Patterns of Enterprise Application Architecture

Martin Fowler
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525 pages
Ref: http://nida.se/patterns/poeaa/index.html

A. Domain Logic Patterns

1. Transaction Script (pp 100-115)

Goal: Organizes business logic by procedures where each procedure handles a single request from the presentation.

How:
```
abstract class TransactionScript {
  abstract void run()
}
```

2. Domain Model (pp 116-124)

Goal: An object model of the domain that incorporates both behavior and data.

3. Table Module (pp 125-132)

Goal: A single instance that handles the business logic for all rows in a database table or view.

4. Service Layer (pp 133-142)

Goal: Defines an application's boundary with a layer of services that establishes a set of available operations and coordinates the application's response in each operation.

B. Data Source Architectural Patterns

When the database is the master model.

```
CREATE TABLE PERSON (
  ID : INTEGER
  LAST_NAME : VARCHAR()
  ..
)
```

5. Table Data Gateway (pp 144-151)

Goal: An object that acts as a Gateway to a database table. One instance handles all the rows in the table.

How:

```
class PersonGateway {
  find(int) : ResultSet
  findWithLastName(String) : ResultSet
  update(id, name)
  insert(id, name)
  delete(id)
}
```

6. Row Data Gateway (pp 145-159)

Goal: An object that acts as a Gateway to a single record in a data source. There is one instance per row.

How:

```
class PersonFinder {
   find(id) : Person
   findWithLastName(String) : Person[]
}

class Person {
  int id;
  String lastName;
  insert()
  update()
  delete()
}
```

7. Active Record (pp 160-164)

Goal: An object that wraps a row in a database table or view, encapsulates the database access, and adds domain logic on that data.

How:

```
class Person {
  int id;
  String lastName;

  //mapper methods
  insert();
  update();
  delete();

  //behavioral methods
  getExemption();
  isFlaggedForAudit();
  getTaxableEarnings();
}
```

Same as Row Data Gateway, but add behavioral methods. Good if domain logic is not too complex.

8. Data Mapper (pp 164-181)

Goal: A layer of Mappers that movers data between objects and a database while keeping them independent of each other and the mapper itself.

How:

```
class Person {
  int id;
  String lastName;

  //behavioral methods
  getExemption();
  isFlaggedForAudit();
  getTaxableEarnings();
}
```

```
abstract class AbstractMapper {
  //mapper methods
  public abstract insert();
  public abstract update();
  public abstract delete();
  protected find(id);
  protected load();
}

class PersonMapper extends AbstractMapper {
  Person person;
  String tablename;
}
```

Advantage: object model and database schema may evolve independently.

C. Object-Relational Behavioral Patterns

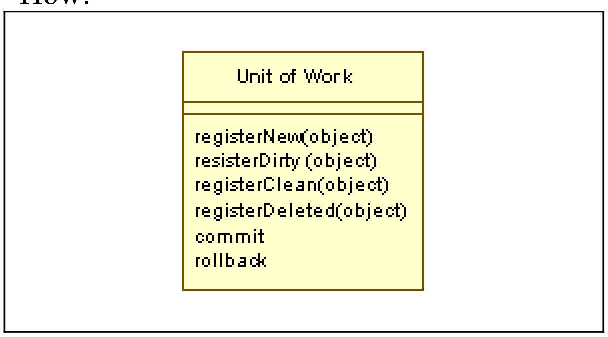
9. Unit of Work (Transaction) (pp 184-194)

Goal: Maintains a list of objects affected by a business transaction and coordinates the writing out of changes and the resolution of concurrency problems.

Unit of works follow the ACID principles:

- **A**tomicity: everything is committed or everything is rolled back
- **C**onsistency: the system must be in a consistent, non-corrupt state just before the start of the transaction and right after its completion.
- **I**solation: the changes are not visible to any other transaction until the transaction successfully commits.
- **D**urability: after the commit, changes are persistent.

