used to create recursive (or self-referential) definitions.

- Example:

```
interface Employee;    //forward declaration

interface Company {
  attribute Employee supervisor;
  attribute Employee secretary;
 };

interface Employee {
  attribute  string department;
  attribute string name;
}
```

# *Data Types*

-IDL enables strong type checking of operation signatures, and includes renaming of intrinsic types in IDL, as well as the creation of user-defined types: enumeration, structures, arrays, sequences, unions

***Basic Types:*** IDL supports most of the basic types supported by modern programming languages (e.g., C,C++, Java).

| **IDL Basic Types** | **Notes** |
|---|---|
| short, unsigned short | Integer-16 bits |
| long, unsigned long | Integer-32 bits |
| long long, unsigned long long | Integer-64 bits |
| float | IEEE single-precision floating point |
| double | IEEE double-precision floating point |
| long double | IEEE double-extended floating point |
| char | 8-bit quantity |
| wchar | Encode wide characters from any character set (size undefined) |
| boolean | True or false |
| Octet | Byte- is guaranteed not to undergo any conversion when it passes over the wire. |
| string, wstring | Are basically array of chars and wchar |

## *IDL Constants*

•IDL constants are expressed using the keyword **const** followed by the type, name and value of the constant.

•Example:

***const*** *unsigned long km=2.2;*
*const char cr=‘/’;*
*const boolean tautology=TRUE;*
*const float pi=3.14;*
*const double av=6.02e25;*
*const string state=“Virginia”;*

## *Renamed Type*

-Construct for naming new IDL types from existing ones.

***typedef*** *unsigned long PhoneNumber;*

***Example: typedef*** *string LastName;*
*const LastName my_lastname =“Smith”;*

***Enumeration type***

-Used to represent an enumerated list.

```
enum ChargeCard {MasterCard, Visa, Diners};
```

***Structure type***

-Container class that may be used to pass a collection of data as a single object.

```
struct  GuestRecord {
    GuestName name;
    Address address;
    PhoneNumber number;
};
```

***Sequence type***

-Single dimension arrays that may be bounded or unbounded

-Are essentially variable-length arrays

-A bounded sequence defines its maximum size in its declaration

***typedef sequence*** *<GuestRecord> record; //unbounded sequence*

***typedef sequence*** *<GuestList,10> list; //bounded sequence*

***Array type***

-Used to create a single-dimension, bounded array of IDL type.

***typedef*** *EmployeeRecord Employees[100];*

## *Union type*

```
enum PersonKind {A_GUEST, AN_EMPLOYEE, OTHER}

union Person switch (PersonKind) {
   case A_GUEST:
      GuestRecord guest_record;
   case AN_EMPLOYEE:
      EmployeeRecord employee_record;
   default: string description;
 };
```

## *Dynamic IDL type* Any

- Allow definition of loosely typed data values
- Useful for defining reusable interfaces
- Example:

```
typedef any DynamicallyTypedValue;
struct RunTimeValue {
  string description;
  any run_time_value;
};
```

## *IDL Exceptions*

- Define the values passed by the interface in case something goes wrong.
- Extend the **org.omg.CORBA.UserException** class
- May contain data that are accessed as public members of the named class and may be passed in the construction of the exception.
- Exception values are declared similar to IDL structure type.

- Example:

```
exception CardExpired {string expiration_data;};
exception CardReportedStolen {
        string reporting_instructions;
        unsigned long hotline_phone_number;
 };
```

- There are two general kinds of exceptions: user-defined and CORBA defined, also called Standard Exceptions and which extend the **org.omg.CORBA.SystemException** class.

## *Operations*

-Define the acceptable way to access an object
-The IDL type of the target object is the declared name of the Interface.
-All operation definitions are declared within specific IDL interfaces.
-By default, IDL operations are synchronous
-An asynchronous option is provided using the ***oneway*** keyword, which indicates that an operation will be executed at most once.
-Operations that are oneway can only have input parameters.

## *Operation Signatures*

-Operation signatures include:
  -the operation attribute (*oneway* or *none*),
  -the operation type specification,
  -the operation identifier,
  -the parameters declarations,
  -an optional ***raises*** expression,

-The operation type specification is the return value: may be any IDL type or the keyword *void*.

