Analyzing Code Comments

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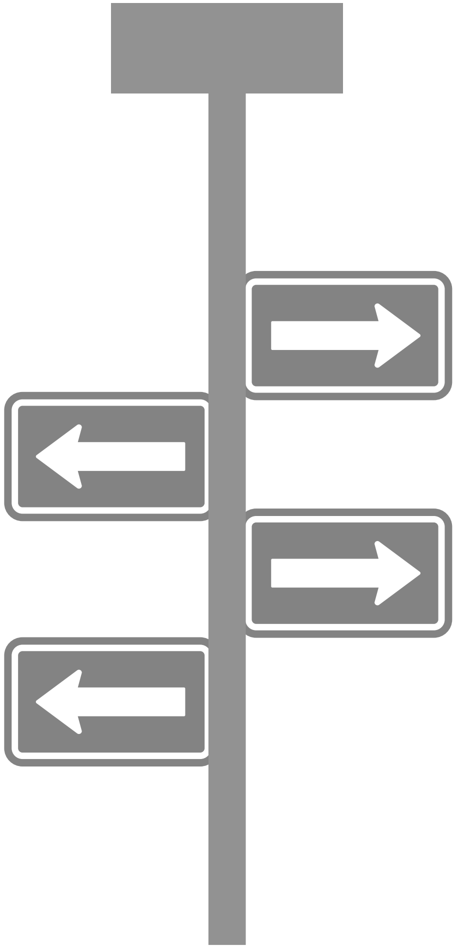
I'll remember this code without comments
And
Other Hilarious Jokes You Can Tell Yourself
Volume II

Roadmap

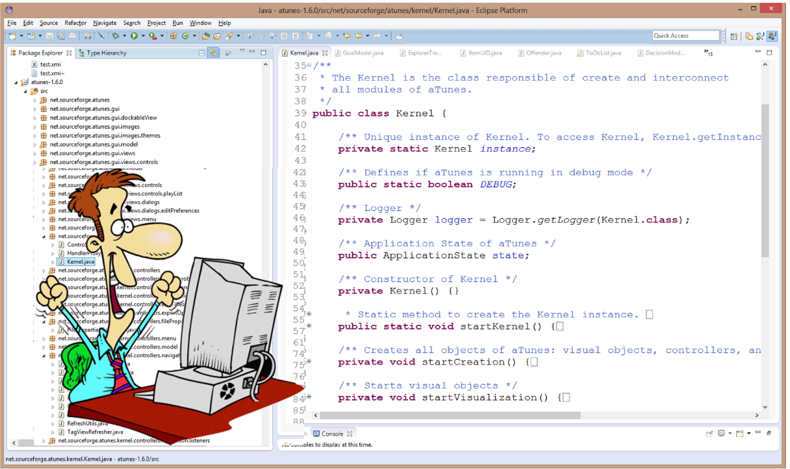
- Importance of code comments
- Code comment types
- What is a good comment?
- Challenges
- Tool support
- Various approaches to analyze



We use different tools and techniques to **understand code.**

Understanding code…

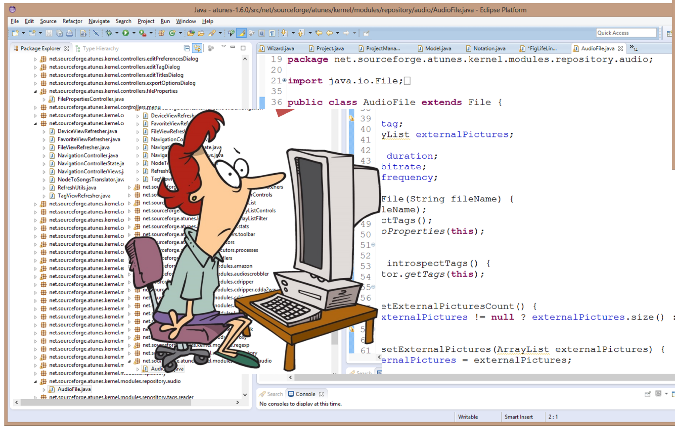
Happy Developers


Java - atunes-1.6.0/src/net/sourceforge/atunes/kernel/Kernel.java - Eclipse Platform
Quick Access
Package Explorer
Type Hierarchy
Kernel.java
GoalModel.java
ExplorerTre...
ItemUID.java
Offender.java
ToDoList.java
DecisionMod...
Console
net.sourceforge.atunes.kernel.Kernel.java - atunes-1.6.0/src

```
/**
 * The Kernel is the class responsible of create and interconnect
 * all modules of aTunes.
 */
public class Kernel {

    /** Unique instance of Kernel. To access Kernel, Kernel.getInstanc
    private static Kernel instance;

    /** Defines if aTunes is running in debug mode */
    public static boolean DEBUG;

    /** Logger */
    private Logger logger = Logger.getLogger(Kernel.class);

    /** Application State of aTunes */
    public ApplicationState state;

    /** Constructor of Kernel */
    private Kernel() {}

     * Static method to create the Kernel instance. 
    public static void startKernel() {

    /** Creates all objects of aTunes: visual objects, controllers, an
    private void startCreation() {

    /** Starts visual objects */
    private void startVisualization() {
```

Comments in the Code

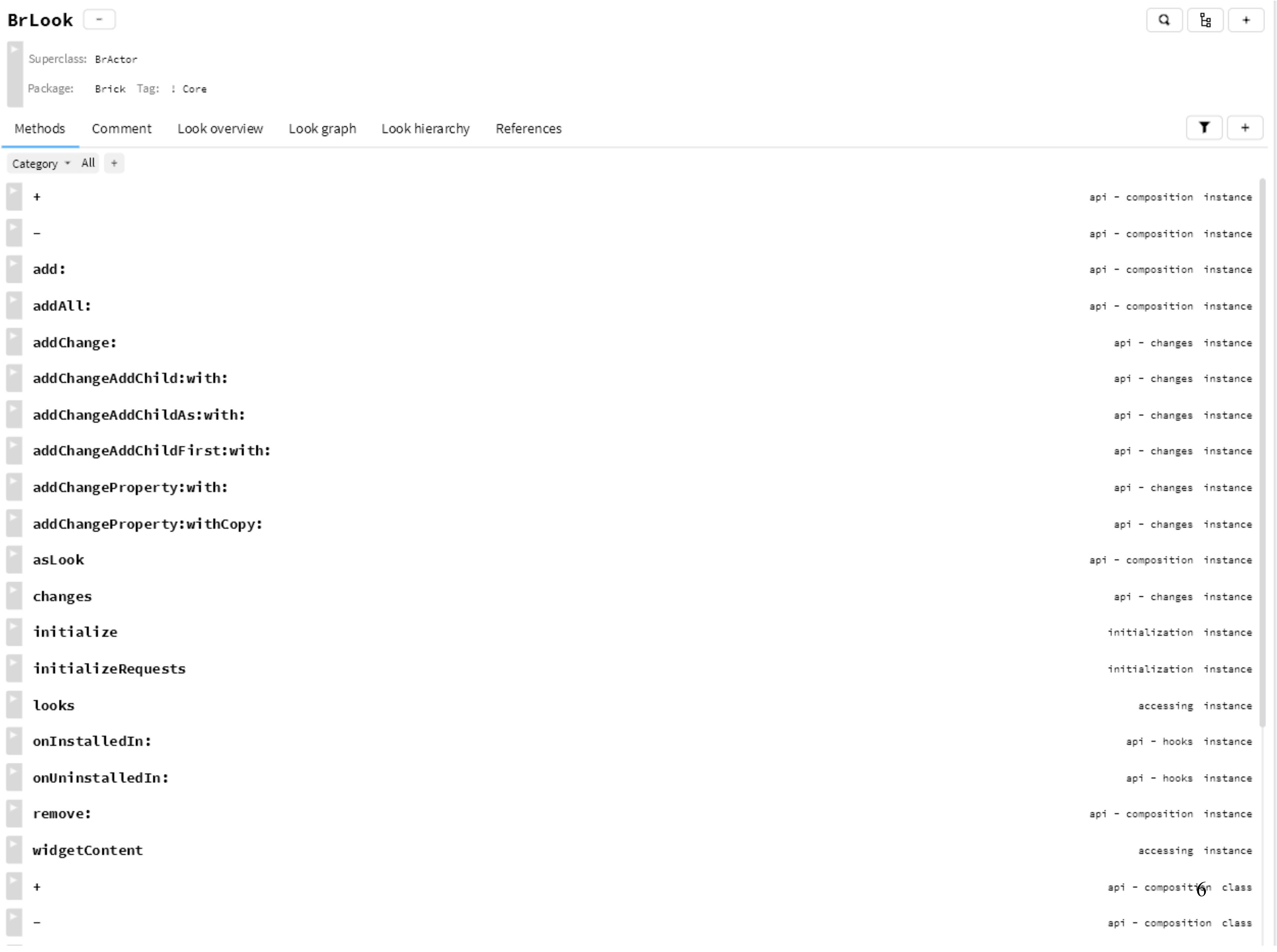
Not So Happy Developers



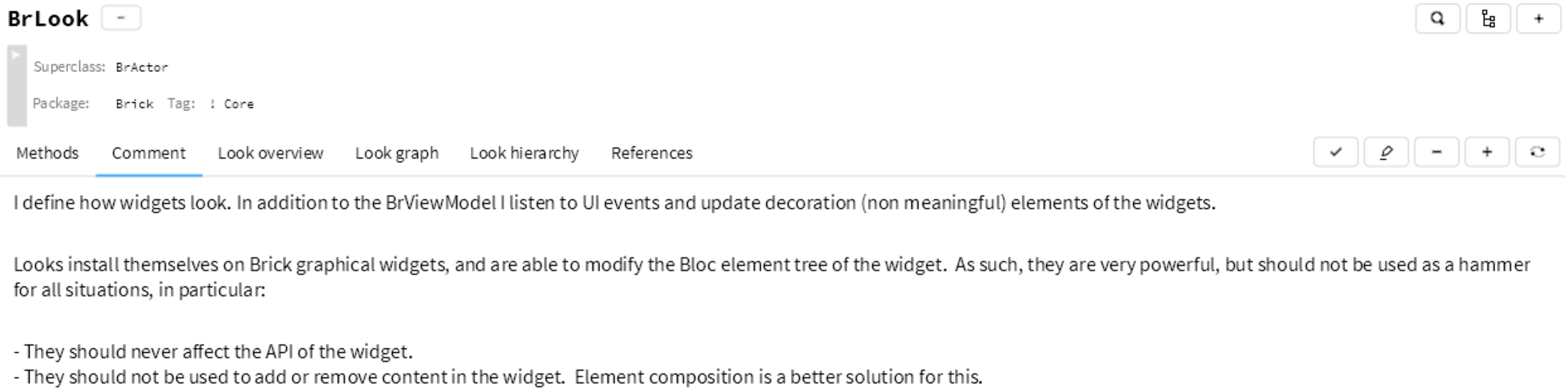
```
package net.sourceforge.atunes.kernel.modules.repository.audio;

import java.io.File;

public class AudioFile extends File {

tag;
yList externalPictures;

 duration;
oitrate;
frequency;

File(String fileName) {
leName);
ctTags();
oProperties(this);


 introspectTags() {
tor.getTags(this);


etExternalPicturesCount() {
xternalPictures != null ? externalPictures.size() : 0;


setExternalPictures(ArrayList externalPictures) {
ernalPictures = externalPictures;
```

Absence of Comments in the Code

In GT, try to understand the class “BrLook”, “BlElement” without class comments.



+	api - composition	instance
-	api - composition	instance
add:	api - composition	instance
addAll:	api - composition	instance
addChange:	api - changes	instance
addChangeAddChild:with:	api - changes	instance
addChangeAddChildAs:with:	api - changes	instance
addChangeAddChildFirst:with:	api - changes	instance
addChangeProperty:with:	api - changes	instance
addChangeProperty:withCopy:	api - changes	instance
asLook	api - composition	instance
changes	api - changes	instance
initialize	initialization	instance
initializeRequests	initialization	instance
looks	accessing	instance
onInstalledIn:	api - hooks	instance
onUninstalledIn:	api - hooks	instance
remove:	api - composition	instance
widgetContent	accessing	instance
+	api - composition	class
-	api - composition	class



BrLook

Superclass: BrActor

Package: Brick Tag: Core

I define how widgets look. In addition to the BrViewModel I listen to UI events and update decoration (non meaningful) elements of the widgets.

Looks install themselves on Brick graphical widgets, and are able to modify the Bloc element tree of the widget. As such, they are very powerful, but should not be used as a hammer for all situations, in particular:

- They should never affect the API of the widget.
- They should not be used to add or remove content in the widget. Element composition is a better solution for this.

Code comments

- Code comprehension tasks
- Code maintenance tasks
- To understand a new domain

You do not need comments if you write clean code.

You do not need comments if you write clean code?

Code can describe how but it can not explain why.