How:



Essential if objects are persisted in a DBMS; useful otherwise.

Instead of updating the DBMS table at each change in the object model (which leads to lots of DB calls), register objects in a cache and perform the change at the commit time.

Advantages:

- Centralize the DB calls in one place, the commit() method
- Undo/Redo easy to implement once we have defined a "unit of work"

10. Identity Map (pp 195-199)

Goal: Ensures that each object gets loaded only once by keeping every loaded object in a map. Looks for objects using the map when referring to them.

11. Lazy Load (pp 200-214)

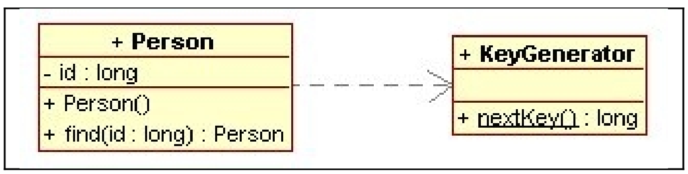
Goal: An object that doesn't contain all the data you need but knows how to get it

D. Object-Relational Structural Patterns

When the object model is the master model.

12. Identity Field (pp 216-235)

Goal: Saves a database ID in an object to maintain identity between an in-memory object and a database row.



Variants:

- if Person() constructor is public, generates the key and stores in the DB.
- if Person() constructor is private, the find() method looks for a key generated by the DBMS (e.g. Oracle SEQUENCE data type).

Recommendations:

- Prefer meaningless key (a surrogate ID) to meaningful key (eg: a U.S. Security Number).
- Prefer simple key (one column) to compound key (on two or more columns).
- Prefer database-unique key to table-unique key.
- Prefer long integer type to String type.

13. Foreign Key Mapping (pp 236-247)

Goal: Maps an association between objects to a foreign key reference between tables.

How (with single-value association) :

//classes (the master model)
class Artist {
}
 	
class Album {
  Artist artist;
}
	//the schema generated from the OO model
	create table ARTIST (
	  long ID
	)
	
	create table ALBUM (
	  long ID,
	  long ARTIST_ID
	)

With a collection of objects, the reference is reversed:

//classes (the master model)
class Track{
}
 	
class Album {
  Track[] tracks;
}
	create table TRACK (
	  long ID,
	  long ALBUM_ID
	)
	
	create table ALBUM (
	  long ID,
	)

Limitation: many-to-many association not supported (see Association Table Mapping)

14. Association Table Mapping (pp 248-261)

Goal: Saves an association as a table with foreign keys to the tables that are linked by the association.

How:

//classes (the master model)
class Skill {
}
 	
class Employee {
  //the same skill can be shared
  //among employees
  List<Skill> skills;
}
	//the schema generated from the OO model
	create table SKILL (
	  long ID (PK)
	)
	
	create table EMPLOYEE (
	  long ID (PK)
	)
	
	create table SKILL-EMPLOYEES (
	  SKILL_ID long,
	  EMPLOYEE_ID long,
	  PK(SKILL_ID, EMPLOYEE_ID)
	)

No: the table SKILL-EMPLOYEES as no ID, because has no corresponding in-memory object. The PK is the compound of the two FKs.

15. Dependent Mapping (pp 248-267)

Goal: Has one class perform the database mapping for a child class.

How:

//a track cannot exist w/o its album
class Track{
  protected Track(Album owner);
}
 	
class Album {
  Track createTrack() {
    new Track(this);
  }
}
	create table TRACK (
	  long ID,
	  long ALBUM_ID,
	  PK(ID, ALBUM_ID)
	)
	
	create table ALBUM (
	  long ID,
	)

16. Embedded Value (pp 268-271)

Goal: Maps an object into several fields of another object's table.

