

The ABEL Persistence Library Tutorial

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Chapter 1

Introducing ABEL

ABEL (A Better EiffelStore Library) is an object-oriented persistence library written in Eiffel and aiming at seamlessly integrating various kinds of data stores.

1.1 Setting things up

ABEL is shipped with EiffelStudio in the *unstable* directory. You can get the latest code from the SVN directory ¹.

If you want to modify the sample code used in this tutorial, just check out the tutorial code from SVN ².

1.2 Getting started

We will be using *PERSON* objects to show the usage of the API. In the source code below you will see that ABEL handles objects "as they are", meaning that to make them persistent you don't need to add any dependencies to their class source code.

```
class PERSON
```

```
3 create  
   make
```

¹<https://svn.eiffel.com/eiffelstudio/trunk/Src/unstable/library/persistence/abel>

²https://svn.eiffel.com/eiffelstudio/trunk/Src/unstable/library/persistence/abel/sample/tutorial_api

```

6 feature {NONE} -- Initialization

    make (first, last: STRING)
9    -- Create a newborn person.
    require
        first_exists: not first.is_empty
12    last_exists: not last.is_empty
    do
        first_name := first
15    last_name := last
        age := 0
    ensure
18    first_name_set: first_name = first
        last_name_set: last_name = last
        default_age: age = 0
21    end

feature -- Basic operations
24
    celebrate_birthday
        -- Increase age by 1.
27    do
        age := age + 1
    ensure
30    age_incremented_by_one: age = old age + 1
    end

33 feature -- Access

    first_name: STRING
36    -- The person's first name.

    last_name: STRING
39    -- The person's last name.

    age: INTEGER
42    -- The person's age.

invariant
45    age_non_negative: age >= 0
    first_name_exists: not first_name.is_empty
    last_name_exists: not last_name.is_empty

```

48 **end**

Listing 1.1: The *PERSON* class

There are three very important classes in ABEL:

- The deferred class *PS_REPOSITORY* provides an abstraction to the actual storage mechanism. It can only be used for read operations.
- The *PS_TRANSACTION* class represents a transaction and can be used to execute read, insert and update operations. Every *PS_TRANSACTION* object is bound to a *PS_REPOSITORY*.
- The *PS_OBJECT_QUERY* [*G*] class is used to describe a read operation over objects of type *G*. You can execute such a query in the *PS_EXECUTOR*. The result will be objects of type *G*.

To start using the library, we first need to create a *PS_REPOSITORY*. For this tutorial we are going to use an in-memory repository to avoid setting up any external database. Each ABEL backend will ship a repository factory class to make initialization easier. The factory for the in-memory repository is called *PS_IN_MEMORY_REPOSITORY_FACTORY*.

```
class START

3 create
  make

6 feature {NONE} -- Initialization

  make
  -- Initialization for 'Current'.
  local
    factory: PS_IN_MEMORY_REPOSITORY_FACTORY
12 do
    create factory
    repository := factory.new_repository
15
    create criterion_factory
    explore
18 end

  repository: PS_REPOSITORY
21 -- The main repository.
```

end

24

end

Listing 1.2: The START class

We will use `criterion_factory` later in this tutorial. The feature `explore` will guide us through the rest of this API tutorial and show the possibilities in ABEL.

Chapter 2

Basic operations

2.1 Inserting

You can insert a new object using feature *insert* in *PS_TRANSACTION*. As every write operation in ABEL needs to be embedded in a transaction, you first need to create a *PS_TRANSACTION* object. Let's add three new persons to the database:

```
insert_persons
-- Populate the repository with some person objects.
3  local
    p1, p2, p3: PERSON
    transaction: PS_TRANSACTION
6  do
    -- Create persons
    create p1.make (...)
9    create ...

    -- We first need a new transaction.
12   transaction := repository.new_transaction

    -- Now we can insert all three persons.
15   transaction.insert (p1)
    transaction.insert (p2)
    transaction.insert (p3)
18
    -- Don't forget to commit.
    transaction.commit
21 end
```

Listing 2.1: Insertion code.