Code comment types

- Documentation (/** … */)

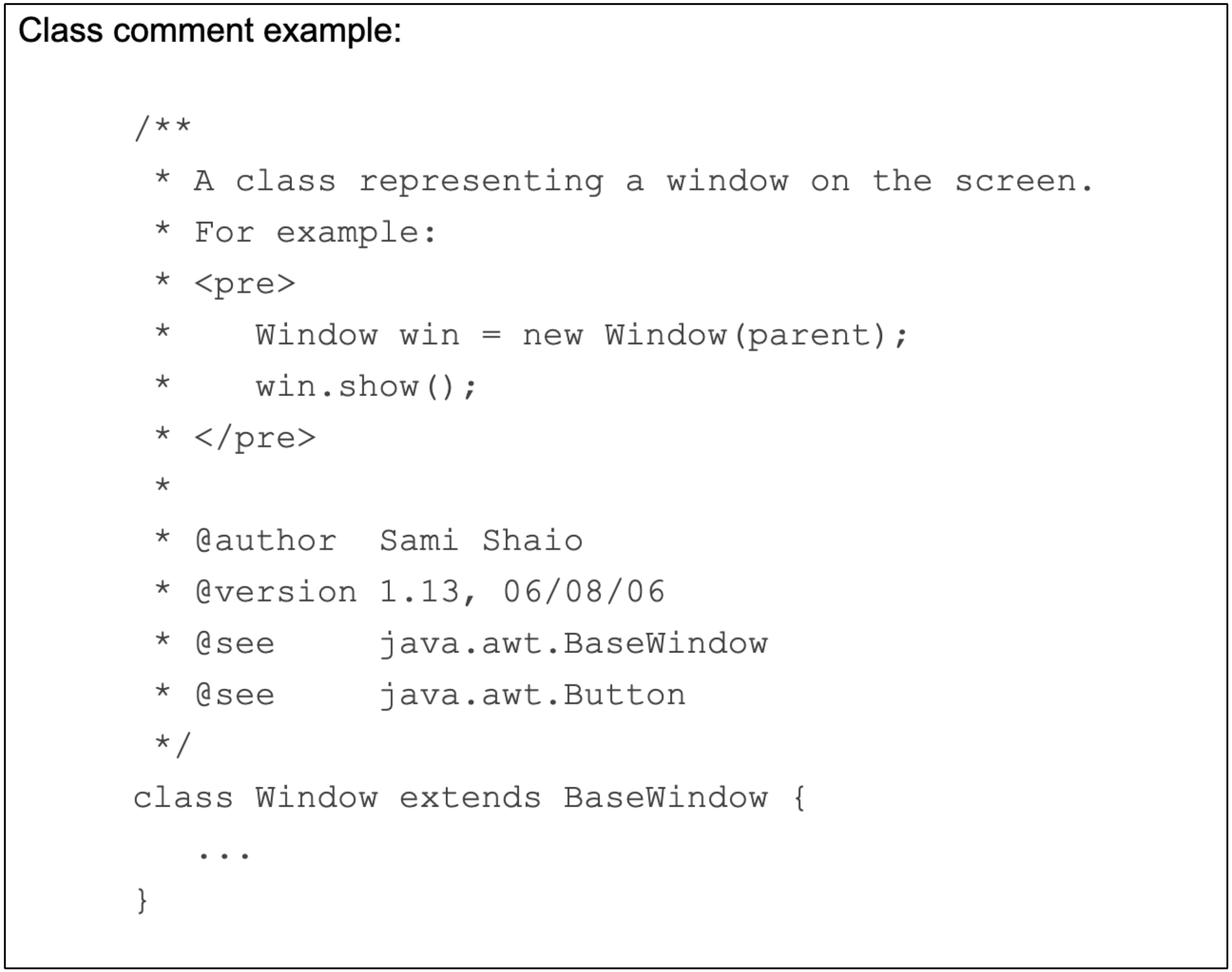
  (also used for packages / classes / methods

- Block comments (/* … */)

- Inline comments (//…)

Programming languages follow different syntaxes for comments.

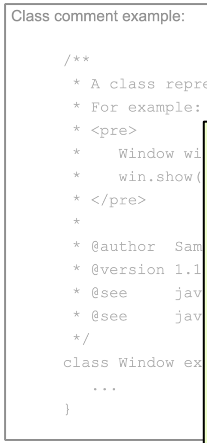
However, most languages support a distinct delimiter for comments.



Class comment example:

```
/**
 * A class representing a window on the screen.
 * For example:
 * <pre>
 *    Window win = new Window(parent);
 *    win.show();
 * </pre>
 *
 * @author  Sami Shaio
 * @version 1.13, 06/08/06
 * @see     java.awt.BaseWindow
 * @see     java.awt.Button
 */
class Window extends BaseWindow {
   ...
}
```

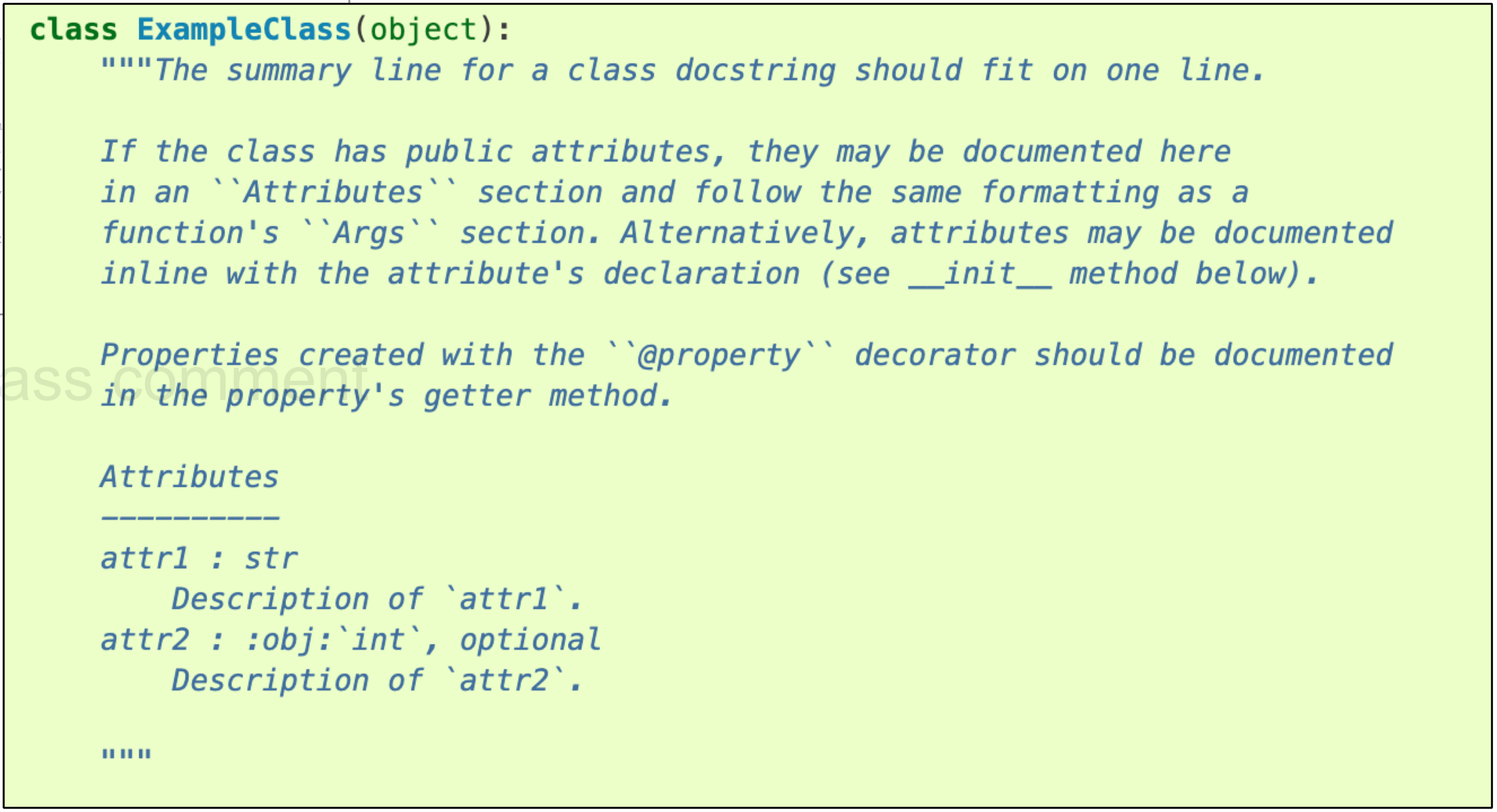
Java class comment



Class comment example:

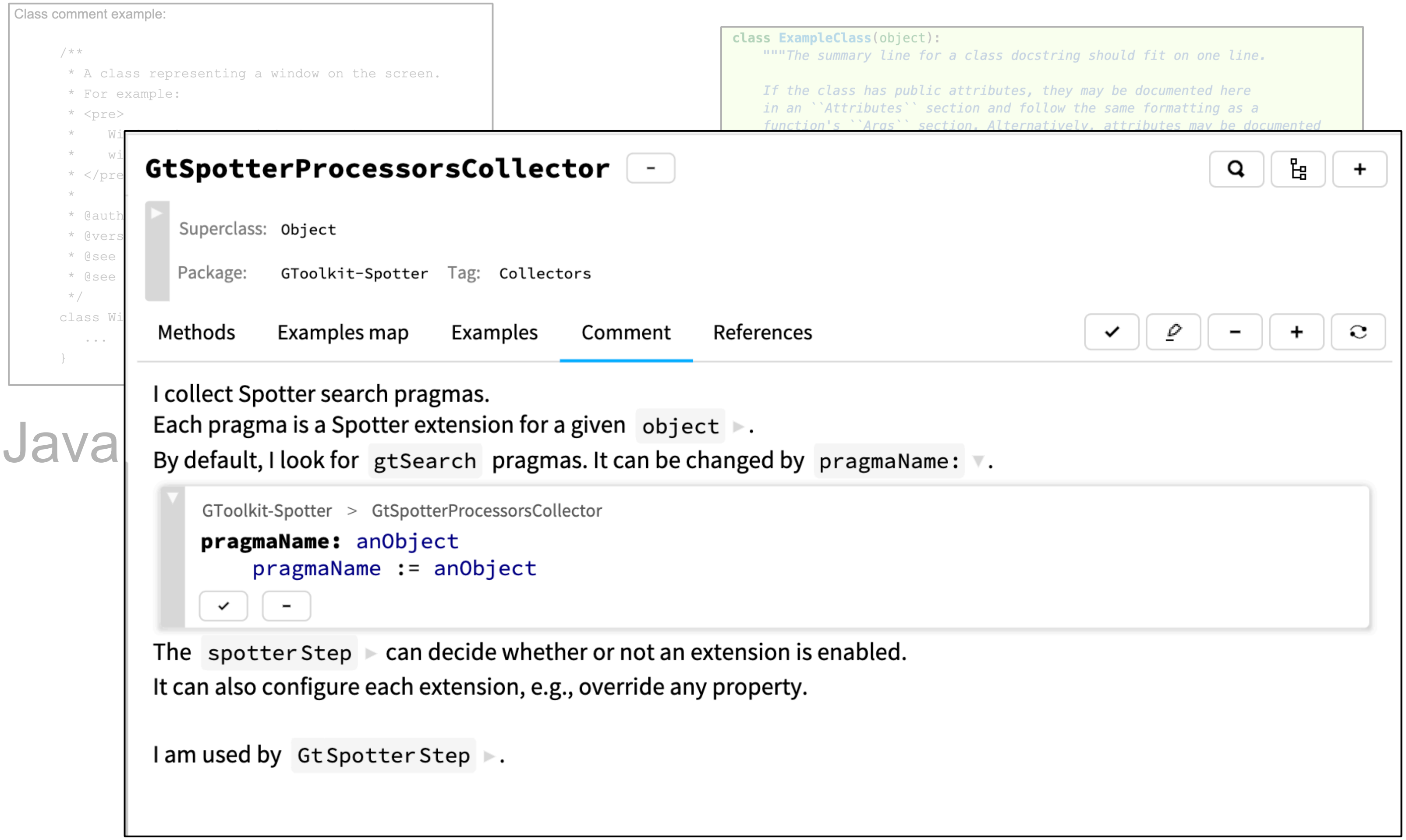
```
/**
 * A class representing a window on the screen.
 * For example:
 * <pre>
 *    Window wi
 *    win.show(
 * </pre>
 *
 * @author  Sam
 * @version 1.1
 * @see     jav
 * @see     jav
 */
class Window ex
   ...
}
```

Java class comment



```
class ExampleClass(object):
    """The summary line for a class docstring should fit on one line.

    If the class has public attributes, they may be documented here
    in an ``Attributes`` section and follow the same formatting as a
    function's ``Args`` section. Alternatively, attributes may be documented
    inline with the attribute's declaration (see __init__ method below).

    Properties created with the ``@property`` decorator should be documented
    in the property's getter method.

    Attributes
    ----------
    attr1 : str
        Description of `attr1`.
    attr2 : :obj:`int`, optional
        Description of `attr2`.

    """
```

Python class comment



Class comment example:

```
/**
 * A class representing a window on the screen.
 * For example:
 * <pre>
 *    Wi
 *    wi
 * </pre
 *
 * @auth
 * @vers
 * @see
 * @see
 */
class Wi
   ...
}
```

Java

```
class ExampleClass(object):
    """The summary line for a class docstring should fit on one line.

    If the class has public attributes, they may be documented here
    in an ``Attributes`` section and follow the same formatting as a
    function's ``Args`` section. Alternatively, attributes may be documented
```

I collect Spotter search pragmas.
Each pragma is a Spotter extension for a given `object` ▸.
By default, I look for `gtSearch` pragmas. It can be changed by `pragmaName:` ▾.

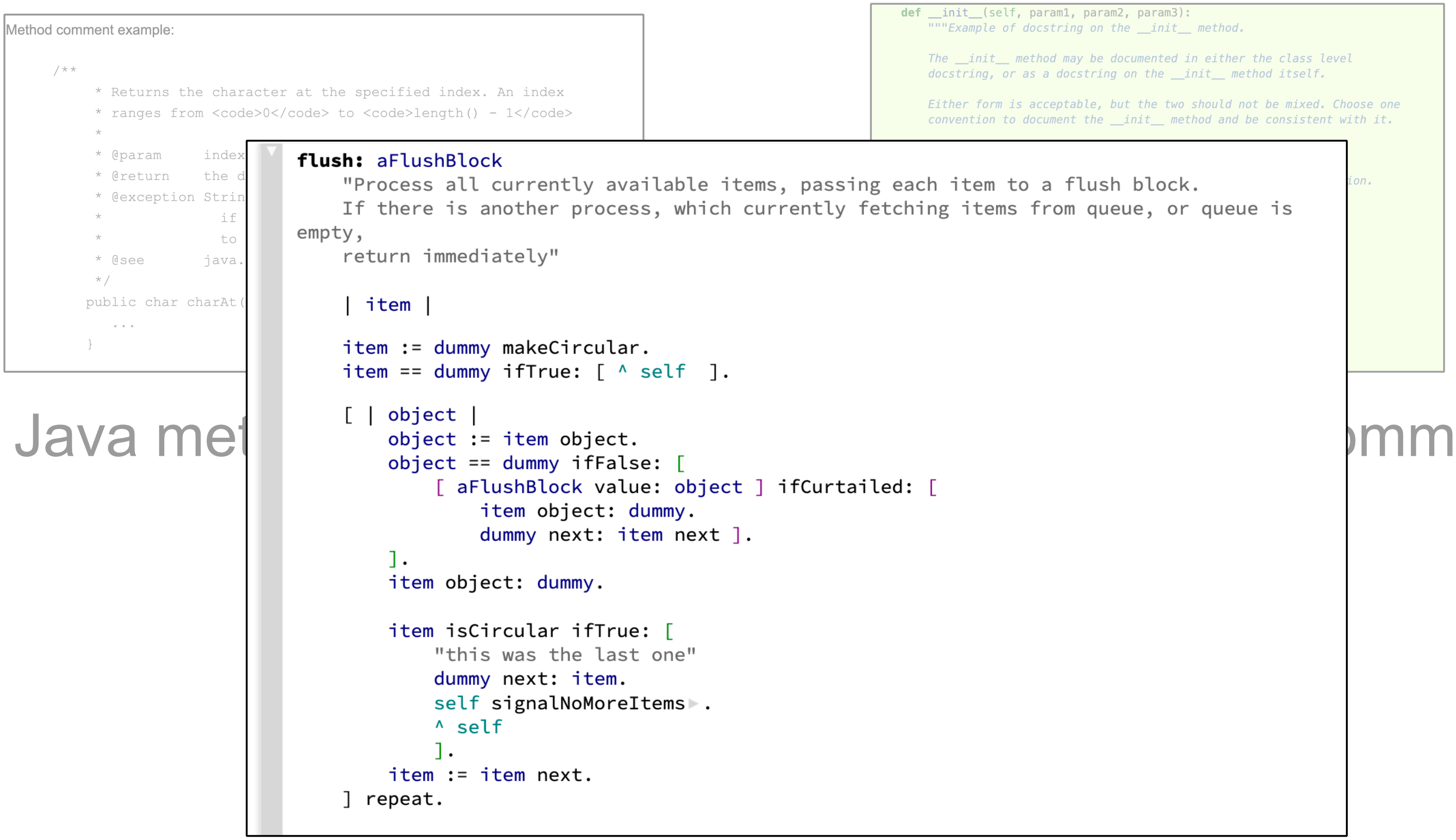
GToolkit-Spotter > GtSpotterProcessorsCollector

```
pragmaName: anObject
    pragmaName := anObject
```

The `spotterStep` ▸ can decide whether or not an extension is enabled.
It can also configure each extension, e.g., override any property.