How:

class Order{
  Address billTo,
  Address shipTo
}
 	
class Address {
  int civicNumber,
  String streetName,
  String city,
  String ZIPCode
}
	CREATE TABLE ORDER (
	  BILL_TO_CIVIC_NUMBER,
	  BILL_TO_STREET_NAME,
	  BILL_TO_CITY,
	  BILL_TO_ZIP_CODE,
	  SHIP_TO_CIVIC_NUMBER,
	  SHIP_TO_STREET_NAME,
	  SHIP_TO_CITY,
	  SHIP_TO_ZIP_CODE,
	)

Advantage: eliminate joint operations in a relational database.

17. Serialized LOB (pp 272-277)

Goal: Saves a graph of objects by serializing them into a single large object (LOB), which it stores in a database field.

How:

class Customer{
   Department[] getDepartments()
}
 	
class Department {
  Department getParent()
  Department[] getChildren()
}
	CREATE TABLE CUSTOMERS (
	  DEPARTMENTS : BLOB
	)

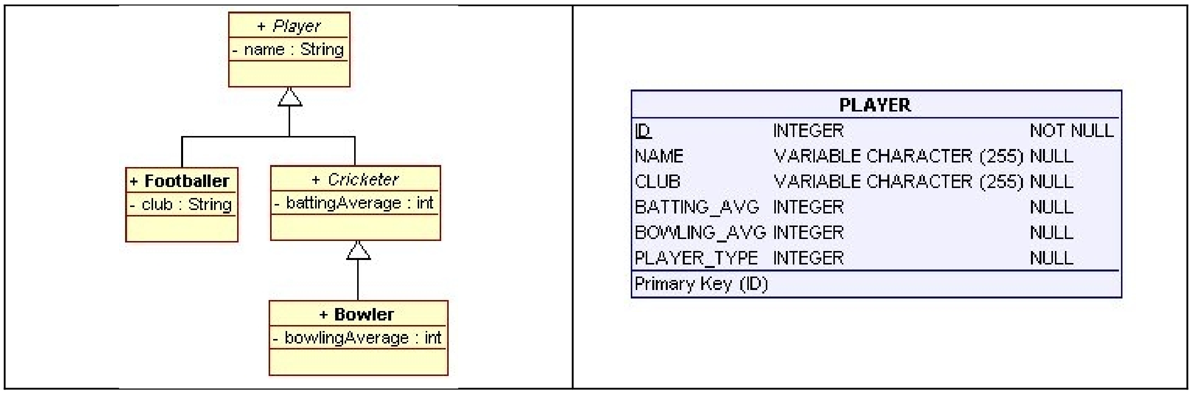
Advantage: eliminate a graph of small database rows:

Inconvenient: the department structure only visible in the object side (hidden in the relational database).

18. Single Table Inheritance (pp 278-284)

Goal: Represents an inheritance hierarchy of classes as a single table that has columns for all the fields of the various classes.

How:



Strengths:

- No joint in retrieving data (fast).
- Refactoring the class model by moving a field upward or downward in the hierarchy does not affect the database.

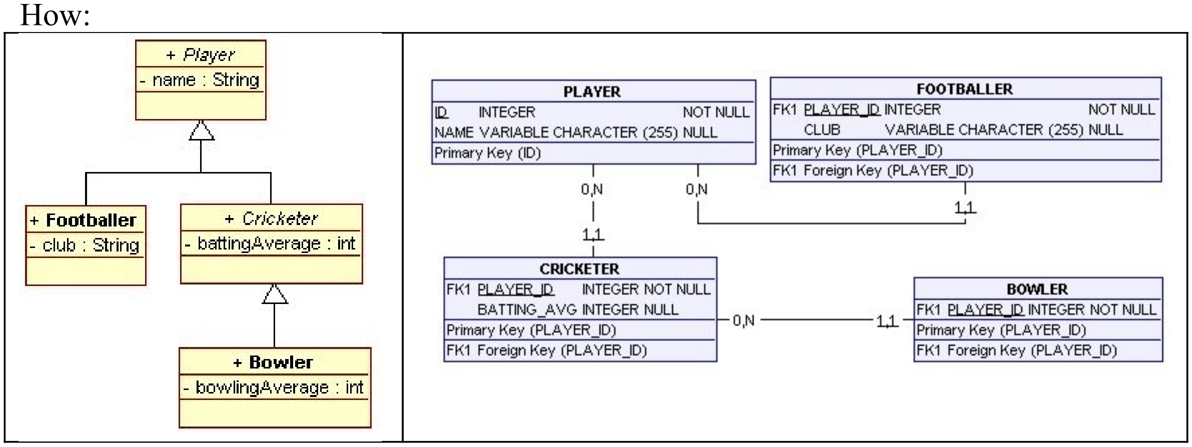
Weaknesses:

- Some columns are irrelevant depending PLAYER_TYPE (wasted space).
- Table may have too many columns; name conflict may occur.

19. Class Table Inheritance (pp 285-292)

Goal: Represents an inheritance hierarchy of classes with one table for each class.

How:



Strengths:

- All columns are relevant for each row: no wasted space
- The database model reflects the OO model (easy to understand)

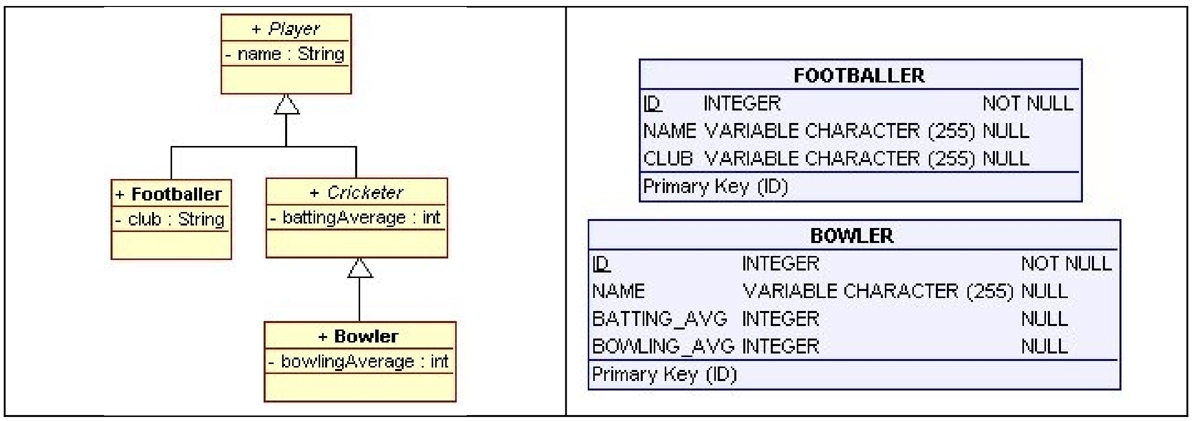
Weaknesses:

- You need to touch multiple tables to load an object: many joints (slow)
- Any refactoring in the OO model affects the database design
- The supertype (PLAYER) may become a bottleneck because they have to be accessed frequently.

20. Concrete Table Inheritance (pp 293-301)

Goal: Represents an inheritance hierarchy of classes with one table per concrete class in the hierarchy.

How:



Strengths:

- Each table is self-contained and has no irrelevant fields (no wasted space)
- There are no joins to do when reading the data (fast)

Weaknesses:

- PKs can be difficult to handle.
- You can't enforce database relationship to abstract classes.
- If superclass field changes, you need to change each table that has this field because the superclass field is duplicated across the tables.
- A find on the superclass forces you to query all the tables (e.g. Select * from <tables> where name equals "Smith").

21. Inheritance Mappers (pp 302-304)

Goal: A structure to organize database mappers that handle inheritance hierarchies.