2.2 Querying

A query for objects is done by creating a *PS_OBJECT_QUERY* [*G*] object and executing it using features of *PS_REPOSITORY* or *PS_TRANSACTION*. The generic parameter *G* denotes the type of objects that should be queried.

After a successful execution of the query, you can iterate over the result using the **across** syntax. The feature *print_persons* below shows how to get and print a list of persons from the repository:

```
print_persons
  -- Print all persons in the repository
3  local
    query: PS_OBJECT_QUERY[PERSON]
  do
6    -- First create a query for PERSON objects.
    create query.make

9    -- Execute it against the repository.
    repository.execute_query (query)

12   -- Iterate over the result.
    across
      query as person_cursor
15   loop
      print (person_cursor.item)
    end
18
    -- Don't forget to close the query.
    query.close
21 end
```

Listing 2.2: Print all PERSON objects.

In a real database the result of a query may be very big, and you are probably only interested in objects that meet certain criteria, e.g. all persons of age 20. You can read more about it in Chapter 3.

Please note that ABEL does not enforce any kind of order on a query result.

2.3 Updating

Updating an object is done through feature *update* in *PS_TRANSACTION*. Like the insert operation, an update needs to happen within a transaction.

Note that in order to *update* an object, we first have to retrieve it.

Let's update the *age* attribute of Berno Citrini by celebrating his birthday:

```
update_berno_citrini
-- Increase the age of Berno Citrini by one.
3  local
    query: PS_OBJECT_QUERY[PERSON]
    transaction: PS_TRANSACTION
6  berno: PERSON
do
    print ("Updating Berno Citrini's age by one.%N")
9
    -- Create query and transaction.
    create query.make
12   transaction := repository.new_transaction

    -- As we're doing a read followed by a write, we
15   -- need to execute the query within a transaction.
    transaction.execute_query (query)

18   -- Search for Berno Citrini
    across
        query as cursor
21   loop
        if cursor.item.first_name ~ "Berno" then
            berno := cursor.item
24
            -- Change the object.
            berno.celebrate_birthday
27
            -- Perform the database update.
            transaction.update (berno)
30   end
end

33   query.close
    transaction.commit
end
```

Listing 2.3: Update Berno Citrini's age.

To perform an update the object first needs to be retrieved or inserted within the same transaction. Otherwise ABEL cannot map the Eiffel object to its database counterpart (see also Section 2.5).

2.4 Deleting

ABEL does not support explicit deletes any longer, as it is considered dangerous for shared objects. Instead of deletion it is planned to introduce a garbage collection mechanism in the future.

2.5 Dealing with Known Objects

Within a transaction ABEL keeps track of objects that have been inserted or queried. This is important because in case of an update, the library internally needs to map the object in the current execution of the program to its specific entry in the database.

Because of that, you can't update an object that is not yet known to ABEL. As an example, the following functions will fail:

```

    failing_update
      -- Trying to update a new person object.
3    local
      bob: PERSON
      transaction: PS_TRANSACTION
6    do
      create bob.make ("Robert", "Baratheon")
      transaction := repository.new_transaction
9      -- Error: Bob was not inserted / retrieved before.
      transaction.update (bob)
      transaction.commit
12    end

    update_after_commit
15    -- Update after transaction committed.
    local
      joff: PERSON
18    transaction: PS_TRANSACTION
    do
      create joff.make ("Joffrey", "Baratheon")
21    transaction := repository.new_transaction
      transaction.insert (joff)
      transaction.commit
24
      joff.celebrate_birthday

27    -- Prepare can be used to restart a transaction.
```

```

transaction.prepare
30      -- Error: Joff was not inserted / retrieved before.
transaction.update (joff)

33      -- Note: After commit and prepare, 'transaction'
      -- represents a completely new transaction.
end

```

Listing 2.4: Common pitfalls with update.

The feature *is_persistent* in *PS_TRANSACTION* can tell you if a specific object is known to ABEL and hence has a link to its entry in the database.

Chapter 3

Advanced Queries

3.1 The query mechanism

As you already know from Section 2.2, queries to a database are done by creating an object of type *PS_OBJECT_QUERY[G]* and executing it against a *PS_TRANSACTION* or *PS_REPOSITORY*. The actual value of the generic parameter *G* determines the type of the objects that will be returned. At the moment descendants of *G* will not be loaded, but this behaviour may change in the future.