I am used by `GtSpotterStep` ▸.

GT class comment



Method comment example:

```
/**
    * Returns the character at the specified index. An index
    * ranges from <code>0</code> to <code>length() - 1</code>
    *
    * @param     index
    * @return    the d
    * @exception Strin
    *               if
    *               to
    * @see       java.
    */
   public char charAt(
      ...
   }
```

Java met

```
def __init__(self, param1, param2, param3):
    """Example of docstring on the __init__ method.

    The __init__ method may be documented in either the class level
    docstring, or as a docstring on the __init__ method itself.

    Either form is acceptable, but the two should not be mixed. Choose one
    convention to document the __init__ method and be consistent with it.

                                                                 ion.
```

omment

```
flush: aFlushBlock
    "Process all currently available items, passing each item to a flush block.
    If there is another process, which currently fetching items from queue, or queue is
empty,
    return immediately"

    | item |

    item := dummy makeCircular.
    item == dummy ifTrue: [ ^ self  ].

    [ | object |
        object := item object.
        object == dummy ifFalse: [
            [ aFlushBlock value: object ] ifCurtailed: [
                item object: dummy.
                dummy next: item next ].
        ].
        item object: dummy.

        item isCircular ifTrue: [
            "this was the last one"
            dummy next: item.
            self signalNoMoreItems.
            ^ self
            ].
        item := item next.
    ] repeat.
```

GT method comment

What is a good comment?

```
/*
 * Dear Maintainer
 *
 * Once you are done trying to ‘optimize’ this routine,
 * and you have realized what a terrible mistake that was,
 * please increment the following counter as a warning
 * to the next guy.
 *
 * total_hours_wasted_here = 73
 *
```

```
// When I wrote this, only God and I understood what I was doing

// Now, God only knows
```

```
#This is brilliant
#Thanks. It’s nap time.
```

What is a good comment?

```
/*
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 *
```

```
// When I wrote this, only God and I understood what I was d

// Now, God only knows
```

```
#This is brilliant
#Thanks. It’s nap time.
```

What do you think?

What is a good comment?

- Helps other developers in working with your code
- Describes why, and not how
- Reveals intent, limitation, assumptions, design decisions
- Justifies the violation of a programming style

What is a good comment?

```
// format matched kk:mm:ss EEE, MMM dd, yyy
Pattern timePattern = Pattern.compile("\\d*:\\d*:\\d* \\w*, \\w*, \\d*, \\d*");
```

Examples

Note that to encode a String as Base64, you first have to encode the characters as bytes using character encoder.

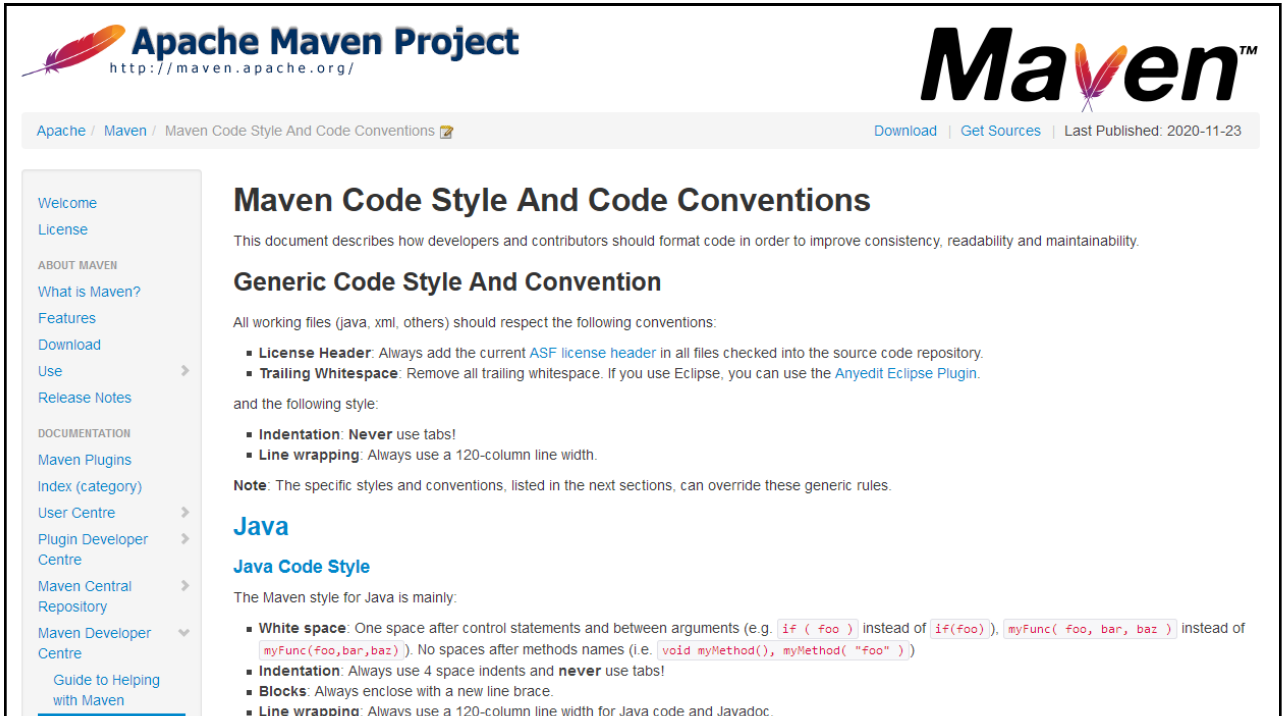
Warnings

It makes sense to use me if scalable element has fixed or matching parent horizontal size but fits content vertically.

Preconditions

Coding style guidelines

- Agreed guidelines to express the information
- To write consistent & informative comments



Apache Maven Project
http://maven.apache.org/

Maven™

Apache / Maven / Maven Code Style And Code Conventions

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Maven Code Style And Code Conventions

This document describes how developers and contributors should format code in order to improve consistency, readability and maintainability.

Generic Code Style And Convention

All working files (java, xml, others) should respect the following conventions:

- **License Header**: Always add the current ASF license header in all files checked into the source code repository.
- **Trailing Whitespace**: Remove all trailing whitespace. If you use Eclipse, you can use the Anyedit Eclipse Plugin.

and the following style:

- **Indentation**: **Never** use tabs!
- **Line wrapping**: Always use a 120-column line width.

Note: The specific styles and conventions, listed in the next sections, can override these generic rules.

Java

Java Code Style

The Maven style for Java is mainly:

- **White space**: One space after control statements and between arguments (e.g. `if ( foo )` instead of `if(foo)`), `myFunc( foo, bar, baz )` instead of `myFunc(foo,bar,baz)`). No spaces after methods names (i.e. `void myMethod(), myMethod( "foo" )`)
- **Indentation**: Always use 4 space indents and **never** use tabs!
- **Blocks**: Always enclose with a new line brace.
- **Line wrapping**: Always use a 120-column line width for Java code and Javadoc.

Guideline examples: Oracle

- Use blank lines after summary line.
- Use 3rd person instead of 2nd person.
- Write a one-line summary of the class.

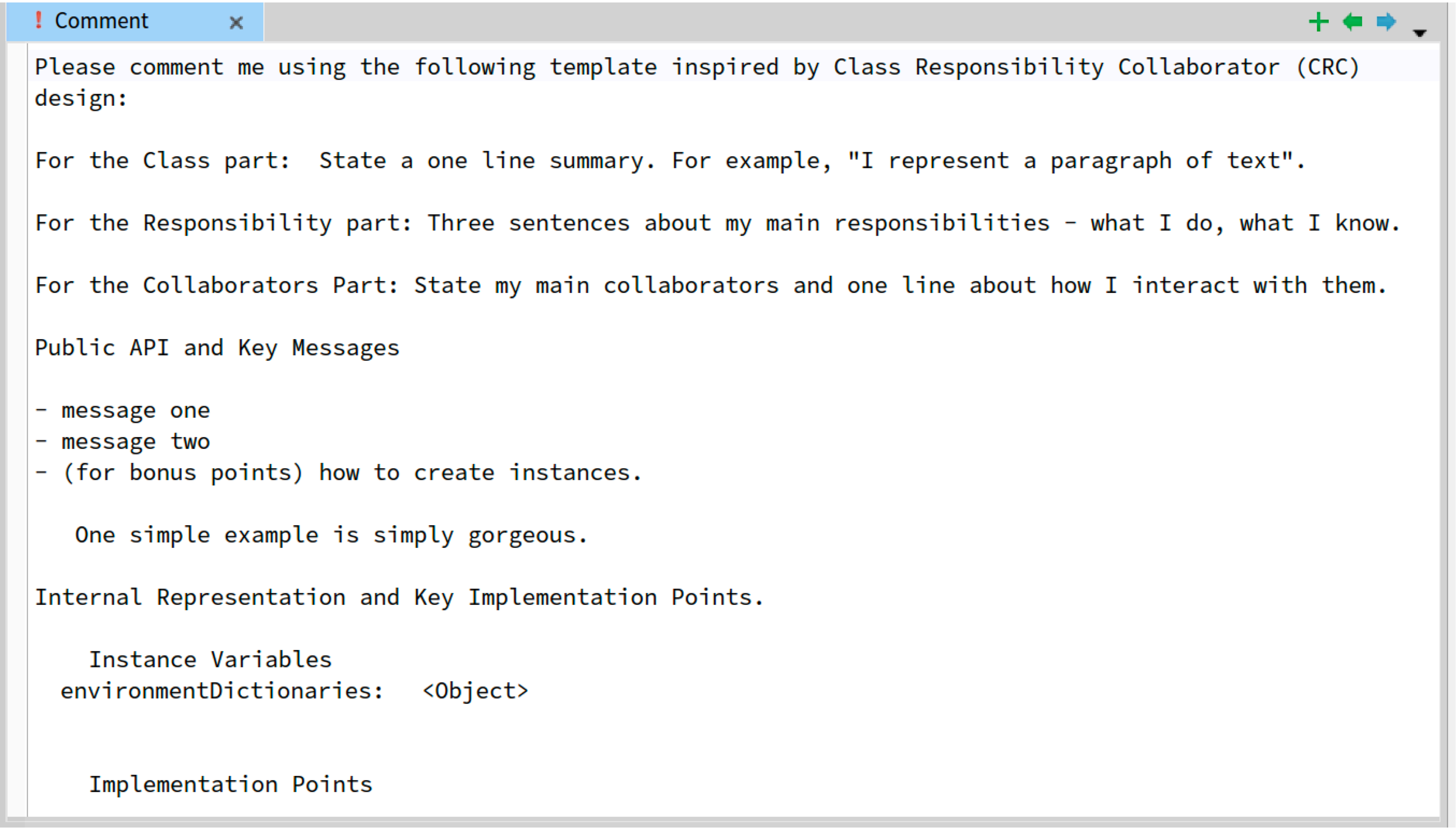
Coding style guidelines

- **Java**: Oracle, Apache, Google
- **Python**: Pep, Google, Numpy
- **Smalltalk**: Smalltalk style guide, comment template
- **Ruby**: RubyStyle

Oracle: https://www.oracle.com/technical-resources/articles/java/javadoc-tool.html

Numpy:https://numpydoc.readthedocs.io/en/latest/format.html#docstring-standard

Smalltalk:http://sdmeta.gforge.inria.fr/FreeBooks/WithStyle/SmalltalkWithStyle.pdf



```
Please comment me using the following template inspired by Class Responsibility Collaborator (CRC)
design:

For the Class part:  State a one line summary. For example, "I represent a paragraph of text".

For the Responsibility part: Three sentences about my main responsibilities - what I do, what I know.

For the Collaborators Part: State my main collaborators and one line about how I interact with them.

Public API and Key Messages

- message one
- message two
- (for bonus points) how to create instances.

   One simple example is simply gorgeous.

Internal Representation and Key Implementation Points.

    Instance Variables
  environmentDictionaries:    <Object>


    Implementation Points
```

Pharo class comment template

Challenges

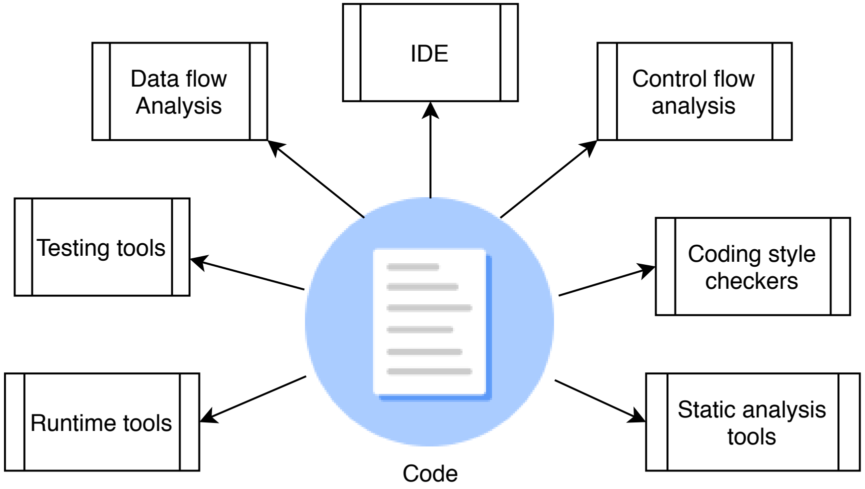
- Multiple conventions
- Personal style
- Incomplete comments
- Outdated comments
- Inconsistent writing style
- Complex comments

Impact overall quality of comments

We use different tools and techniques to analyze code quality.