E. Object-Relational Metadata Mapping Patterns

22. Metadata Mapping (pp 306-304)

Goal: Holds details of object-relational mapping in metadata.

How:

```
class DataMap {
  Class domainClass,
  String tableName,
  ColumnMap[] columns,
}
```

```
class ColumnMap {
  String fieldName,
  String columnName,
}
```

23. Query Object (pp 316-321)

Goal: An object that represents a database query.

How:

```
class Query {
  Criterion[] criteria; //linked by AND

  addCriterion(criterion);
}
```

```
class Criterion{
  String operator = "<",
  String field = "salary",
  Object value = 50;
}
```

How (most sophisticated):

```
class Query {
  ICriterion criterion;


}

interface ICriterion{
}
```

```
class SimpleCriterion -> ICriterion {
  String operator = "<",
  String field = "salary",
  Object value = 50;
}

class CompoundCriterion -> ICriterion {
  booleanOperator {OR, AND, XOR}
  leftOperand: ICriterion,
  rightOperand: ICriterion,
}
```

Advantage: hides SQL queries, changing column names does not affect Java code.

24. Repository (pp 322-327)

Goal: Mediates between the domain and the data mapping layers using a collection-like interface for accessing domain objects.

How:

abstract class Repository {
  protected List matching(Criteria);
}
	class RelationalStrategy extends Repository {
	}
	
	class InMemoryStrategy extends Repository {
	}

F. Web Presentation Patterns

25. Model View Controller (pp 330-332)

Goal: Splits user interface interaction into three distinct roles.

Advantages:

- Different concerns. Often people prefer one area to another and they specialize in one side of the line.
- Multiple presentations (rich client, web browser, command-line interface) for the same model.
- Nonvisual objects easier to test than visual ones; test domain logic w/o awkward GUI scripting tools.

26. Page Controller (pp 333-343)

Goal: An object that handles a request for a specific page or action on a Web site.

How:

client (web browser)	class PageController {
	  //handle HTTP get and post
	
	  //decide which model and
	  //view to use
	}
		class Model {
		}
		
		class View {
		  //generate HTML
		}

27. Front Controller (pp 344-349)

Goal: A controller that handles all requests for a Web site.

How:

class Handler {
  doGet();
  doPost();
}
	interface ICommand {
	  process()
	}
	
	class Command -> ICommand {
	}

28. Template View (pp 350-360)

Goal: Renders information into HTML by embedding markers in an HTML page.

29. Transform View (pp 361-364)

Goal: A view that processes domain data element by element and transforms it into HTML.

30. Two Step View (pp 365-378)

Goal: Turns domain data into HTML in two steps: first by forming some kind of logical page, then rendering the logical page into HTML.

31. Application Controller (pp 379-386)

Goal: A centralized point for handling screen navigation and the flow of an application.

G. Distribution Patterns

32. Remote Facade (pp 388-400)

Goal: Provides a coarse-grained facade on fine-grained objects to improve efficiency over a network.

33. Data Transfer Object (pp 401-413)

Goal: An object that carries data between processes in order to reduce the number of method calls.

H. Offline Concurrency Patterns

34. Optimistic Offline Lock (pp 416-425)

Goal: Prevents conflicts between concurrent business transactions by detecting a conflict and rolling back the transaction.

Optimistic assumes that the chances of conflict is low: it is not likely that multiple users to work with the same data in the same time.

How:

```
WriteTransaction tx = session.createWriteTransaction();

try {
   data.write(tx, newvalue); //throw exception if data is being written by another user
   tx.commit();
} catch (DbException ex) {
   tx.rollback(); //data set back to oldvalue
}
```

35. Pessimistic Offline Lock (pp 426-437)

Goal: Prevents conflicts between concurrent business transactions by allowing only one business transaction at a time to access data.

Pessimistic assumes that the chances of conflict is low: it is likely that multiple users to work with the same data in the same time.