ABEL will by default load an object completely, meaning all objects that can be reached by following references will be loaded as well (see also Chapter 4).

3.2 Criteria

You can filter your query results by setting criteria in the query object, using feature *set_criterion* in *PS_OBJECT_QUERY*. There are two types of criteria: predefined and agent criteria.

3.2.1 Predefined Criteria

When using a predefined criterion you pick an attribute name, an operator and a value. During a read operation, ABEL checks the attribute value of the freshly retrieved object against the value set in the criterion, and filters away objects that don't satisfy the criterion.

Most of the supported operators are pretty self-describing (see class *PS_CRITERION_FACTORY* in Section 3.2.3). An exception could be the **like** operator, which does pattern-matching on strings. You can provide the

like operator with a pattern as a value. The pattern can contain the wildcard characters `*` and `?`. The asterisk stands for any number (including zero) of undefined characters, and the question mark means exactly one undefined character.

You can only use attributes that are strings or numbers, but not every type of attribute supports every other operator. Valid combinations for each type are:

- Strings: `=`, `like`
- Any numeric value: `=`, `<`, `<=`, `>`, `>=`
- Booleans: `=`

Note that for performance reasons it is usually better to use predefined criteria, because they can be compiled to SQL and hence the result can be filtered in the database.

3.2.2 Agent Criteria

An agent criterion will filter the objects according to the result of an agent applied to them.

The criterion is initialized with an agent of type `PREDICATE [ANY, TUPLE [ANY]]`. There should be either an open target or a single open argument, and the type of the objects in the query result should conform to the agent's open operand. For an example see Section 3.2.3.

3.2.3 Creating criteria objects

The criteria instances are best created using the `CRITERION_FACTORY` class.

The main features of the class are the following:

```

class
    PS_CRITERION_FACTORY
3 create
    default_create

6 feature -- Creating a criterion

    new_uniform alias "[" (tuple: TUPLE [ANY]): PS_CRITERION
9    -- Creates a new criterion according to a 'tuple'
    -- containing either a single PREDICATE or three
    -- values of type [STRING, STRING, ANY].

```

```

12     new_agent (a_predicate: PREDICATE [ANY, TUPLE [ANY]]):
        PS_CRITERION
        -- Creates an agent criterion.
15     new_predefined (object_attribute: STRING;
        operator: STRING; value: ANY): PS_CRITERION
18     -- Creates a predefined criterion.

feature -- Operators
21     equals: STRING = "="
24     greater: STRING = ">"

        greater_equal: STRING = ">="
27     less: STRING = "<"

        less_equal: STRING = "<="
30     like_string: STRING = "like"
33 end

```

Listing 3.1: The *CRITERION_FACTORY* class interface

Assuming you have an object *f*: *PS_CRITERION_FACTORY*, to create a new criterion you have two possibilities:

- The “traditional” way
 - *f.new_agent (agent an_agent)*
 - *f.new_predefined (an_attr_name, an_operator, a_val)*
- The “syntactic sugar” way
 - *f[[an_attr_name, an_operator, a_value]]*
 - *f[[agent an_agent]]*

caption=The *PS_CRITERION_FACTORY* interface

```

create_criteria_traditional : PS_CRITERION
3  -- Create a new criteria using the traditional approach.
  do
    -- for predefined criteria
6    Result :=
      factory.new_predefined ("age", factory.less, 5)

    -- for agent criteria
    Result :=
      factory.new_agent (agent age_more_than (?, 5))
12  end

create_criteria_double_bracket : PS_CRITERION
15  -- Create a new criteria using the double bracket syntax
    .
  do
    -- for predefined criteria
18    Result := factory[["age", factory.less, 5]]

    -- for agent criteria
21    Result := factory[[agent age_more_than (?, 5)]]
  end

24  age_more_than (person: PERSON; age: INTEGER): BOOLEAN
    -- An example agent
  do
27    Result := person.age > age
  end

```

Listing 3.2: Different ways of creating criteria.