Code analysis tools

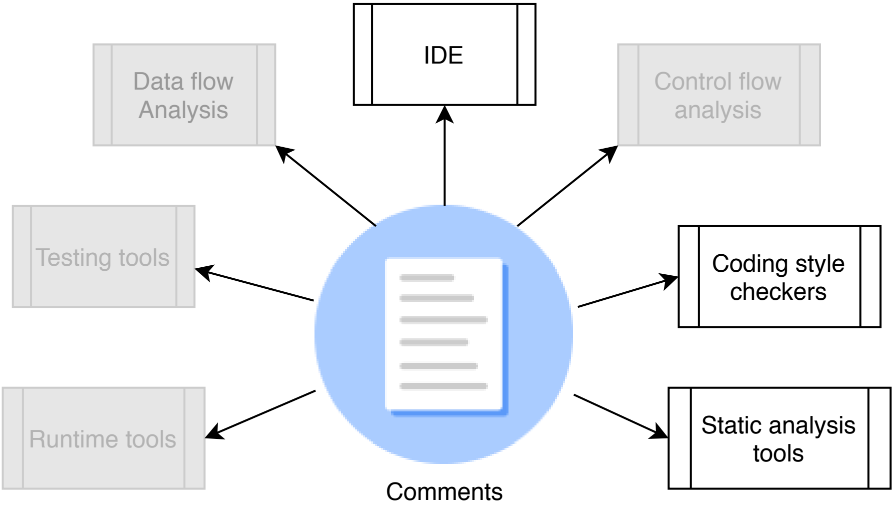
- Syntax
- Semantics
- Style



But what about comments?

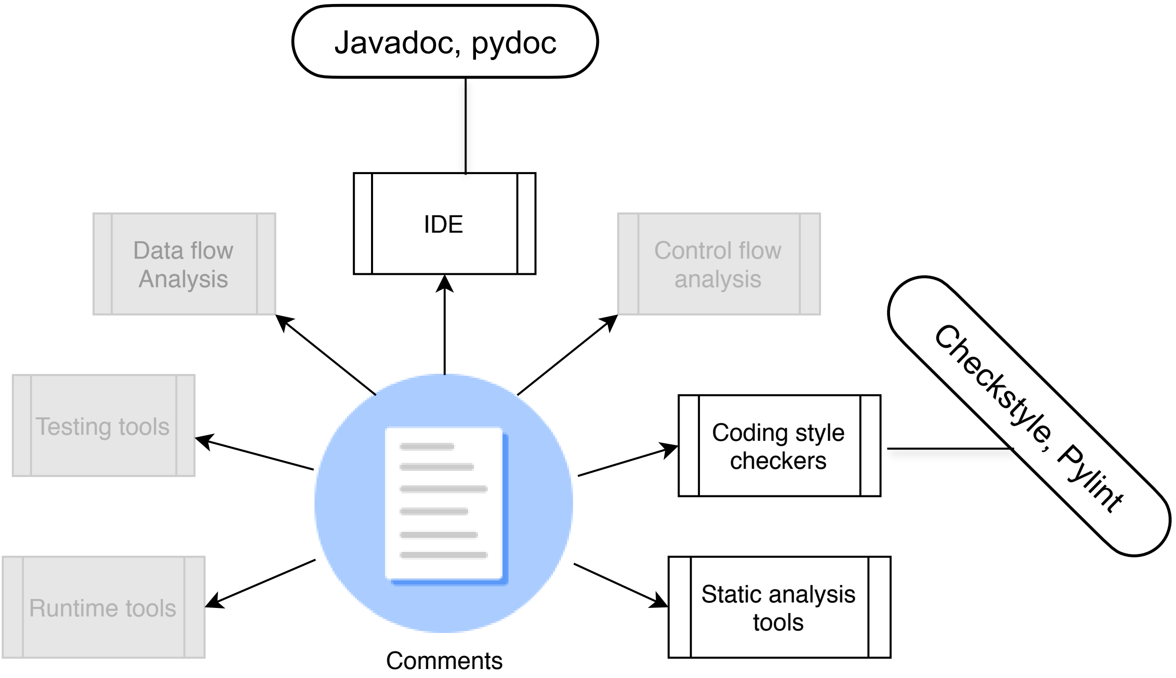
Comment analysis tools

- Syntax
- Semantics
- Style



Comment analysis tools

- Syntax
- Semantics
- Style



Documentation tools

- Check syntax of comments
- Do **not** check the content

Coding style checkers

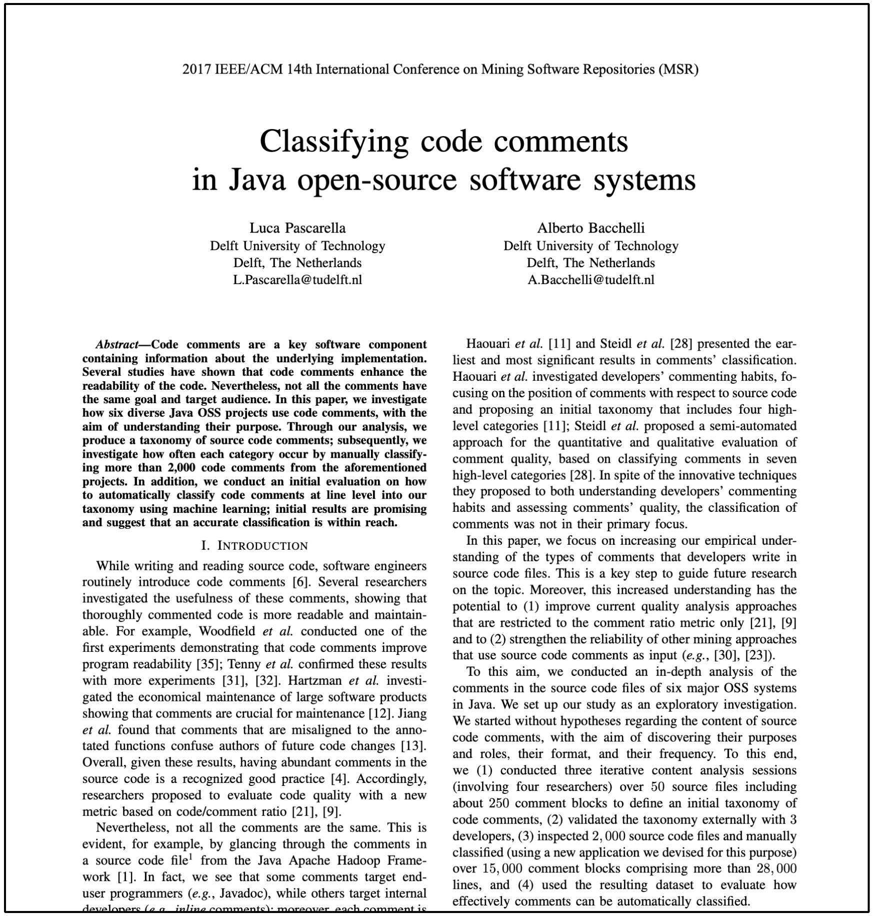
- **Java**: Checkstyle, PMD
- **Python**: pylint, pycodestyle
- **Smalltalk**: No linter
- **Ruby**: RuboCop

Coding style checkers

- Detect presence/absence of comments
- Check whether comments follow style guidelines
- Limited to selected metrics (code/comment ratio)

Comment Content Analysis

Information types in Java code comments



2017 IEEE/ACM 14th International Conference on Mining Software Repositories (MSR)

Classifying code comments in Java open-source software systems

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***Abstract*—Code comments are a key software component containing information about the underlying implementation. Several studies have shown that code comments enhance the readability of the code. Nevertheless, not all the comments have the same goal and target audience. In this paper, we investigate how six diverse Java OSS projects use code comments, with the aim of understanding their purpose. Through our analysis, we produce a taxonomy of source code comments; subsequently, we investigate how often each category occur by manually classifying more than 2,000 code comments from the aforementioned projects. In addition, we conduct an initial evaluation on how to automatically classify code comments at line level into our taxonomy using machine learning; initial results are promising and suggest that an accurate classification is within reach.**

I. Introduction

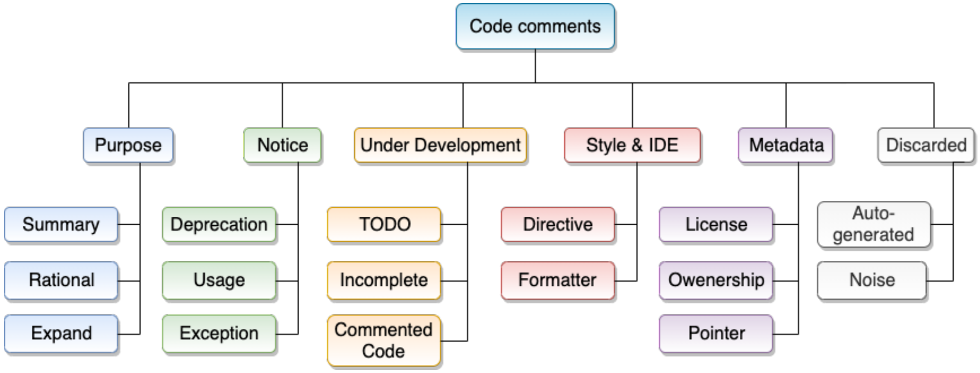
While writing and reading source code, software engineers routinely introduce code comments [6]. Several researchers investigated the usefulness of these comments, showing that thoroughly commented code is more readable and maintainable. For example, Woodfield *et al.* conducted one of the first experiments demonstrating that code comments improve program readability [35]; Tenny *et al.* confirmed these results with more experiments [31], [32]. Hartzman *et al.* investigated the economical maintenance of large software products showing that comments are crucial for maintenance [12]. Jiang *et al.* found that comments that are misaligned to the annotated functions confuse authors of future code changes [13]. Overall, given these results, having abundant comments in the source code is a recognized good practice [4]. Accordingly, researchers proposed to evaluate code quality with a new metric based on code/comment ratio [21], [9].

Nevertheless, not all the comments are the same. This is evident, for example, by glancing through the comments in a source code file[1] from the Java Apache Hadoop Framework [1]. In fact, we see that some comments target end-user programmers (*e.g.*, Javadoc), while others target internal developers (*e.g.*, *inline* comments); moreover, each comment is

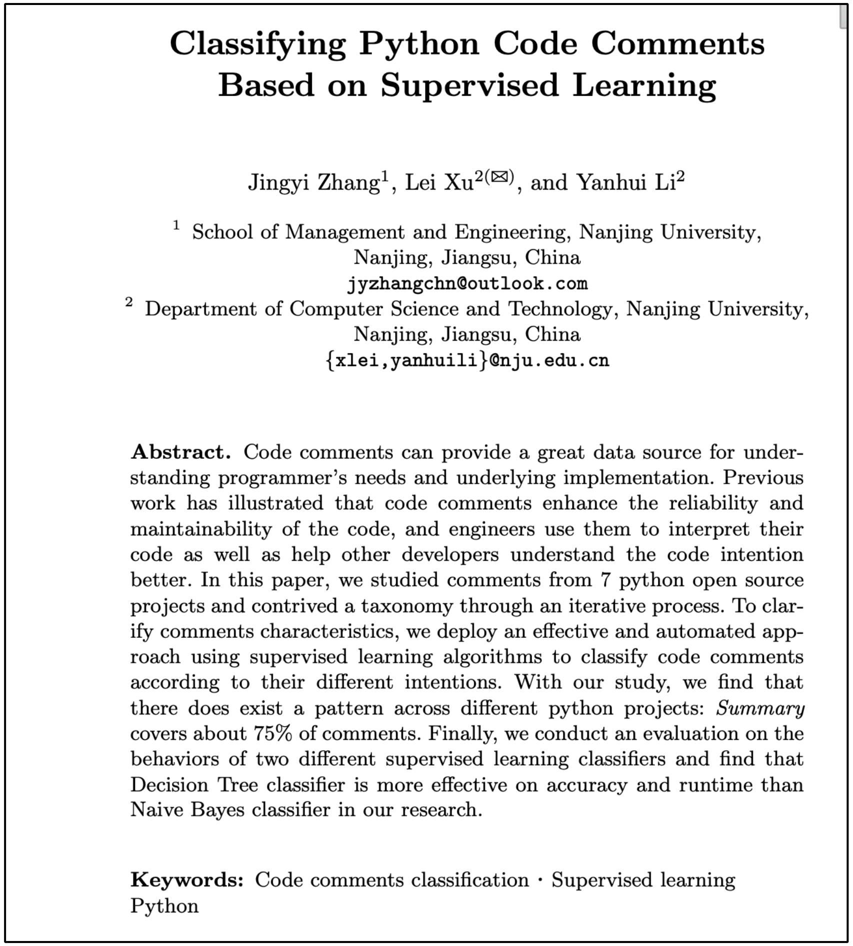
Haouari *et al.* [11] and Steidl *et al.* [28] presented the earliest and most significant results in comments' classification. Haouari *et al.* investigated developers' commenting habits, focusing on the position of comments with respect to source code and proposing an initial taxonomy that includes four high-level categories [11]; Steidl *et al.* proposed a semi-automated approach for the quantitative and qualitative evaluation of comment quality, based on classifying comments in seven high-level categories [28]. In spite of the innovative techniques they proposed to both understanding developers' commenting habits and assessing comments' quality, the classification of comments was not in their primary focus.

In this paper, we focus on increasing our empirical understanding of the types of comments that developers write in source code files. This is a key step to guide future research on the topic. Moreover, this increased understanding has the potential to (1) improve current quality analysis approaches that are restricted to the comment ratio metric only [21], [9] and to (2) strengthen the reliability of other mining approaches that use source code comments as input (*e.g.*, [30], [23]).

To this aim, we conducted an in-depth analysis of the comments in the source code files of six major OSS systems in Java. We set up our study as an exploratory investigation. We started without hypotheses regarding the content of source code comments, with the aim of discovering their purposes and roles, their format, and their frequency. To this end, we (1) conducted three iterative content analysis sessions (involving four researchers) over 50 source files including about 250 comment blocks to define an initial taxonomy of code comments, (2) validated the taxonomy externally with 3 developers, (3) inspected 2, 000 source code files and manually classified (using a new application we devised for this purpose) over 15, 000 comment blocks comprising more than 28, 000 lines, and (4) used the resulting dataset to evaluate how effectively comments can be automatically classified.