Different strategies:

- Exclusive write lock: no more than one write transaction in the same time. Acceptable for non-critical operations.
- Exclusive read-lock: no more than one transaction (read or write) in the same time.
- Read/write lock: a write lock blocks either write or read transactions; concurrent read locks are acceptable (the best strategy, but the most complicated to implement).

How:

```
try {
  //throw ConcurrencyException if Data.class locked by another user
  WriteTransaction tx = session.createWriteTransaction(data.class);
  data.write(tx, newvalue);
  tx.commit();
} catch (ConcurrencyException ex) {
   //report exception
}
```

36. Coarse-Grained Lock (pp 438-448)

Goal: Locks a set of related objects with a single lock.

How:

```
class Version {
  int ID;
  static Version create(); //increment id
  static Version load(id);
}
```

```
class Customer {
  Version version;
  Address[] addresses;
}

class Address {
  Customer owner;
  Version version = owner.version;
}
```

37. Implicit Lock (pp 449-453)

Goal: Allows framework or layer supertype code to acquire offline locks.

How:

```
class BusinessTransaction {
  HibernateTransaction tx_m;

  BusinessTransaction() {
    tx_m = new HibernateTransaction();
  }
  ..

  void commit() {
    tx_m.commit();
  }
}
```

```
HibernateTransaction {
   ...
}
```

I. *Session State Patterns*

38. Client Session State (pp 456-461)

Goal: Stores session state on the client.

39. Database Session State (pp 462-464)

Goal: Stores session data as committed data in the database.

J. Base Patterns

40. Gateway (pp 466-472)

Goal: An object that encapsulates access to an external system or resource.

41. Mapper (pp 473-474)

Goal: An object that sets up a communication between two independent objects.

42. Layer Supertype (p 475)

Goal: A type that acts as the supertype of all types in its layer.

43. Separate interface (pp 476-479)

Goal: Defines an interface in a separate package from its implementation.

44. Registry (pp 480-485)

Goal: A well-known object that other objects can use to find common objects and services.

45. Value Object (pp 486-487)

Goal: A small simple object, like money or a date range, whose equality isn't based on identity.

How:

```
class Address {
  //fields: civic number, street name, etc..

  public boolean equals(Object other) { //overrides java.lang.Object
    return (other instanceof Address) && (equals(Address)other);
 }

  public boolean equals(Address addr) {
    compare fields..
  }

  public int hash() { //everytime we define equals(), we must redefine hash()
  }
}
```

46. Money (pp 488-495)

Goal: Represents a monetary value

How:

```
class Money {
  //amount of cents, or the smaller base unit, enough to store 92 223 720 G$..
  long amount_m;
  Currency currency;

  //amount in dollars
  Money(long amount, currency) {
    amount_m = amount * centFactor();
  }

 Money(double amount, currency) {
   amount_m = Math.round(amount * centFactor());
 }

 Money(double amount) {
   this(amount, Currency.USD);
 }

 //compareTo
 public int compareTo(Object other) {
   return compareTo(Money)other);
 }
 public int compareTo(Money other) {
   assertSameCurrencyAs(other);
   if (amount < other.amount) return -1;
   else if (amount == other.amount) return 0;
   else return 1;
 }

 public boolean greaterThan(Moner other) { return (compareTo(other) > 0); }

 //define equals() & hashCode()

 //monetary operations
 Money add(Moner other) {
   assertSameCurrency(other);
   return new Money(amount + other.amount);
 }

 Money multiply(double factor, int roundingMode) { //to solve Foemmel's Conundrum
 }
}
```

47. Special Case (pp 496-498)

Goal: A subclass that provides special behavior for particular class.

48. Plugin (pp 499-503)

Goal: Links classes during configuration rather than compilation.

49. Service Stub (pp 504-507)

Goal: Removes dependence upon problematic services during testing.

50. Record Set (pp 508-510)

Goal: An in-memory representation of tabular data.

Missing:
 nullable,
 indexes