3.2.4 Combining criteria

You can combine multiple criterion objects by using the standard Eiffel logical operators. For example, if you want to search for a person called “Albo Bitossi” with $age \leq 20$, you can just create a criterion object for each of the constraints and combine them:

```

1  composite_search_criterion : PS_CRITERION
    -- Combining criterion objects.
4  local
    first_name_criterion: PS_CRITERION

```

```

    last_name_criterion: PS_CRITERION
7   age_criterion: PS_CRITERION
do
    first_name_criterion:=
10    factory[[ "first_name", factory.equals, "Albo" ]]

    last_name_criterion :=
13    factory[[ "last_name", factory.equals, "Bitossi" ]]

    age_criterion :=
16    factory[[ agent age_more_than (?, 20) ]]

    Result := first_name_criterion and last_name_criterion
           and not age_criterion
19
    -- Using double brackets for compactness.
    Result := factory[[ "first_name", "=", "Albo" ]]
22    and factory[[ "last_name", "=", "Bitossi" ]]
    and not factory[[ agent age_more_than (?, 20) ]]
end

```

Listing 3.3: Combining criteria.

ABEL supports the three standard logical operators **AND**, **OR** and **NOT**. The precedence rules are the same as in Eiffel, which means that **NOT** is stronger than **AND**, which in turn is stronger than **OR**.

Chapter 4

Dealing with references

In ABEL, a basic type is an object of type *STRING*, *BOOLEAN*, *CHARACTER* or any numeric class like *REAL* or *INTEGER*. The *PERSON* class only has attributes of a basic type. However, an object can contain references to other objects. ABEL is able to handle these references by storing and re-constructing the whole object graph (an object graph is roughly defined as all the objects that can be reached by recursively following all references, starting at some root object).

4.1 Inserting objects with dependencies

Let's look at the new class *CHILD*:

```
class
3  CHILD

create
6  make

feature {NONE} -- Initialization
9
    make (first, last: STRING)
        -- Create a new child.
12  require
        first_exists: not first.is_empty
        last_exists: not last.is_empty
15  do
        first_name := first
        last_name := last
```

```

18     age := 0
    ensure
      first_name_set: first_name = first
21     last_name_set: last_name = last
      default_age: age = 0
    end
24
  feature -- Access

27    first_name: STRING
      -- The child's first name.

30    last_name: STRING
      -- The child's last name.

33    age: INTEGER
      -- The child's age.

36    father: detachable CHILD
      -- The child's father.

39  feature -- Element Change

    celebrate_birthday
42      -- Increase age by 1.
    do
      age := age + 1
45    ensure
      age_incremented_by_one: age = old age + 1
    end

48    set_father (a_father: CHILD)
      -- Set a father for the child.
51    do
      father := a_father
    ensure
54      father_set: father = a_father
    end

57  invariant
    age_non_negative: age >= 0
    first_name_exists: not first_name.is_empty
60    last_name_exists: not last_name.is_empty

```

end

Listing 4.1: The CHILD class.

This adds in some complexity: instead of having a single object, ABEL has to insert a *CHILD*'s mother and father as well, and it has to repeat this procedure if their parent attribute is also attached. The good news are that the examples above will work exactly the same.

However, there are some additional caveats to take into consideration. Let's consider a simple example with *CHILD* objects "Baby Doe", "John Doe" and "Grandpa Doe". From the name of the object instances you can already guess what the object graph looks like:



Now if you insert "Baby Doe", ABEL will by default follow all references and insert every single object along the object graph, which means that "John Doe" and "Grandpa Doe" will be inserted as well. This is usually the desired behavior, as objects are stored completely that way, but it also has some side effects we need to be aware of:

- Assume an insert of "Baby Doe" has happened to an empty database. If you now query the database for *CHILD* objects, it will return exactly the same object graph as above, but the query result will actually have three items, as the object graph consists of three single *CHILD* objects.
- After inserting "Baby Doe", an insert of "John Doe" or "Grandpa Doe" will result in a precondition violation, because they have already been inserted as references of "Baby Doe".