Information types in Python code comments



Classifying Python Code Comments Based on Supervised Learning

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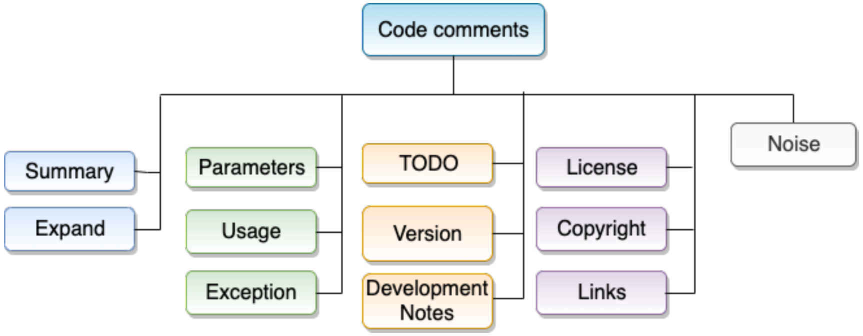
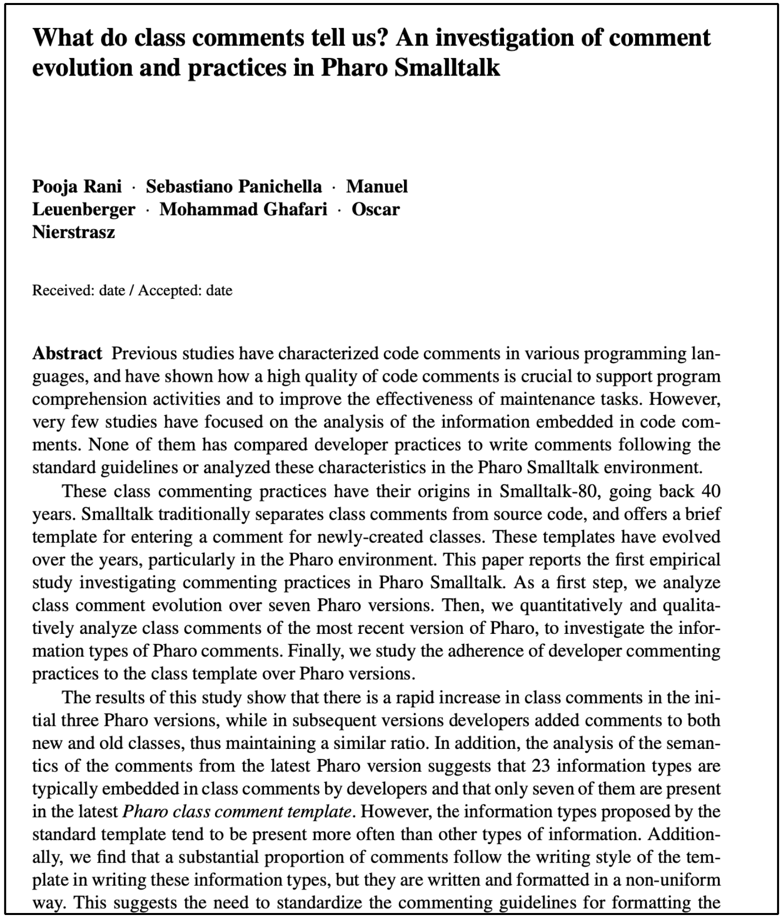
Abstract. Code comments can provide a great data source for understanding programmer's needs and underlying implementation. Previous work has illustrated that code comments enhance the reliability and maintainability of the code, and engineers use them to interpret their code as well as help other developers understand the code intention better. In this paper, we studied comments from 7 python open source projects and contrived a taxonomy through an iterative process. To clarify comments characteristics, we deploy an effective and automated approach using supervised learning algorithms to classify code comments according to their different intentions. With our study, we find that there does exist a pattern across different python projects: *Summary* covers about 75% of comments. Finally, we conduct an evaluation on the behaviors of two different supervised learning classifiers and find that Decision Tree classifier is more effective on accuracy and runtime than Naive Bayes classifier in our research.

Keywords: Code comments classification · Supervised learning
Python



Information types in Pharo code comments



What do class comments tell us? An investigation of comment evolution and practices in Pharo Smalltalk

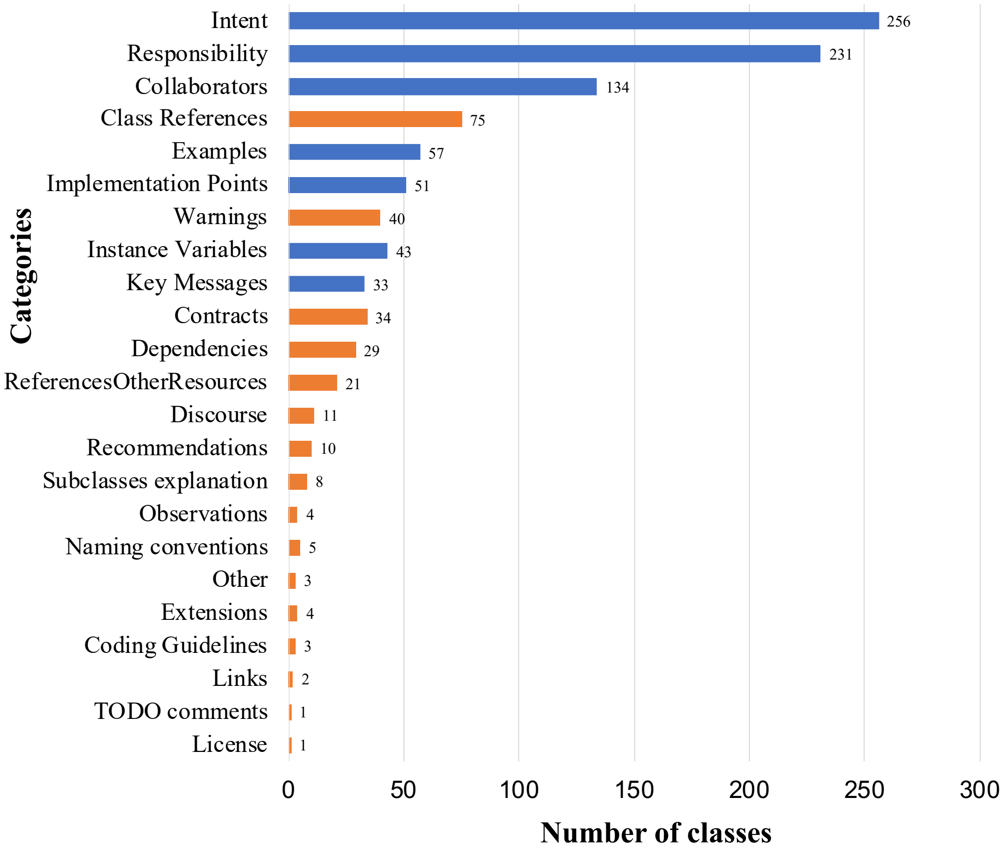
Pooja Rani · Sebastiano Panichella · Manuel Leuenberger · Mohammad Ghafari · Oscar Nierstrasz

Received: date / Accepted: date

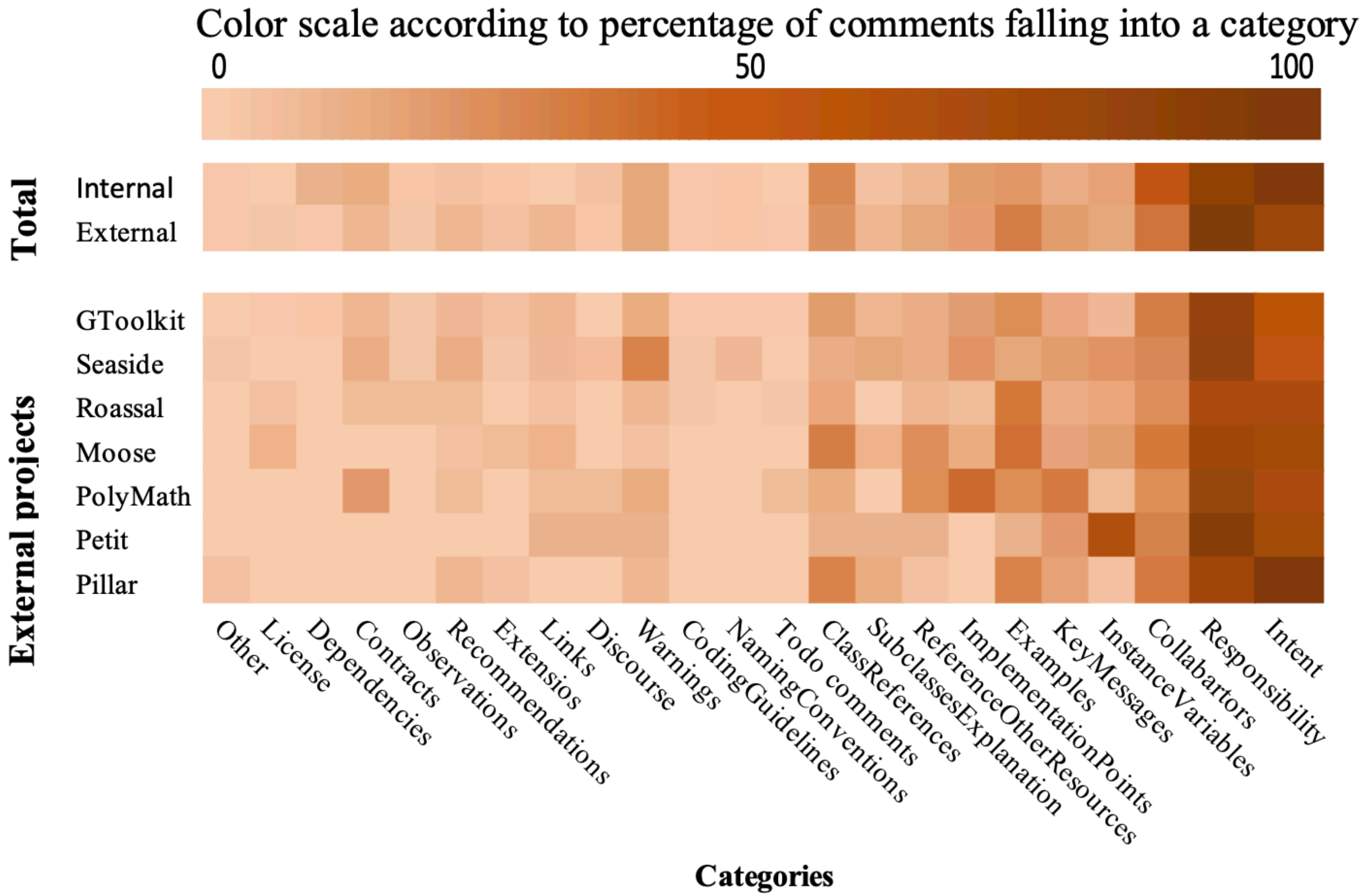
Abstract Previous studies have characterized code comments in various programming languages, and have shown how a high quality of code comments is crucial to support program comprehension activities and to improve the effectiveness of maintenance tasks. However, very few studies have focused on the analysis of the information embedded in code comments. None of them has compared developer practices to write comments following the standard guidelines or analyzed these characteristics in the Pharo Smalltalk environment.

These class commenting practices have their origins in Smalltalk-80, going back 40 years. Smalltalk traditionally separates class comments from source code, and offers a brief template for entering a comment for newly-created classes. These templates have evolved over the years, particularly in the Pharo environment. This paper reports the first empirical study investigating commenting practices in Pharo Smalltalk. As a first step, we analyze class comment evolution over seven Pharo versions. Then, we quantitatively and qualitatively analyze class comments of the most recent version of Pharo, to investigate the information types of Pharo comments. Finally, we study the adherence of developer commenting practices to the class template over Pharo versions.

The results of this study show that there is a rapid increase in class comments in the initial three Pharo versions, while in subsequent versions developers added comments to both new and old classes, thus maintaining a similar ratio. In addition, the analysis of the semantics of the comments from the latest Pharo version suggests that 23 information types are typically embedded in class comments by developers and that only seven of them are present in the latest *Pharo class comment template*. However, the information types proposed by the standard template tend to be present more often than other types of information. Additionally, we find that a substantial proportion of comments follow the writing style of the template in writing these information types, but they are written and formatted in a non-uniform way. This suggests the need to standardize the commenting guidelines for formatting the



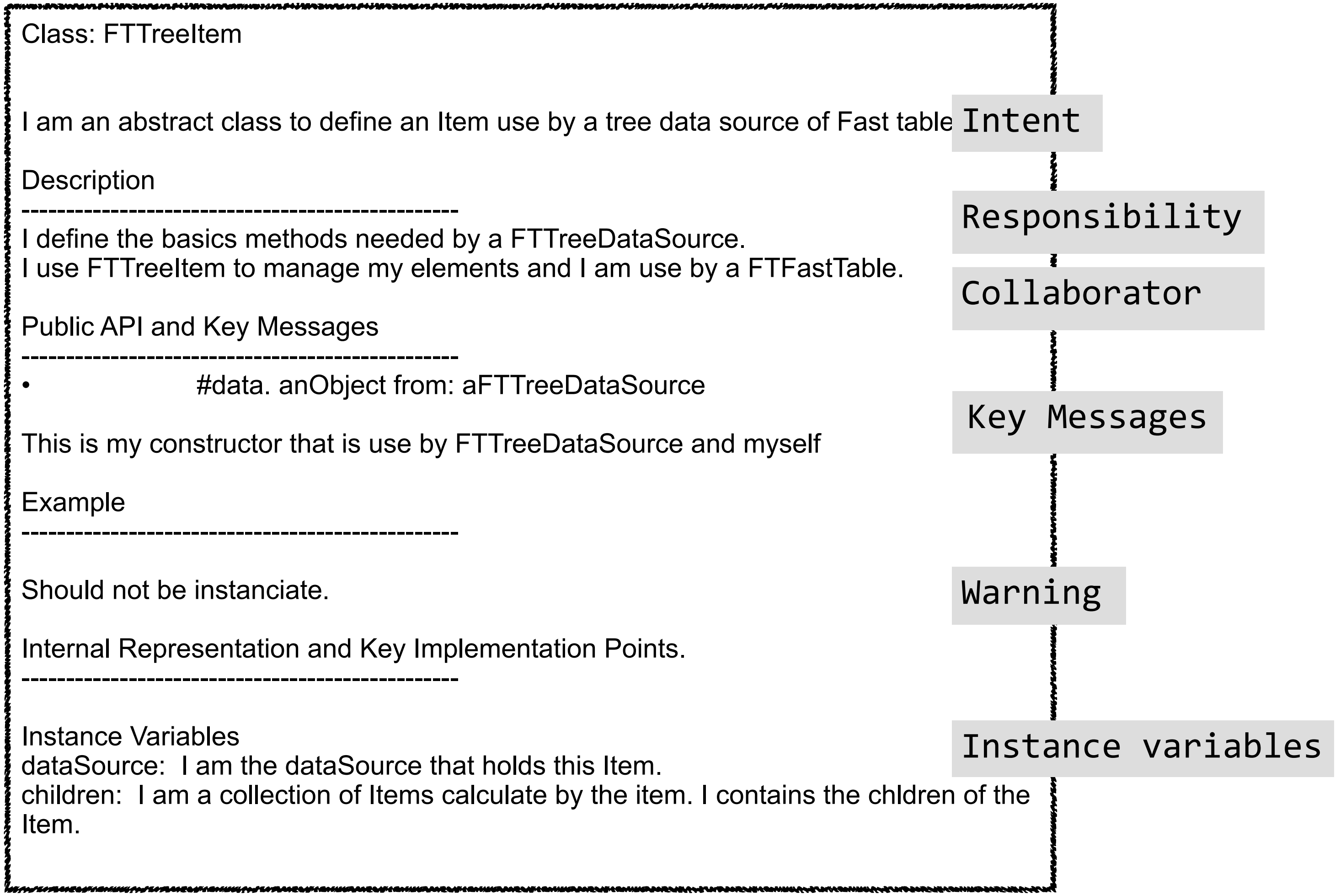
Information types across Pharo projects



Collected data

```
Class: FTTreeItem


I am an abstract class to define an Item use by a tree data source of Fast table.

Description
------------------------------------------------
I define the basics methods needed by a FTTreeDataSource.
I use FTTreeItem to manage my elements and I am use by a FTFastTable.

Public API and Key Messages
------------------------------------------------
•                    #data. anObject from: aFTTreeDataSource

This is my constructor that is use by FTTreeDataSource and myself

Example
------------------------------------------------

Should not be instanciate.

Internal Representation and Key Implementation Points.
------------------------------------------------

Instance Variables
dataSource:  I am the dataSource that holds this Item.
children:  I am a collection of Items calculate by the item. I contains the chldren of the
Item.
```

