Bridge [GoF]

Intent

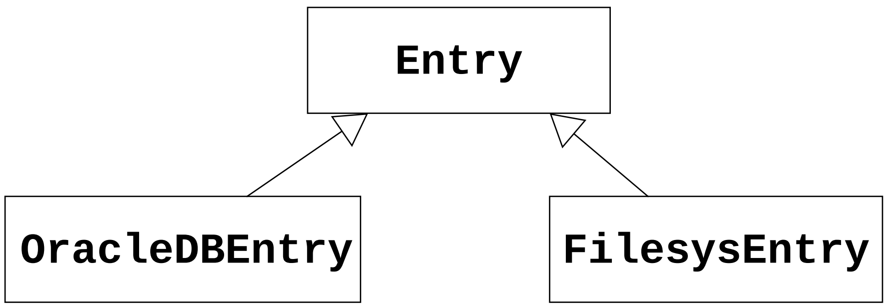
Decouple an abstraction from its implementation so that the two can vary independently.

Also Known As

Handle/Body.

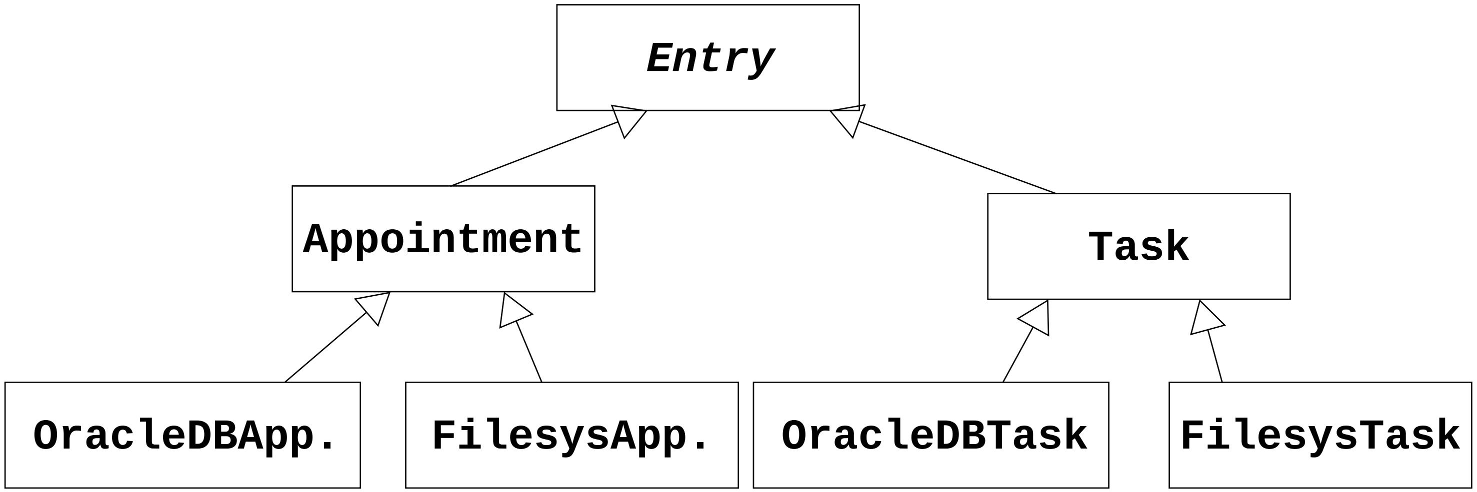
Motivation

Suppose we have an abstraction `Entry`, and we want to implement its persistence in two different ways. One possibility is to provide subclasses for each way:



Subclass `OracleDBEntry` is responsible to store the attributes of class `Entry` in table of the Oracle DB whereas subclass `FilesysEntry` stores them in files.