-Arguments to operations declare the call semantics of the argument: **in**, **out**, or **inout**

- An **in** parameter is called by value
- The **out** parameters use call-by-reference semantics.
- The **inout** parameter semantics is call-by-value/return-by-reference

-Operations can declare that they raise an exception using the construct **raises** (*ExceptionName*) in their signature.

- Exceptions in the raises clauses must be declared before they can be used.

***Example:***

```
interface AirlineReservation {
  typedef unsigned long ConfirmationNumber;
  exception BadConfirmationNumber {};
  oneway void cancel_reservation (in ConfirmationNumber number)
       raises (BadConfirmationNumber);
  };
```

# *Comments and Pre-compiler Directives*

## *Comments*

- Two forms:
  - single line comments that begin with a // symbol
  - multiple lines comments enclosed by /* and */ symbols.
- Example:

```
// This is a single line comment
/* This is a multiple-
    line comment. */
```

## *Pre-Compiler Directives*

- IDL provides pre-compiler directives, as do C and C++
- Example: the *include* statement allows IDL files to reference each other's definitions.
- By convention, IDL files are named after the module they contain.
- Example:

```
//Enable access to CORBA Naming Service
        #include <Cosnaming.idl>
```

# *Example: A Course Registration System*

- ***OO Model:***


- ***Abstract IDL model***

```
module CourseRegistration {
    interface Student {
      attribute any personalInfo;
      attribute any major;
      void enroll();
      void graduate();
    };
   interface Course {
      attribute any subject;
      attribute any semester;
      void register();
      void cancel();
    };
};
```

## •*Refined IDL model:*


```
module CourseRegistration {
   // Forward Declarations
   interface Course;

   interface Student {

     struct StudentRecord {
        String name;
        String address;
        unsigned long studentNo;
      };

        attribute StudentRecord personalInfo;
        attribute string major;
        exception ClassFull {};
        void enroll(in Course course) raises (ClassFull);
        exception HasNotCompletedReqts {};
        void graduate() raises (HasNotCompletedReqts);
       };

interface Course {
        attribute string subject;
       enum SchoolSemestsers {FALL, SPRING, SUMMER};
        attribute SchoolSemesters semester;
        void register(in Student student);
        void cancel();
      };
};
```

# 4. IDL to Java Language Mapping

-CORBA programming language mappings "map" one-to-one correspondences from OMG IDL constructs to programming language constructs.

÷These constructs tell client and object-implementation writers what to write to invoke an operation on a CORBA object.

÷In a non-OO language, invocations typically map to function calls. In OO languages, mappings make CORBA invocations look like language-object invocations.

## *Programming Conventions*

-Programming conventions for Java and IDL differs slightly:

- IDL convention does not require capitalization for the names of modules, etc.
- IDL convention uses underscores instead of mixed case for long names.
- An IDL file is composed of several elements that together create a naming scope.
- Identifiers in IDL are case *insensitive* and may be used only once in the naming scope.
- IDL does *not support the overloading* and *overriding* of operations, although inheritance (single and multiple) is supported.

# *IDL Module*

•Each module construct compiles to a Java package name

•Example:

```
//IDL
module BookStore {
    interface Account {
            …
    };
  };
```

//Java code generated by **idltojava** compiler would include:

```
package BookStore;
        …
```

# *IDL Types*

•CORBA types can either be standard IDL types or another IDL interface

| **IDL** | **Java** |
|---|---|
| float | float |
| double | double |
| long, unsigned long | int |
| long long,<br>unsigned long long | long |
| short, unsigned short | short |
| char, wchar | char |
| boolean | boolean |
| octet | byte |
| string, wstring | java.lang.String |
| any | class Org.omg.CORBA.Any.java |
| enum, struct, union | class |

## *IDL typedef*

- Does not directly map onto Java, so the IDL compiler will substitute and replace any instance of the *typedef* name for the actual type in the IDL before compiling it.
- Example:

```
//IDL typedef
typedef string CustomerName;
typedef sequence <long> CustomerOrderID;
```

## *IDL sequence*

- An IDL sequence is mapped to a java array; bounds checking is always done on bounded sequences.
- A Java Helper and Holder class is generated for each sequence
- Example:

```
//IDL
  typedef sequence <long,10> openOrders;
```

## *IDL Arrays*

- Mapped to Java the same way as a bounded IDL sequence; bounds checking is always done.
- A Holder class is also generated for the array.