In our main tutorial class *START* we have the following two features that show how to deal with object graphs. You will notice it is very similar to the corresponding routines for the flat *PERSON* objects.

```
insert_children
-- Populate the repository with some children objects.
3  local
    c1, c2, c3: CHILD
    transaction: PS_TRANSACTION
6  do
    -- Create the object graph.
    create c1.make ("Baby", "Doe")
```

```

9      create c2.make ("John", "Doe")
      create c3.make ("Grandpa", "Doe")
      c1.set_father (c2)
12     c2.set_father (c3)

      print ("Insert 3 children in the database.%N")
15     transaction := repository.new_transaction

           -- It is sufficient to just insert "Baby Joe",
18     -- as the other CHILD objects are (transitively)
           -- referenced and thus inserted automatically.
      transaction.insert (c1)
21     transaction.commit
      end

24     print_children
           -- Print all children in the repository
      local
27     query: PS_QUERY[CHILD]
      do
           create query.make
30     repository.execute_query (query)

           -- The result will also contain
33     -- all referenced CHILD objects.
      across
           query as person_cursor
36     loop
           print (person_cursor.item)
      end
39     query.close
      end

```

Listing 4.2: Dealing with object graphs.

4.2 Going deeper in the Object Graph

ABEL has no limits regarding the depth of an object graph, and it will detect and handle reference cycles correctly. You are welcome to test ABEL's capability with very complex objects, however please keep in mind that this may impact performance significantly.

Chapter 5

Error handling

As ABEL is dealing with I/O and databases, runtime errors may happen. The library will in general raise an exception in case of an error and expose the error to the library user as an *PS_ERROR* object. ABEL recognizes two different kinds of errors:

- Irrecoverable errors: fatal errors happening in scenarios like a dropped connection or a database integrity constraint violation. The default behavior is to rollback the current transaction and raise an exception. If you catch the exception in a rescue clause and manage to solve the problem, you can continue using ABEL.
- Recoverable errors: exceptional situations typically not visible to the user, because no exception is raised when they occur. An example is a conflict between two transactions. ABEL will detect the issue and, in case of implicit transaction management, retry. If you use explicit transaction management, ABEL will just doom the current transaction to fail at commit time.

ABEL maps database specific error messages to its own representation for errors, which is a hierarchy of classes rooted at *PS_ERROR*. The following list shows all error classes that are currently defined.

If not explicitly stated otherwise, the errors in this lists belong to the first category (fatal errors).

- *CONNECTION_PROBLEM*: A broken internet link, or a deleted serialization file.
- *TRANSACTION_CONFLICT*: A write conflict between two transactions. This is a recoverable error.

- *UNRESOLVABLE_TRANSACTION_CONFLICT*: A write conflict between implicit transactions that doesn't resolve after a retry.
- *ACCESS_RIGHT_VIOLATION*: Insufficient privileges in database, or no write permission to serialization file.
- *VERSION_MISMATCH*: The stored version of an object isn't compatible any more to the current type.
- *INTERNAL_ERROR*: Any error happening inside the library, e.g. a wrong SQL compilation.
- *GENERAL_ERROR*: Anything that doesn't fit into one of the categories above.

If you want to handle an error, you have to add a **rescue** clause somewhere in your code.

You can get the actual error from the feature *PS_EXECUTOR.error* or *PS_TRANSACTION.error* or - due to the fact that the *PS_ERROR* class inherits from *DEVELOPER_EXCEPTION* - by performing an object test on Eiffel's *EXCEPTION_MANAGER.last_exception*.

For your convenience, there is a visitor pattern for all ABEL error types. You can just implement the appropriate functions and use it for your error handling code.

The following code shows an example. Note that only relevant features are shown:

```

class
3  MY_PRIVATE_VISITOR
  inherit
    PS_ERROR_VISITOR
6
  feature
    shall_retry: BOOLEAN
9    -- Should my client retry the operation?

    visit_access_right_violation (
12      error: PS_ACCESS_RIGHT_VIOLATION)
      -- Visit an access right violation error.
    do
15      add_some_privileges
        shall_retry := True
    end