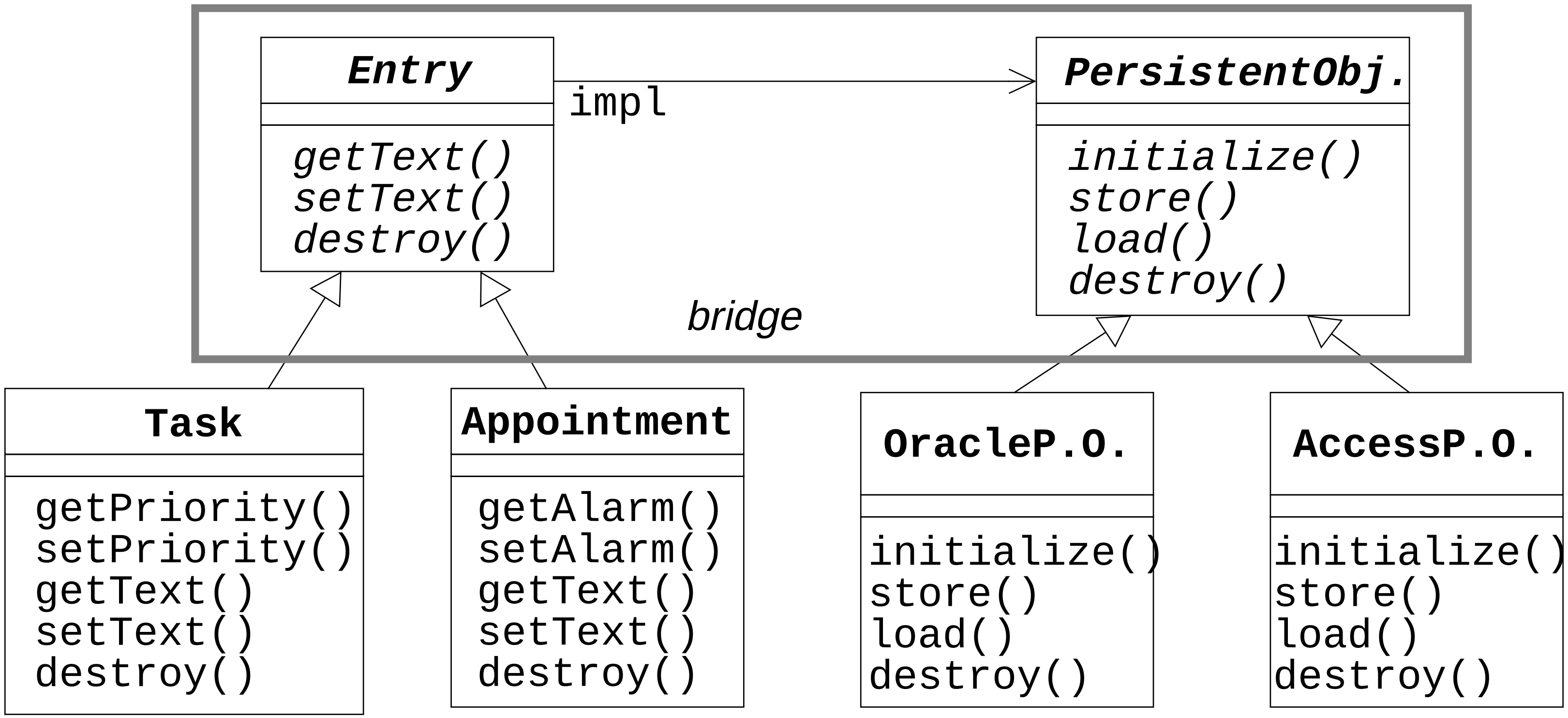
Consider the proliferation of classes if we introduce a specialized subclass with business meaning, say class `Task`, for class `Entry`:



Drawbacks:

1. It is inconvenient to extend the business classes to cover different kinds of `Entry` or different new persistent storage areas.
2. Above class hierarchy makes client code dependent from the media on which entries of different kinds will be stored.