Example:

```
//IDL
  const long length=20;
  typedef string custName[length];
```

## *IDL Any*

- Maps to the *org.omg.CORBA.Any* java class.
- Nonprimitive types are inserted into an **any** via the static methods provided in the corresponding helper class.

*Example:*

To insert the CORBA object reference for an instance *obj* of *Account* interface into an *any* requires the following code:

```
AccountHelper.insert(any, obj);
```

To extract from the any:

```
obj = AccountHelper.extract(any);
```

- For each primitive type *XXX*, there is a pair of methods *insert_XXX* and *extract_XXX* to update or return a typed value contained in the Any.

*Example:*

To create new Any and then initialize it from a short:

```
org.omg.CORBA.Any x = orb.create_any();
x.insert_short((short) 4);
```

To retrieve the value in the Any:

```
shrt y = x.extract_short();
```

## *IDL enum*

- Maps to a Java final class with the same name.

- Example:

//IDL
*enum Card {visas, master,amex};*

//maps to a Java final class with the same name: *Card.java*

-Contains one *value* method, two static data members per label, an integer conversion method, and a private constructor.

-Holder and Helper classes are also generated for an enum.

## *Generated Java Code for enum*

```
final public class Card {

  //static data members
   final public static  int _visas = 0;
   final public static Card visas = new Card(_visas);
    final public static  int _master = 1;
   final public static Card master = new Card(_master);
    final public static  int _amex = 2;
   final public static Card amex = new Card(_amex);

   //Private constructor
    private int _value;

    private Card(int value) {
       this._value = value;
    }

    //Value accessor methods
    public int value() {
      return _value;
     };
```

***//Generated java code (ctd.)***

```
public static Card from_int(int $value) {
       case _visas: return visas;
       case _master: return master;
       case _amex: return amex;
       default: throw new org.omg.CORBA.BAD_PARAM(“Enum out of range:
                [0..” + (5 – 1) + “]: “ + $value);
     }
  }
//string conversion
   public java.lang.String toString () {
      org.omg.CORBA.Any any = org.omg.CORBA.ORB.init().create_any();
      CardHelper.insert(any,this);
      Return any.toString();
    }
}
```

## *Code Snippet for enum*

```
Card creditCard = Card.visas;
System.out.println(“Credit card type =  “ + creditCard);
```

## *IDL struct*

- Maps to Java final class with public data members.

- Example:

```
//an IDL struct
Struct Address {
  string street;
  long number;
};

//maps to a Java class that is final: Address.java
```

-has public member variables with the same name and type as the struct fields.
-contains two constructors: the default constructor, and one to initialize each field to a non-default value.
-Holder and Helper classes are also generated for each IDL struct.

## *Generated Java code for struct*

```
final public class Address {
   //Data members
   public java.lang.String street;
   public int number;

   //Constructors
   public Address() {}
   public Address (java.lang.String street, int number) {
       this.street = street;
       this.number = number;
    }
//string conversion
   public java.lang.String toString () {
      org.omg.CORBA.Any any = org.omg.CORBA.ORB.init().create_any();
      AddressHelper.insert(any,this);
      return any.toString();
    }
}
```

## *Code Snippet for struct*

```
Address addr = new Address(“Hills”,9567);
System.out.println(“My street is: “ + addr.street);
```

## *IDL union*

- Maps to Java final class.

-Has a default constructor, an accessor method for the discriminator, and an accessor and a modifier methods for each branch.

-Helper and Holder classes are also generated for a union.