Collected data



```
Class: FTTreeItem


I am an abstract class to define an Item use by a tree data source of Fast table

Description
------------------------------------------------
I define the basics methods needed by a FTTreeDataSource.
I use FTTreeItem to manage my elements and I am use by a FTFastTable.

Public API and Key Messages
------------------------------------------------
•                    #data. anObject from: aFTTreeDataSource

This is my constructor that is use by FTTreeDataSource and myself

Example
------------------------------------------------

Should not be instanciate.

Internal Representation and Key Implementation Points.
------------------------------------------------

Instance Variables
dataSource:  I am the dataSource that holds this Item.
children:  I am a collection of Items calculate by the item. I contains the chldren of the Item.
```

Intent

Responsibility

Collaborator

Key Messages

Warning

Instance variables

Identification of heuristics

Class: FTTreeItem

I am an abstract class to define an Item use by a tree data source of Fast table

Intent

Description

I define the basics methods needed by a FTTreeDataSource.
I use FTTreeItem to manage my elements and I am **use by** a FTFastTable.

Responsibility

Collaborator

Public API and Key Messages

- #data. anObject from: aFTTreeDataSource

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Should not be instanciate.

Warning

Internal Representation and Key Implementation Points.

Instance Variables
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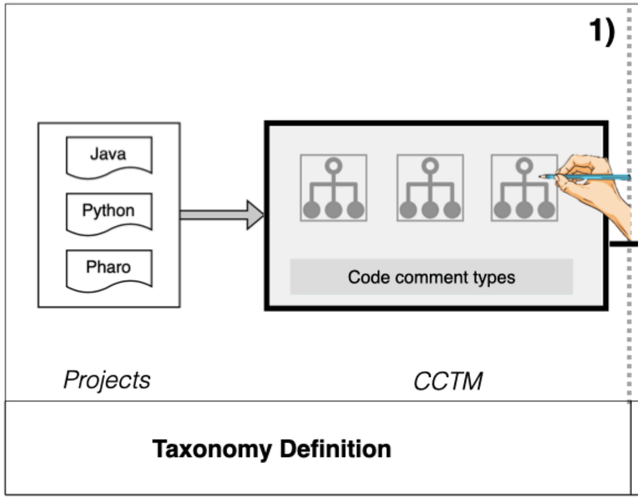
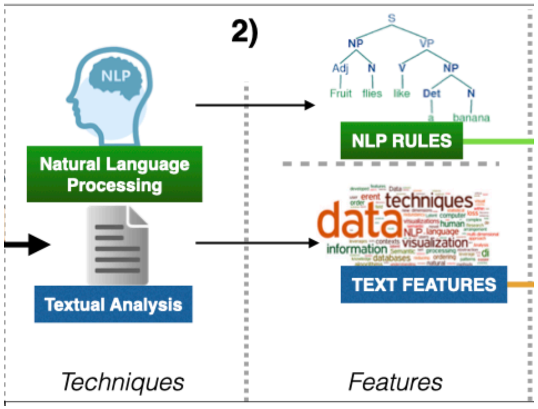
children: I am a collection of Items calculate by the item. I contains the chldren of the Item.

Instance variables

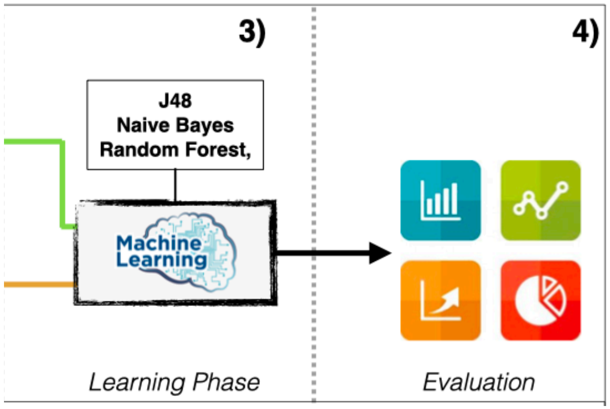
Taxonomy


1)
Java
Python
Pharo
Code comment types
Projects
CCTM
Taxonomy Definition

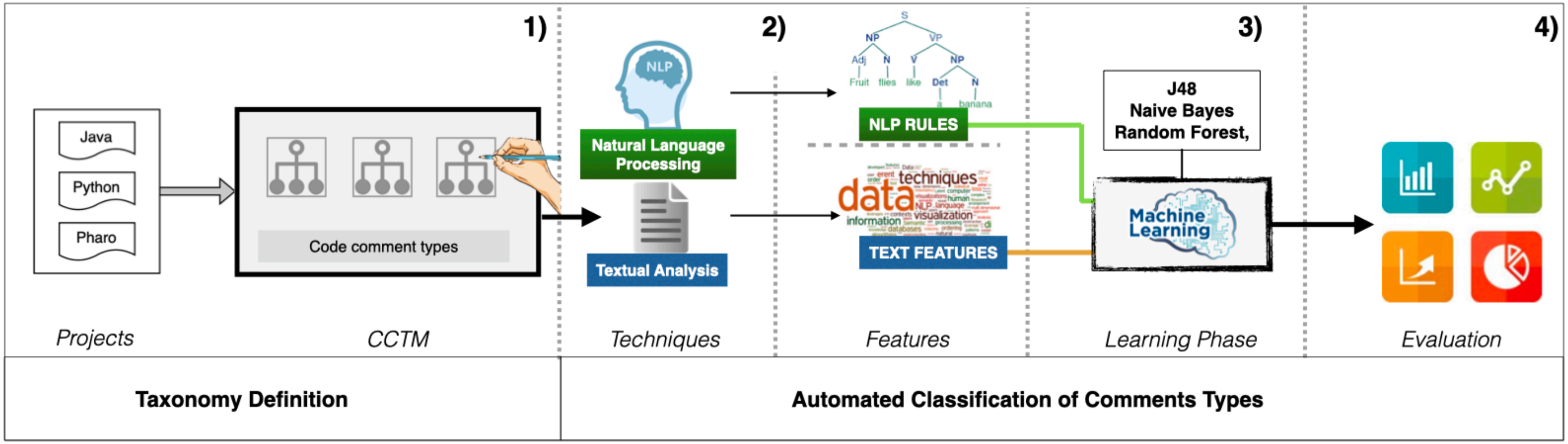
Techniques


2)
NLP
Natural Language Processing
Textual Analysis
S
NP
VP
Adj
N
V
NP
Fruit
flies
like
Det
N
a
banana
NLP RULES
data
techniques
information
visualization
NLP
language
human
computer
databases
TEXT FEATURES
Techniques
Features

Training & Testing

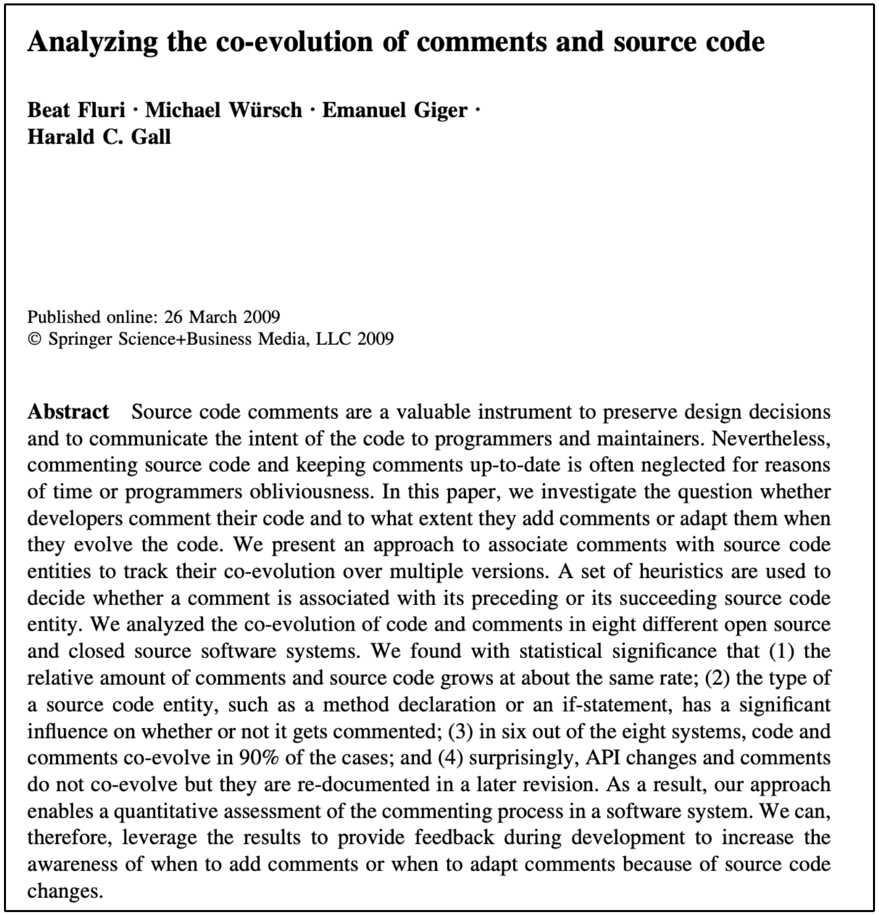


Workflow


1)
2)
3)
4)
Java
Python
Pharo
Code comment types
NLP
Natural Language Processing
Textual Analysis
S
NP
VP
Adj
N
V
NP
Fruit
flies
like
Det
N
a
banana
NLP RULES
data
techniques
information
visualization
TEXT FEATURES
J48
Naive Bayes
Random Forest,
Machine Learning
Projects
CCTM
Techniques
Features
Learning Phase
Evaluation
Taxonomy Definition
Automated Classification of Comments Types

Comment Evolution

Java code comment co-evolution



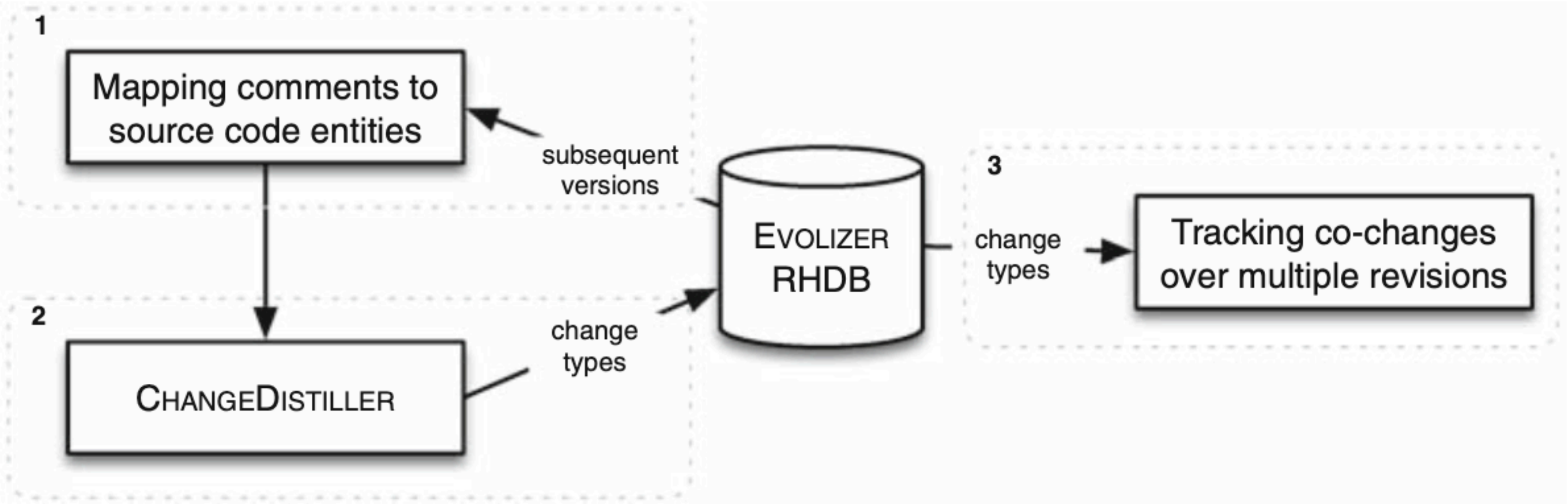
Analyzing the co-evolution of comments and source code

