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Software Engineering Design & Construction

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Template Method Pattern

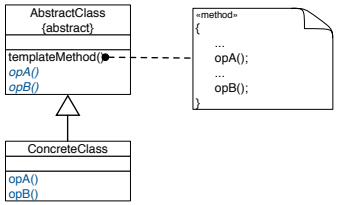
The Template-Method Pattern in a Nutshell

Intent:

- Separate high-level policies from detailed low-level mechanisms.
- Separate invariant from variant parts.

Solution Idea:
Use abstract classes to:

- Define interfaces to detailed mechanisms and variant parts.
- Implement high-level policies and invariant parts to these interfaces.
- Control sub-class extensions.
- Avoid code duplication.



The Template-Method Pattern plays a key role in the design of object-oriented frameworks.

(Separate high-level policies from detailed low-level mechanisms. => This is related to the recommendation not to override methods from superclasses.)

Example Application of Template Method

Functional requirements:

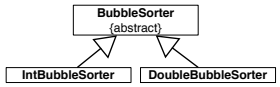
- Need a family of sorting algorithms …(bubble sort, quick sort, etc.)
- for different kinds of data (int, double, etc.)
- Clients that use sorting algorithms should be reusable with a variety of specific algorithms.

Non-functional requirements on the design:

- Need to separate the high-level „sorting“ policies from low-level mechanisms.
- Low-level mechanisms are responsible for:
  - deciding when an element is out of order,
  - swapping out-of-order elements.

Separating the Policy of Sorting

```
public abstract class BubbleSorter {
  protected int length = 0;
```



Policy

```
 protected void sort() {
    if (length <= 1) return;
      for (int nextToLast = length - 2; nextToLast >= 0; nextToLast--)
        for (int index = 0; index <= nextToLast; index++)
          if (outOfOrder(index)) swap(index);
  }
```

Mechanism

```
  protected abstract void swap(int index);
  protected abstract boolean outOfOrder(int index);

}
```

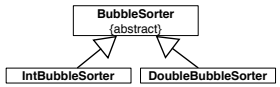

Implement the sorting policy in a **template method, sort**. Hide mechanisms needed for implementing the sorting policy behind abstract methods (outOfOrder and swap), which are called by the template method.

Filling the Template for Specific Algorithms

```
public class IntBubbleSorter
  extends BubbleSorter {

  private int[] array = null;

  public void sort(int[] theArray) {
    array = theArray;
    length = array.length;
    /*"super"*/sort();
  }
  protected void swap(int index) {
    int temp = array[index];
    array[index] = array[index + 1];
    array[index + 1] = temp;
  }
  protected boolean outOfOrder(int index) {
    return (array[index] > array[index + 1]);
  }
}
```



What are the advantages and deficiencies of the Template-Method Pattern?

The advantages and deficiencies of the Template-Method Pattern are basically those of inheritance:

Template method forces mechanisms to extend a specific policy.

- Implementation of low-level mechanisms depends on the template.
- Cannot **re-use low-level mechanisms** functionality.
  swap and outOfOrder implemented in IntBubbleSorter may be useful in other contexts as well, e.g., for quick sort.

Task: Identify the *Template Method Pattern* in *Log4J*

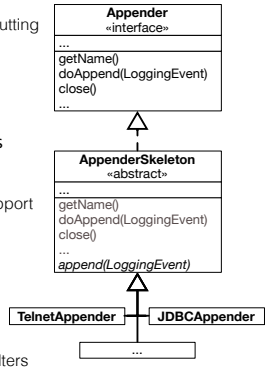
`interface Appender`
Implement this interface for your own strategies for outputting log statements. […]

`public void doAppend(LoggingEvent event)`
Log in Appender specific way.

`abstract class AppenderSkeleton implements Appender`
Abstract superclass of the other appenders. This class provides the code for common functionality, such as support for threshold filtering and support for general filters. […]

`abstract void append(LoggingEvent event)`
Subclasses should implement this method to perform actual logging.

`void doAppend(LoggingEvent event)`
This method performs threshold checks and invokes filters before delegating actual logging to the append(LoggingEvent) method.



In case of an exam, it would be possible that we provide you with this example and would ask about the used patterns.

Ask yourself which method is the “Template Method”?

Functional Counterpart of Template

One can look at the Template-Method Pattern as a style for emulating higher-order functions available in programming languages that support functional-style programming.

Alternative design for Log4J in Scala?

```
class AppenderSkeleton(
  private val append : (LoggingEvent) => Unit // Function1[LoggingEvent,Unit]
) {
  def doAppend(loggingEvent : LoggingEvent) {
    // filtering, threshold checks,…
    append(loggingEvent)
  }
}
```


Whether this is a feasible design or not requires a detailed analysis of the context; i.e., the AppenderSkeleton class. In this case, the method `close` indicates that an Appender may be in different states which suggests that the standard implementation approach is best suited (also in Scala).

Higher-order Functions:

- *First-**order** functions abstract over variations in data. ("Supported by basically all languages.")*
- *Higher-**order** function: A function parameterized by other functions.*
  *Higher-**order** functions abstract over variations in sub-computations.*
- *First-**class** functions are values that can be passed as parameters and returned as results.*

Scala (2.11.x) HashTable

```
/**
[…]
There are mainly two parameters that affect the performance of a hashtable: the initial size
and the load factor. The size refers to the number of buckets in the hashtable, and the load
factor is a measure of how full the hashtable is allowed to get before its size is
automatically doubled. Both parameters may be changed by overriding the corresponding
values in class HashTable.
*/
trait HashTable[A, Entry >: Null <: HashEntry[A, Entry]] extends HashTable.HashUtils[A] {
  […]
  /** The actual hash table.*/
  @transient protected var table: Array[HashEntry[A, Entry]] = new Array(initialCapacity)

  /** The initial size of the hash table.*/
  protected def initialSize: Int = 16

  private def initialCapacity = capacity(initialSize)

  […]

}
```


Again, ask yourself where is the template method?

Ask yourself, why it is better/safer to define a method initialSize then a variable?

Here, the usage of the Template Method Pattern is a technical artifact, because Scala (up to 2.12) does not support trait parameters! In general, using inheritance in such a way is ill-advised.