- Example:

```
enum DataType {BYTE_TYPE, SHORT_TYPE, LONG_TYPE}

union DataValue switch(DataType) {

        case BYTE_TYPE: octet byteValue;
        case SHORT_TYPE: short shortValue;
        case LONG_TYPE: long longValue;

};
```

## *Generated Java Code for Union*

```
final public class DataValue {
   //constructor
    public DataValue () {}

   //discriminator
   private java.lang.Object _object;
   private short _disc;
   public DataValue discriminator () {
      return _disc;
    };

   //Accessor and modifier methods for the branches
  public byte byteValue() {…}
  public void byteValue (byte value) {…}
  public short shortValue() {…}
  public void shortValue(short value) {…}
  public int longValue() {…}
  public shortValue (int value) {…}

//string conversion
  public java.lang.String toString() {…}
}
```

## *Code Snippet for Union*

```
//create a union
DataValue data = new DataValue();

//initialize its value
data.longValue(1234);

//display a failure when the wrong method is called
System.out.println(“This works: data value is “ + data.longValue());
System.out.println(“This fails: data value is “ + data.shortValue());
```

## *IDL Interface*

- Maps to a Java interface class
- Can contain *attributes*, *operations*, and *exceptions.*

- The **idlj** compiler generates a certain number of files according to the option used.

Example:

```
module bank {
        interface Account {
                void deposit();
        };
};
```

**idlj –fall bank.idl** command will generate the following files:

| **Generated Files** | **Purpose** |
|---|---|
| AccountOperations.java | all the operations provided by the IDL interface are defined in this file, which is shared by both the stubs and the skeletons. |
| Account.java | contains the java version of the IDL interface; used as signature type in method declarations. |
| _AccountStub.java | a java class that contains the **stub** code |
| _AccountImplBase | a java class that contains the **skeleton** code |
| AccountHolder.java | a **Holder** class that is used to contain a reference to the IDL interface object if the interface is passed as an argument. |
| AccountHelper.java | a **Helper** class that is used to downcast a CORBA object to this type |

***Attributes***

- An attribute will generate accessor and modifier methods for the type declared: the compiler does not generate a variable, but just the methods to access the variable.

-Example:

*attribute float price;* //IDL

*float price();* //generated Java methods
*void price(float arg);*

- The attribute may be declared **readonly**, in which case only an accessor is declared.

-Example: *readonly attribute BookList theOrder;*

## *IDL Operations*

- Compiled to Java methods
- Each operation must declare a return type and may have zero or more arguments.
- Arguments to operations declare the call semantics of the argument: **in**, **out**, or **inout**
  - An **in** parameter is called by value and is mapped directly to the corresponding Java type.
  - The **out** parameters use call-by-reference semantics. Since java does not support call-by-reference, **out** parameters are mapped onto a **JavatypeHolder** class, which encapsulates a data variable containing the parameter, and the value of the class reference is passed.
  - The **inout** parameter semantics is call-by-value/return-by-reference, and is also mapped onto a Java Holder class.

## Example:

```
// IDL

module Monitor {
interface Modes {
        long process(in long inArg,
                                out long outArg,
                                inout long inoutArg);
};
};


// Generated Java
package Monitor;
public interface ModesOperations {
        int process(int inArg,
                        org.omg.CORBA.IntHolder outArg,
                        org.omg.CORBA.IntHolder inoutArg);
}

public interface Modes extends ModesOperations,
        org.omg.CORBA.Object, org.omg.CORBA.portable.IDLEntity {

}
```

```
// Holder Class
final public class ModesHolder
        implements org.omg.CORBA.portable.Streamable {
        public Modes value;
        public ModesHolder() {}
        public ModesHolder(Modes initial) {...}
        public void _read(org.omg.CORBA.portable.InputStream is) {...}
        public void _write(org.omg.CORBA.portable.OutputStream os){...}
        public org.omg.CORBA.TypeCode _type() {...}
}
```

-Holder classes are used for out and inout IDL operation parameters:

÷Holder classes exist for all primitive java types (in the org.omg.CORBA package) and for all user-defined types except those that are defined by *typedef*.

÷Each Holder class has two constructors and a public member variable always named *value*. You can get/set the value of the Holder variable using the *value* member variable.

```
// Helper Class
abstract public class ModesHelper {
        public static void insert(org.omg.CORBA.Any a, Modes t) {...}
        public static Modes extract(Any a) {...}
        public static org.omg.CORBA.TypeCode type() {...}
        public static String id() {...}
        public static Modes read(
                org.omg.CORBA.portable.InputStream is) {...}
        public static void write(
                org.omg.CORBA.portable.OutputStream os,Modes val) {...}
        public static Modes narrow(java.lang.Object obj){...}
}
```

-Contains a number of static methods that are used to manipulate the type.