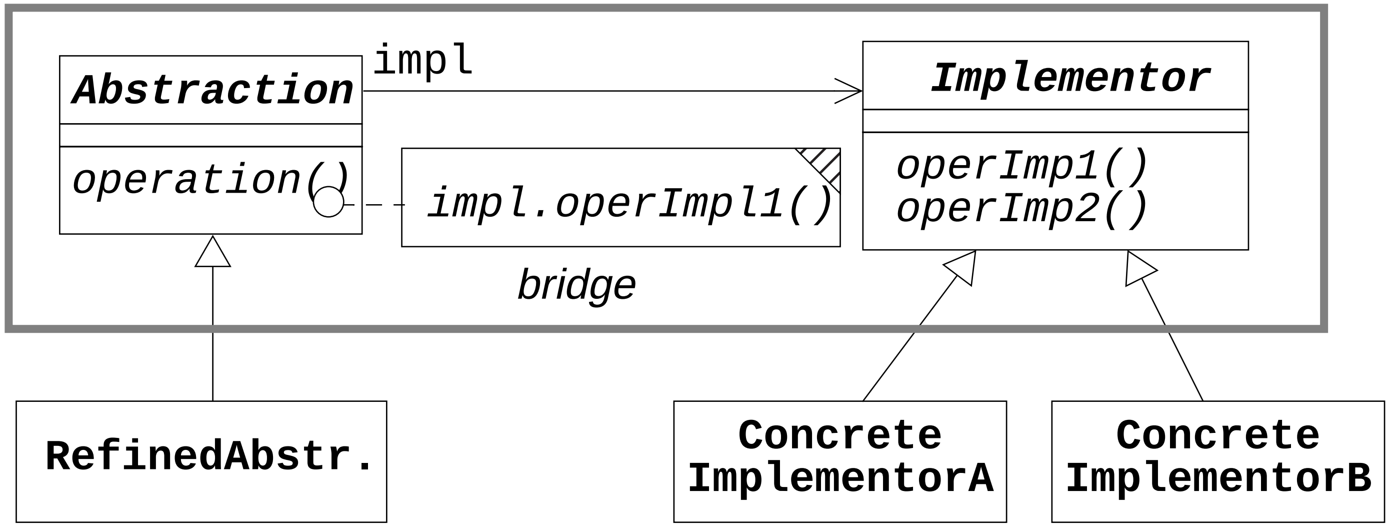
A better solution is based on the idea that the abstractions (`Entry`, `Task`) are separated from their implementation (Oracle DB, file system). The Bridge pattern addresses this problem:



Applicability

- Both, abstractions and implementations should be extensible by subclassing in different ways.
- Changes of the implementations should have no impact on clients.
- You want to avoid the proliferation of classes.

Structure



Participants

- **`Abstraction`** `(Entry)`:
  - defines the `Abstraction`'s interface
  - maintains a reference to an object of type `Implementor`
- **`RefinedAbstraction`** `(Task)`:
  - extends the interface defined by `Abstraction`
- **`Implementor`** `(PersistentObject)`:
  - defines an interface for implementation classes. This interface doesn't have to correspond exactly to `Abstraction's` interface. Typically, the `Implementor's` interface provides only primitive methods.
- **`ConcreteImplementor`** `(OraclePersistentObject`, `AccessP.O.)`:
  - implements the `Implementor`'s interface.

Collaborations

- `Abstraction` forwards client requests to its `Implementor` object.

Consequences

The bridge pattern has the following consequences:

- Decoupling of interface and implementation
- Improved extensibility
- Hiding implementation details from clients

Implementation

- Creating the *right* `Implementor`: you might use the Abstract Factory pattern
- Only *one* `Implementor`: the separation is still useful
- *Sharing* implementations: it's sometimes possible