Beat Fluri · Michael Würsch · Emanuel Giger ·
Harald C. Gall

Published online: 26 March 2009

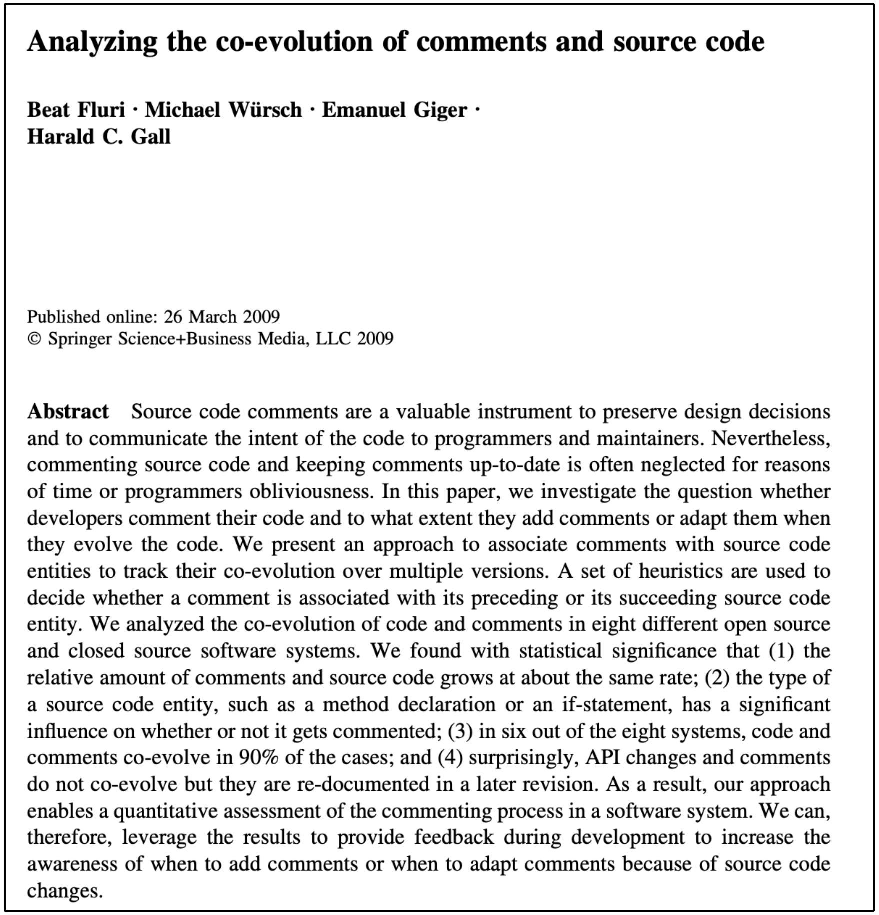
Abstract Source code comments are a valuable instrument to preserve design decisions and to communicate the intent of the code to programmers and maintainers. Nevertheless, commenting source code and keeping comments up-to-date is often neglected for reasons of time or programmers obliviousness. In this paper, we investigate the question whether developers comment their code and to what extent they add comments or adapt them when they evolve the code. We present an approach to associate comments with source code entities to track their co-evolution over multiple versions. A set of heuristics are used to decide whether a comment is associated with its preceding or its succeeding source code entity. We analyzed the co-evolution of code and comments in eight different open source and closed source software systems. We found with statistical significance that (1) the relative amount of comments and source code grows at about the same rate; (2) the type of a source code entity, such as a method declaration or an if-statement, has a significant influence on whether or not it gets commented; (3) in six out of the eight systems, code and comments co-evolve in 90% of the cases; and (4) surprisingly, API changes and comments do not co-evolve but they are re-documented in a later revision. As a result, our approach enables a quantitative assessment of the commenting process in a software system. We can, therefore, leverage the results to provide feedback during development to increase the awareness of when to add comments or when to adapt comments because of source code changes.

Java code comment co-evolution


1
Mapping comments to source code entities
subsequent versions
2
CHANGEDISTILLER
change types
EVOLIZER RHDB
3
change types
Tracking co-changes over multiple revisions

Source: *Analyzing the co-evolution of comments and source code, fig 1*

Java code comment co-evolution



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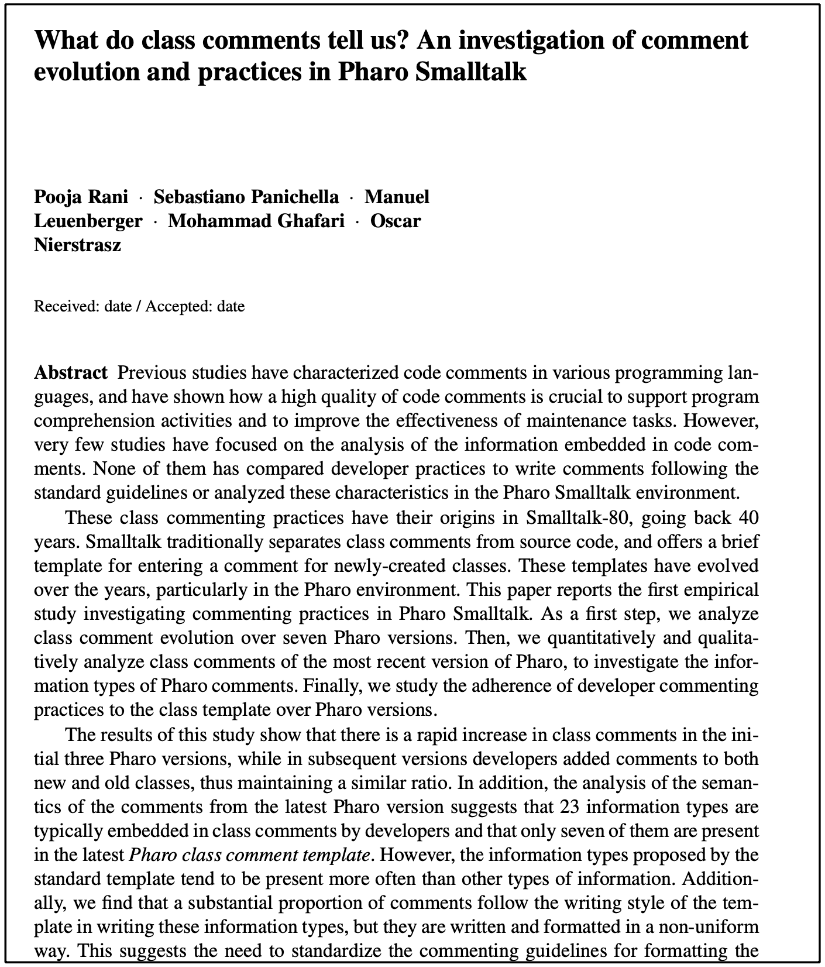
- Over 50% of the comment changes are related to source code changes
- Newly added code gets barely commented
- Growth factor of code and comments are equal over time

Pharo class comment co-evolution



What do class comments tell us? An investigation of comment evolution and practices in Pharo Smalltalk

Pooja Rani · Sebastiano Panichella · Manuel Leuenberger · Mohammad Ghafari · Oscar Nierstrasz

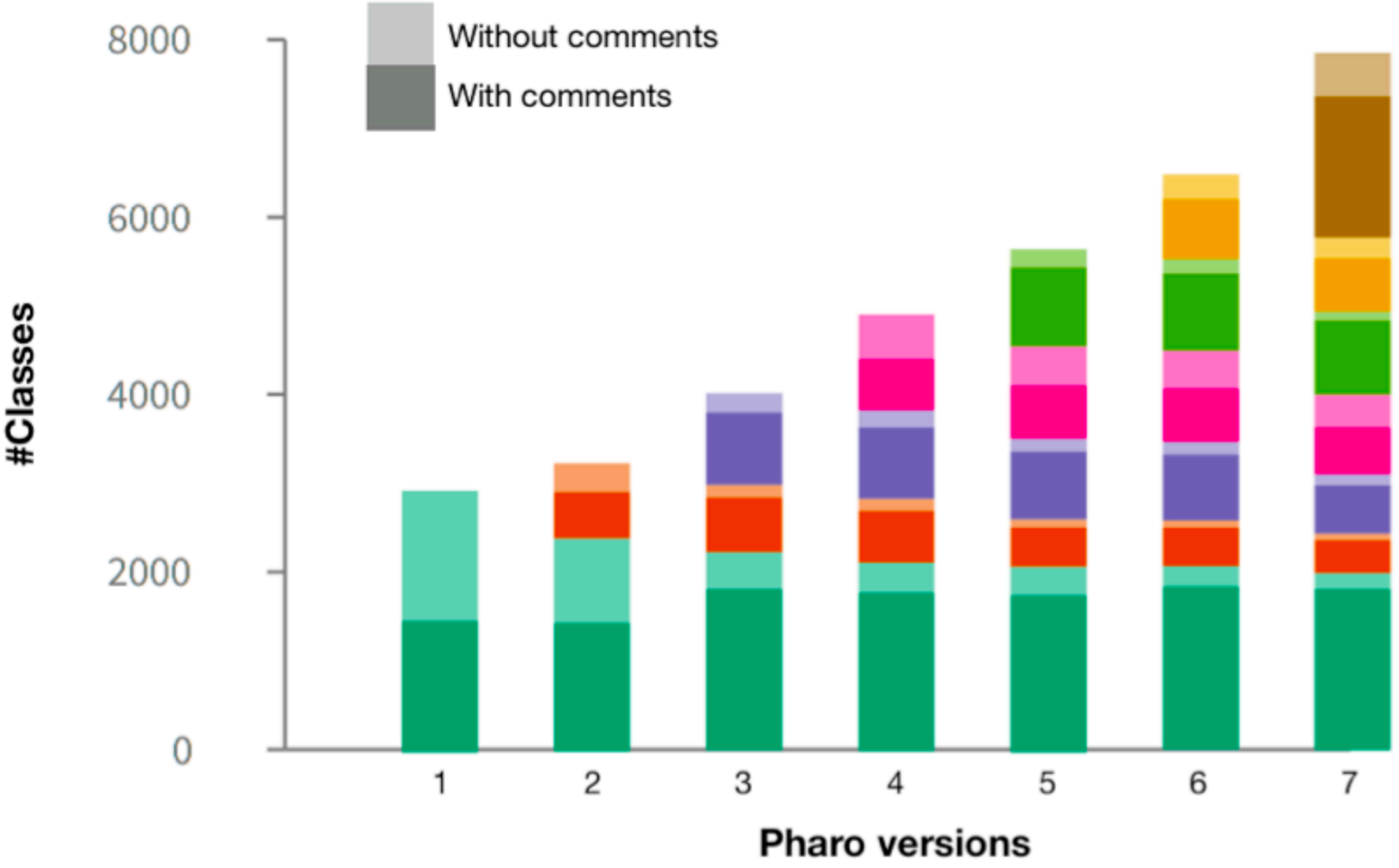
Received: date / Accepted: date

Abstract Previous studies have characterized code comments in various programming languages, and have shown how a high quality of code comments is crucial to support program comprehension activities and to improve the effectiveness of maintenance tasks. However, very few studies have focused on the analysis of the information embedded in code comments. None of them has compared developer practices to write comments following the standard guidelines or analyzed these characteristics in the Pharo Smalltalk environment.

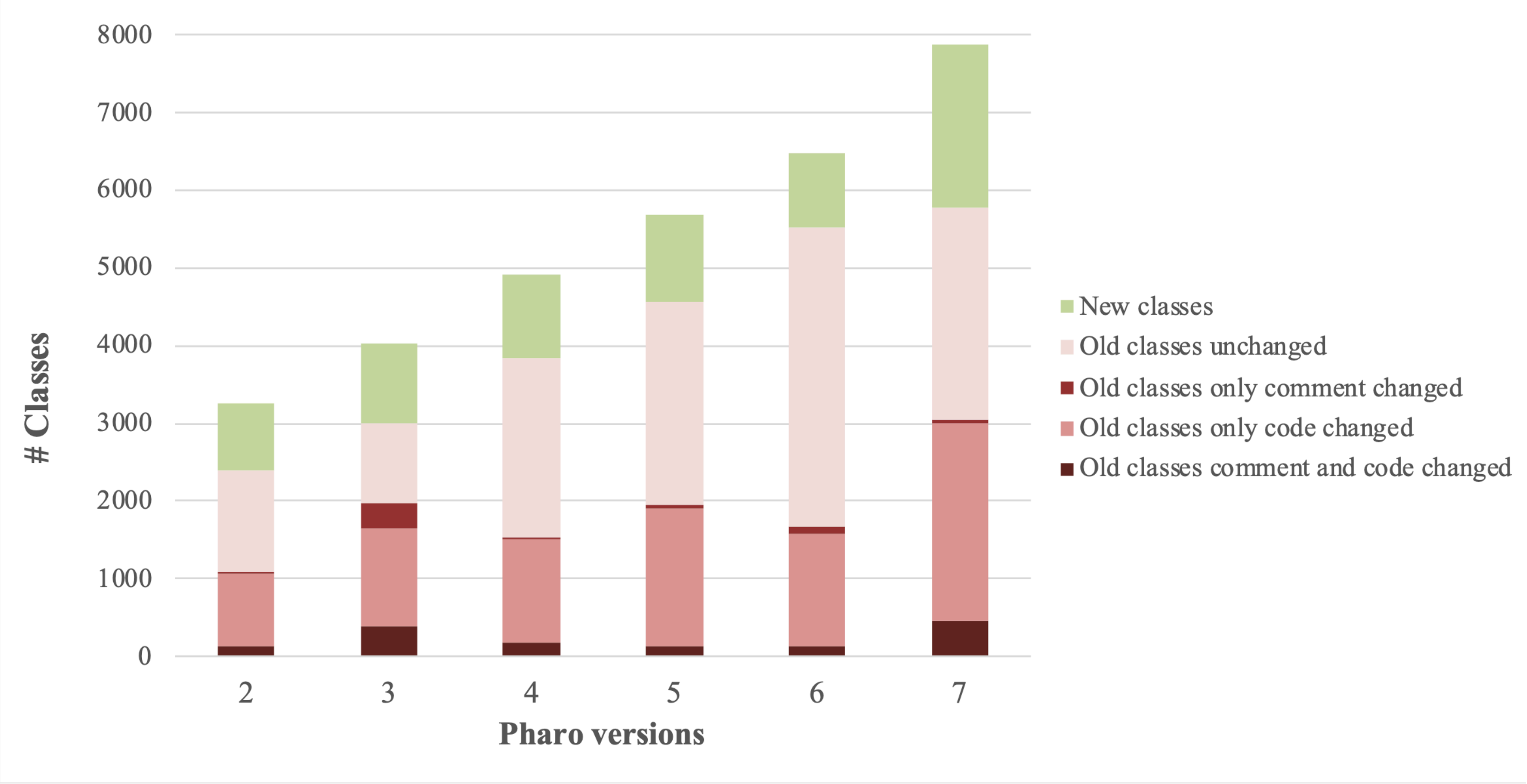
These class commenting practices have their origins in Smalltalk-80, going back 40 years. Smalltalk traditionally separates class comments from source code, and offers a brief template for entering a comment for newly-created classes. These templates have evolved over the years, particularly in the Pharo environment. This paper reports the first empirical study investigating commenting practices in Pharo Smalltalk. As a first step, we analyze class comment evolution over seven Pharo versions. Then, we quantitatively and qualitatively analyze class comments of the most recent version of Pharo, to investigate the information types of Pharo comments. Finally, we study the adherence of developer commenting practices to the class template over Pharo versions.