÷The most important methods are the *any insert* and *extract* methods for that type, getting the *ReposirotyID*, getting the typecode, and reading and writing the type from and to a stream.

÷Another important static method called *narrow* performs a safe down-casting (i.e., from *org.omg.CORBA.Object* to interface type).

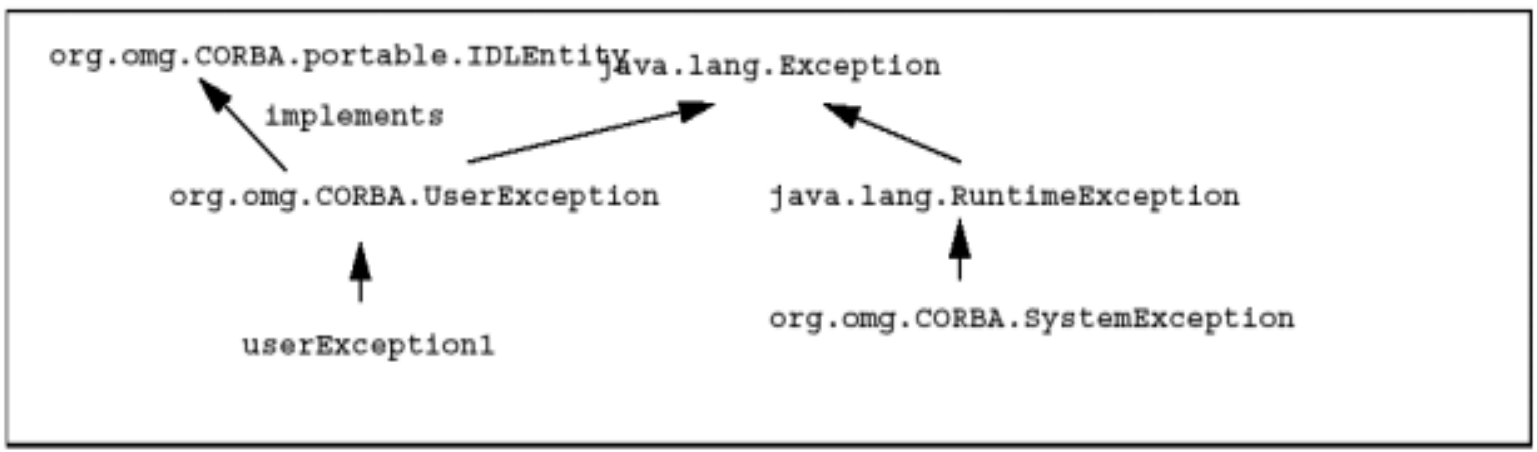
```
// user Java code
// select a target object
Monitor.Modes target = ...;

// get the in actual value
int inArg = 57;

// prepare to receive out
IntHolder outHolder = new IntHolder();

// set up the in side of the inout
IntHolder inoutHolder = new IntHolder(131);

// make the invocation
int result=target.process(inArg, outHolder, inoutHolder);

// use the value of the outHolder
... outHolder.value ...

// use the value of the inoutHolder
... inoutHolder.value ...
```

## *IDL Exception*

•Map into a Java final class that has instance variables for the fields of the exception.

-Has a default constructor, and a constructor allowing to initialize each field of the exception.

•CORBA system exceptions are direct subclasses of *java.lang.RuntimeException*. User defined exceptions subclasses of *java.lang.Exception.*




•Helper and holder classes are also generated.

## *Example*

```
// IDL
module bank {
        exception account_exception {long reason_code;};
};

// Generated Java
package bank;
final public class AccountException extendsg
                        org.omg.CORBA.UserException {
        public int reason_code; // instance
        public AccountException() { // default constructor
                super(AccountException Helper.id());
        }
        public AccountException(int reason_code) {// constructor
                super(AccountException Helper.id());
                this.reason_code = reason_code;
        }
        public AccountException(String reason, int reason_code) {
        // full constructor
                super(AccountException.id()+" "+reason);
                this.reason_code = reason_code;
        }
}
```