Sample Code

We consider the example given in the motivation section. An abstraction of different kinds of entries is provided by the (here: *abstract*) class `Entry`:

```
public abstract class Entry {

   private PrimaryKey pk;
   private PersistentObject impl;
```

```
// Constructors:
// The first one is used for the first-time initialization
// of any kind of an Entry.
// The second one is used to recreate an Entry given a
// primary key.
protected Entry(String tableName,
   String[] colNames, Class[] colTypes) throws Exception
{
   impl = PersistentObjectFactory.getInstance()
      .makePersistentObject(tableName, colNames, colTypes);
}

protected Entry(String tableName, String[] colNames,
   Class[] colTypes, PrimaryKey pk) throws Exception
{
   this.pk = pk;
   impl = PersistentObjectFactory.getInstance()
   .makePersistentObject(tableName, colNames, colTypes, pk);
}
```

```
// Helper method that returns the concrete implementation.
protected PersistentObject getPersistentObject()
   throws Exception
{
   return impl;
}

// Helper methods that return the abstraction of the
// primary key. Objects of class PrimaryKey are
// serializable.
public final PrimaryKey getPrimaryKey() throws Exception
{
   if (pk != null) {
      return pk;
   } else {
      pk = getPersistentObject() .getPrimaryKey();
   }
   return pk;
}
```

```
    // Business methods:
    public abstract void setDate(Date date) throws Exception;
    public abstract Date getDate() throws Exception;
    public abstract void setText(String text) throws Exception;
    public abstract String getText() throws Exception;

    public abstract void destroy() throws Exception;

    // Enforcing the implementation of equals() and hashCode()
    // methods:
    public abstract boolean equals(Object o);
    public abstract int hashCode();
}
```

Notice that in the code above the constructors use the factory class `PersistentObjectFactory` (Abstract Factory pattern, Singleton pattern) for creating the correct implementation. This class returns the correct implementation (code not shown).

Subclasses of `Entry` define different kinds of entries the application might use.
For example, `Task` might look like:

```
public final class Task extends Entry
{
   private Object[] data = new Object[3];
   // data[0]: theDate, data[1]: theText, data[2]: thePriority

   static final String tableName = "TASK";
   static final String[] colNames = {
      "Datum", "Text", "Priority"
   };
   static final Class[] colTypes = {
      java.util.Date.class, java.lang.String.class,
      java.lang.Integer.class
   };
```

```
// First-time constructor for inexistent row in table.
public Task(Date date, String text, int priority)
   throws Exception
{
   super(tableName, colNames, colTypes);
   data[0] = date;
   data[1] = text;
   data[2] = new Integer(priority);
   getPersistentObject().initialize(data);
}

// Constructor for already persisted Task object.
public Task(PrimaryKey pk) throws Exception
{
   super(tableName, colNames, colTypes, pk);
   data = getPersistentObject().load();
}
```

```
// Implementation of business methods
public void setDate(Date date) throws Exception {
   data[0] = date;
   getPersistentObject().store(data);
}
public Date getDate() throws Exception {
   //..
}
public void setText(String text) throws Exception {
   //..
}
public String getText() throws Exception {
   //..
}
public void setPriority(int priority) throws Exception {
   //..
}
public int getPriority() throws Exception {
   //..
}
public void destroy() throws Exception {
   getPersistentObject().destroy(); }
```

```
// Helpers.
public boolean equals(Object o) {
   if (o instanceof Task) {
      try {
         return getPrimaryKey().equals(((Task) o)
                                      .getPrimaryKey());
      } catch (Exception e) {
         throw new RunTimeException(e);}
   }
   return false;
}

public int hashCode() {
   try {
      return getPrimaryKey() .hashCode();
   } catch (Exception e) {
         throw new RunTimeException(e);}
}

public String toString() {
   return data[0] .toString() + " " + ... ;
}
```

```
} // Task
```

Objects of kind `PrimaryKey` are a common abstraction of primary keys (also referred to as object identifiers OID). The field depends on the particular implementation used. For Oracle, for example, subclass `OraclePrimaryKey` is a concrete implementation:

```
public abstract class PrimaryKey implements Serializable {
   public abstract boolean equals(Object otherPrimaryKey);
   public abstract int hashCode();
}

public class OraclePrimaryKey extends PrimaryKey {
   int theKey;
   OraclePrimaryKey(int i) { theKey = i; }
   public boolean equals(Object otherPrimaryKey) {
      if ((otherPrimaryKey != null) &&
         otherPrimaryKey instanceof OraclePrimaryKey) {
         return true;
      } else { return false; }
   }
```

```
    public int hashCode() { return theKey; }
}
```

The implementation of a concrete subclass of `PrimaryKey` for Access contains a string as elementary key (code not shown).