```

```

18      visit_connection_problem (error: PS_CONNECTION_PROBLEM)
        -- Visit a connection problem error.
21      do
          notify_user_of_abort
          shall_retry:=False
24      end
    end

27  class
    TUTORIAL

30  feature

    my_visitor: MY_PRIVATE_VISITOR
33    -- A user-defined visitor to react to an error.

    executor: PS_EXECUTOR
36    -- The CRUD executor used throughout the tutorial.

39  do_something_with_error_handling
    -- Perform some operations. Deal with errors in case of
      a problem.
    do
42    -- Some complicated operations
    rescue
      my_visitor.visit (executor.last_error)
45    if my_visitor.shall_retry then
      retry
    else
48    -- The exception propagates upwards, and maybe
      -- another feature can handle it
    end
51  end
end

```

Listing 5.1: Sample error handling using a visitor.

Chapter 6

CouchDB Support

ABEL does not only work with an in-memory database. It is also able to store objects in other database, both relational (like MySQL and SQLite) and non-relational like CouchDB, always using the same API.

6.1 What is CouchDB

CouchDB is a free, open-source document-oriented database¹. CouchDB stores objects on a persistent database using JSON documents. JSON is a textual notation similar to XML that stores Eiffel objects like this:

```
{
  "firstname": "Albo",
3  "lastname": "Bitossi",
  "age": 0
}
```

Listing 6.1: Sample Eiffel Object in JSON

6.2 Setting up CouchDB

Before we can start using CouchDB from within Eiffel we have to set it up either on a local machine or get hold of a database on the internet. To install CouchDB locally visit www.couchdb.com and download the appropriate package.

Once installed, CouchDB should be running in the background and is accessible through a browser by accessing `127.0.0.1:5984/_utils` To work with

¹<http://couchdb.apache.org>

CouchDB in Eiffel we have created another tutorial which you can get at abel/apps/sample/tutorial-couchdb/. Look for the *tutorial_project.ecf* and open it with EiffelStudio.

6.3 Getting started with CouchDB

On the surface there is not much difference between using the in-memory database and CouchDB. You may notice that all we changed in the tutorial is the call to the *repo_factory*.

```
1  explore
    -- Tutorial code.
    local
4    p1, p2, p3: PERSON
    c1, c2, c3: CHILD
    couchdb_repo: PS_RELATIONAL_REPOSITORY
7  do
    print ("---o--- CouchDB Tutorial ---o---")
    io.new_line
10   couchdb_repo := repo_factory.create_cdb_repository ("
        127.0.0.1", 5984)
    create executor.make (couchdb_repo)
    ...
```

Listing 6.2: The CouchDB Tutorial

Instead of using *repo_factory.create_in_memory_repository* we now use *repo_factory.create_cdb_repository("127.0.0.1", 5984)*. Whereby the first argument of this method denotes the URL where the database is located (In this case we use the localhost) and the second argument is the used port (we use the default CouchDB port which is 5984). If for some reason your couch is not located on your own machine, you might have to adjust these values to point to the correct location.

If you compare the output of this tutorial to the output you got when using the in-memory database you might notice that nothing changed. On the surface both these databases provide the same services. Namely storing Eiffel objects.

6.4 Beneath the surface

Using CouchDB, Eiffel can store objects on a persistent database that can also be accessed by other programs. If not deleted, the data will persist

after your program has ended. To accomplish this, ABEL will convert Eiffel objects to JSON documents, whereby each attribute will get its own "name": "value" pair. The resulting document for a person will look similar to *Listing 7.1*. After running the tutorial, the stored objects can also be explored by visiting `127.0.0.1:5984/_utils`.

You will notice that for both person and child a sub-database was created. The person database will only contain person-objects and the child database will only contain child-objects. If you don't want your data to remain in the database after the program has ended, insert a `couchdb_repo.wipe_out` at the end of the feature `explore`

6.5 Limitations

CouchDB is not meant to be a relational database: it can nicely store objects as JSON Documents, that can then be searched by key. CouchDB was mainly developed for the world wide web. For its basic API it uses cURL which is really easy to use but for its more advanced features like map-reduce it uses JavaScript. Map-reduce would come in handy when querying for objects in the database but it is not yet integrated and therefore for queries rather than using the inbuilt map-reduce of CouchDB ABEL uses an Eiffel function to accomplish the same.

For more information on CouchDB see the online documentation.