An object of a subclass of `Entry` maintains a reference to `PersistentObject`, the abstract class that declares an interface to the underlying persistence implementations used:

```
public abstract class PersistentObject
{
   protected String tableName;
   protected String[] colNames;
   protected Class[] colTypes;

   protected PersistentObject(String tableName,
              String[] colNames, Class[] colTypes)
   {
      this.tableName = tableName;
      this.colNames = colNames;
      this.colTypes = colTypes;
   }
```

```
    public abstract PrimaryKey getPrimaryKey() throws Exception;
    public abstract void initialize(Object[] data) throws Ex.;
    public abstract void store(Object[] data) throws Exception;
    public abstract Object[] load() throws Exception;
    public abstract void destroy() throws Exception;
}
```

Concrete subclasses of `PersistentObject` implement the concrete kinds of `Entry` objects. For example, a sketch of an implementation using Oracle might look like:

```
public final class OraclePersistentObject
    extends PersistentObject
{
    private HashMap javaSqlTypeMap = new HashMap();

    private ConnectionManager cm;
    private int internalKey = -1; // effective value set later
```

```
// Constructors.
public OraclePersistentObject(String tableName,
   String[] colNames, Class[] colTypes) throws Exception
{
   super(tableName, colNames, colTypes);
   cm = ConnectionManager.getInstance();
   setInternalKey();
}

public OraclePersistentObject(String tableName,
   String[] colNames, Class[] colTypes,
   PrimaryKey pk) throws Exception
{
   super(tableName, colNames, colTypes);
   // The following line does not guarantee that
   // a corresponding row in the database really exists :-(
   this.internalKey = ((OraclePrimaryKey) pk) .theKey;
   cm = ConnectionManager.getInstance();
 }
```

```
// Helper method.
private void setInternalKey() throws Exception {
   if (internalKey < 0) { // Not yet associated with a row.
      Connection con = null;Statement stmt = null;
      ResultSet rs = null;
      try {
         con = cm.getConnection();
         stmt = con.createStatement();
         // Get unique OID. Oracle-specific.
         StringBuffer sqlCmd=new StringBuffer("SELECT ");
         sqlCmd.append(tableName);
         sqlCmd.append("_Seq.nextval FROM dual");
         rs = stmt.executeQuery(sqlCmd.toString());
         if (rs.next()) { internalKey = rs.getInt(1); }
      } catch (Exception e) { throw e; }
      finally {
         if (rs != null) rs.close();
         if (stmt != null) stmt.close();
         if (con != null) cm.close(con);
      }
   } // end of if (internalKey < 0)
 }
```

```
// Implementor's public methods
public PrimaryKey getPrimaryKey() throws Exception {
   return new OraclePrimaryKey(internalKey);
}

// ... turn over
```

```
public void initialize(Object[] data) throws Exception
{
   Connection con = null; PreparedStatement stmt = null;
   try {
      con = cm.getConnection();
      StringBuffer
         sqlCmd = new StringBuffer("INSERT INTO ");
      sqlCmd.append(tableName); sqlCmd.append(" ( ");
      sqlCmd.append("OID");
      for (int i = 0; i < colNames.length; i++) {
         sqlCmd.append(", "); sqlCmd.append(colNames[i]);
      }
      sqlCmd.append(" ) VALUES ( "); sqlCmd.append(" ? ");
      for (int i = 0; i < colNames.length; i++) {
         sqlCmd.append(", ? ");
      }
      sqlCmd.append(" )");
      stmt = con.prepareStatement(sqlCmd.toString());
      stmt.setInt(1, internalKey);
      for (int i = 0; i < colNames.length; i++) {
         dynamicDispatchSetXxxMethod(stmt, i+2, data[i]);
      }
```

```
            stmt.executeUpdate();
         } catch (Exception e) {
            throw e;
         } finally {
            if (stmt != null) stmt.close();
            if (con != null) cm.close(con);
         }
      }

      public void store(Object[] data) throws Exception
      {
         Connection con = null;
         PreparedStatement stmt = null;
         // Use SQL UPDATE, code not shown...
      }
```

```
public Object[] load() throws Exception
{
   Connection con = null;
   Statement stmt = null;
   ResultSet rs = null;
   Object[] data = null;
   // Use SQL SELECT, code not shown...
   }
   return data;
}

public void destroy() throws Exception {
   // Use SQL DELETE, code not shown...
}
```

```
// Further private helper methods.
private void setupDefaultJavaSqlTypeMap() {
   javaSqlTypeMap.put(java.lang.String.class,
      "VARCHAR2(40)");
   // Integer --> "NUMBER"
}
private java.util.Date
   convertTimestamp(java.sql.Timestamp t) throws Exception {
   //...
}
private java.sql.Timestamp convertDate(java.util.Date d) {
   //...
}
```

```
    private void dynamicDispatchSetXxxMethod(
    PreparedStatement stmt, int pos, Object o) throws Exception
    {
       //..
    }
    private Object dynamicDispatchGetXxxMethod(
       ResultSet rs, int pos) throws Exception {
       //...
    }
    private String sqlTypeName(int type) {
       //...
    }
} // OraclePersistentObject
```

Implementing entries using Access differs. For example, we use a different sub-class of `PrimaryKey` to handle primary keys, as well a different kinds or Java to SQL type mappings. An excerpt of class `AccessPersistentObject` might look like:

```
public class AccessPersistentObject extends PersistentObject {
   // utilities for conversions
   private HashMap javaSqlTypeMap = new HashMap();
   private HashMap sqlJavaTypeConversionMap = new HashMap();
   private HashMap javaSqlTypeConversionMap = new HashMap();
   private ConnectionManager cm;

   // Assume that internalKey is appropriately set in the
   // construcors.
   private String internalKey;

   //...

   public PrimaryKey getPrimaryKey() throws Exception {
      return new AccessPrimaryKey(internalKey);
   }
```

```
private void setPrimaryKey() throws Exception {
   if (internalKey == null) {
      Connection con = null;
      Statement stmt = null;
      ResultSet rs = null;
      java.util.Date date = new java.util.Date();
      // Not bullet-proof, however:
      String internalKey = String.valueOf(date.getTime());
      try {
         con = cm.getConnection();
         stmt = con.createStatement();
         String sqlCommand = "INSERT INTO ";
         sqlCommand += tableName + " ( OID ) ";
         sqlCommand += "VALUES ( ’" + internalKey + "’ )";
         stmt.execute(sqlCommand);
      } catch (Exception e) {
         throw e;
      } finally {
         if (stmt != null) stmt.close();
         if (con != null) cm.close(con);
      }
   }  }
```

```
    private void setupDefaultJavaSqlTypeMap() {
       javaSqlTypeMap.put(java.lang.String.class,  "VARCHAR");
       javaSqlTypeMap.put(java.lang.Integer.class, "LONG");
       ...
    }

    private void setupDefaultSqlJavaTypeConversionMap() {...}
    private void setupDefaultJavaSqlTypeConversionMap() {...}

    // Conversion methods, not shown...

 } // AccessTable
```

Known Uses

Java AWT is built upon the Bridge pattern. JNDI uses the Bridge pattern in two ways:

- The JNDI service API (used by *clients*) corresponds to the `Abstraction` (`Entry`) class.
- The `Implementor` (`PersistentObject`) class defines the hooks for the implementor of a particular *service provider*.

Related Patterns

- Abstract Factory and/or Factory Method can create and configure particular bridges.