The results of this study show that there is a rapid increase in class comments in the initial three Pharo versions, while in subsequent versions developers added comments to both new and old classes, thus maintaining a similar ratio. In addition, the analysis of the semantics of the comments from the latest Pharo version suggests that 23 information types are typically embedded in class comments by developers and that only seven of them are present in the latest *Pharo class comment template*. However, the information types proposed by the standard template tend to be present more often than other types of information. Additionally, we find that a substantial proportion of comments follow the writing style of the template in writing these information types, but they are written and formatted in a non-uniform way. This suggests the need to standardize the commenting guidelines for formatting the

Pharo Comment Evolution



Pharo class comment evolution



Pharo class comment co-evolution

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- Newly added code gets commented often
- Growth factor of code and comments are not equal over time

Automatic generation and summarization of comments

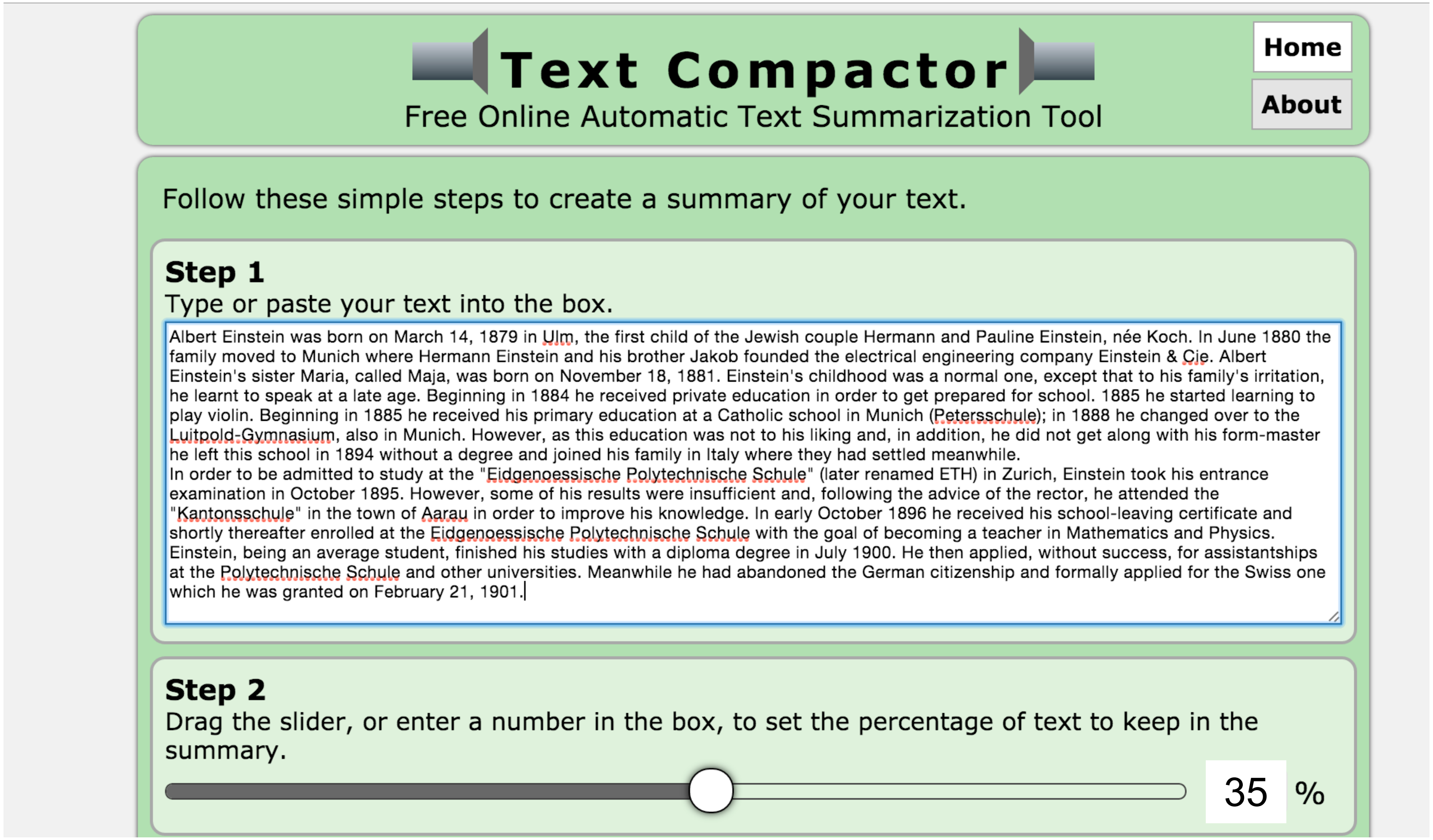
Code summaries

- “*Automatically generated, short, yet accurate descriptions of source code entities*”.

- They give more information than just the header or the name of an artifact.

- Significantly shorter and faster to read than the source code they summarize

Example of natural language summaries



Follow these simple steps to create a summary of your text.

Step 1
Type or paste your text into the box.

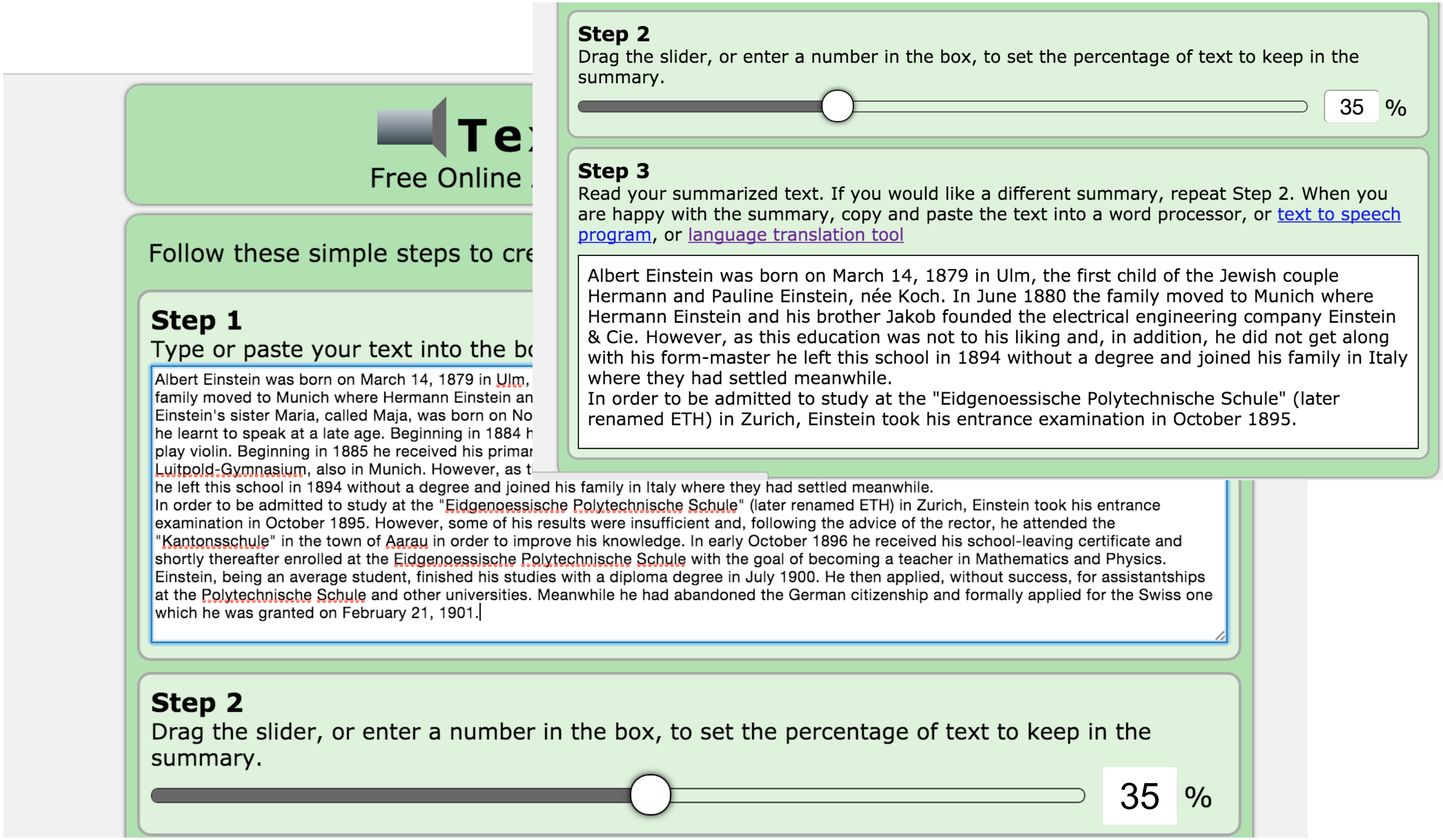
Albert Einstein was born on March 14, 1879 in Ulm, the first child of the Jewish couple Hermann and Pauline Einstein, née Koch. In June 1880 the family moved to Munich where Hermann Einstein and his brother Jakob founded the electrical engineering company Einstein & Cie. Albert Einstein's sister Maria, called Maja, was born on November 18, 1881. Einstein's childhood was a normal one, except that to his family's irritation, he learnt to speak at a late age. Beginning in 1884 he received private education in order to get prepared for school. 1885 he started learning to play violin. Beginning in 1885 he received his primary education at a Catholic school in Munich (Petersschule); in 1888 he changed over to the Luitpold-Gymnasium, also in Munich. However, as this education was not to his liking and, in addition, he did not get along with his form-master he left this school in 1894 without a degree and joined his family in Italy where they had settled meanwhile.
In order to be admitted to study at the "Eidgenoessische Polytechnische Schule" (later renamed ETH) in Zurich, Einstein took his entrance examination in October 1895. However, some of his results were insufficient and, following the advice of the rector, he attended the "Kantonsschule" in the town of Aarau in order to improve his knowledge. In early October 1896 he received his school-leaving certificate and shortly thereafter enrolled at the Eidgenoessische Polytechnische Schule with the goal of becoming a teacher in Mathematics and Physics. Einstein, being an average student, finished his studies with a diploma degree in July 1900. He then applied, without success, for assistantships at the Polytechnische Schule and other universities. Meanwhile he had abandoned the German citizenship and formally applied for the Swiss one which he was granted on February 21, 1901.

Step 2
Drag the slider, or enter a number in the box, to set the percentage of text to keep in the summary.

35 %

https://www.textcompactor.com/

Example of natural language summaries



Tex

Free Online

Follow these simple steps to cre

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Type or paste your text into the bo

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https://www.textcompactor.com/

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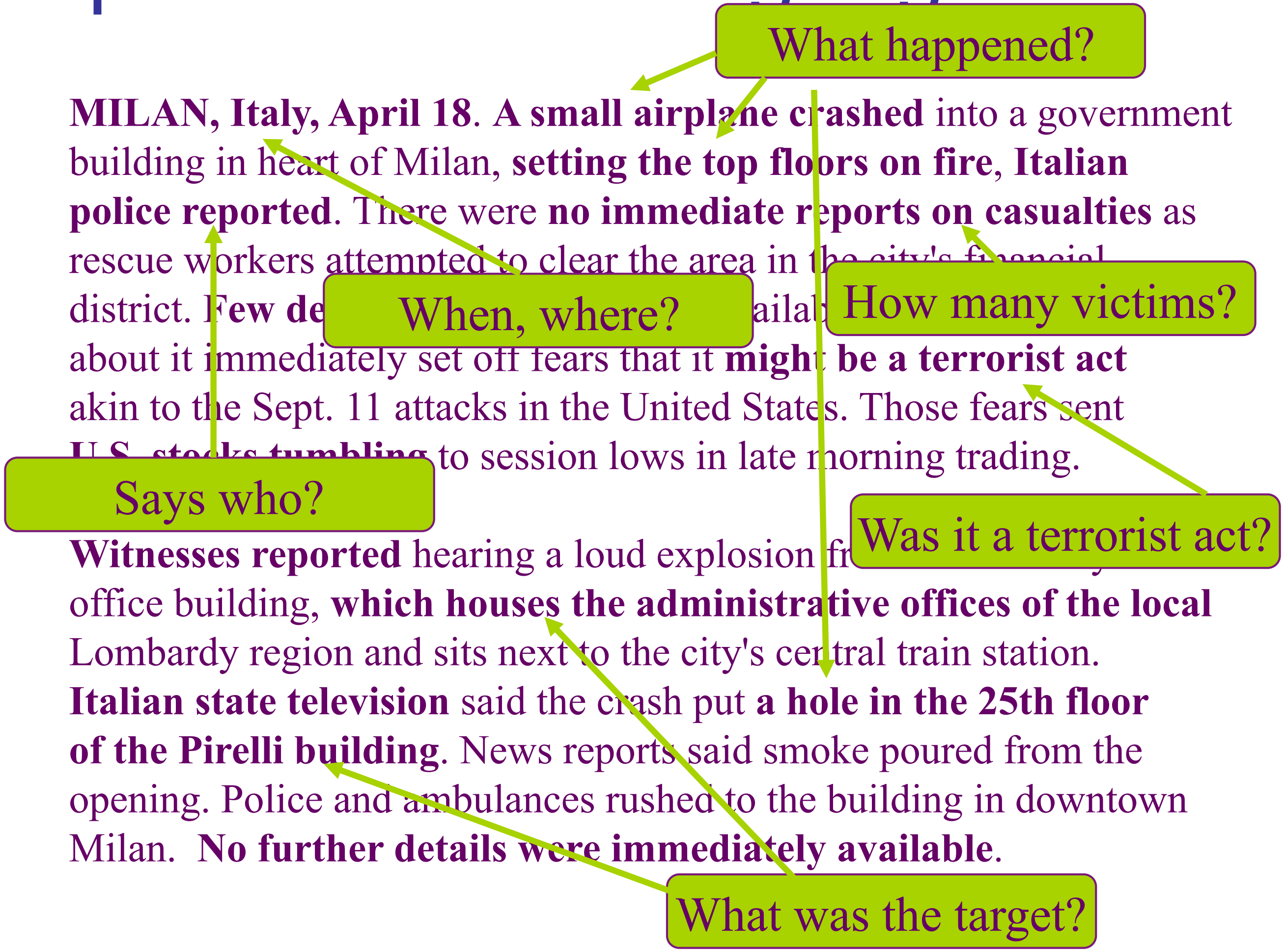
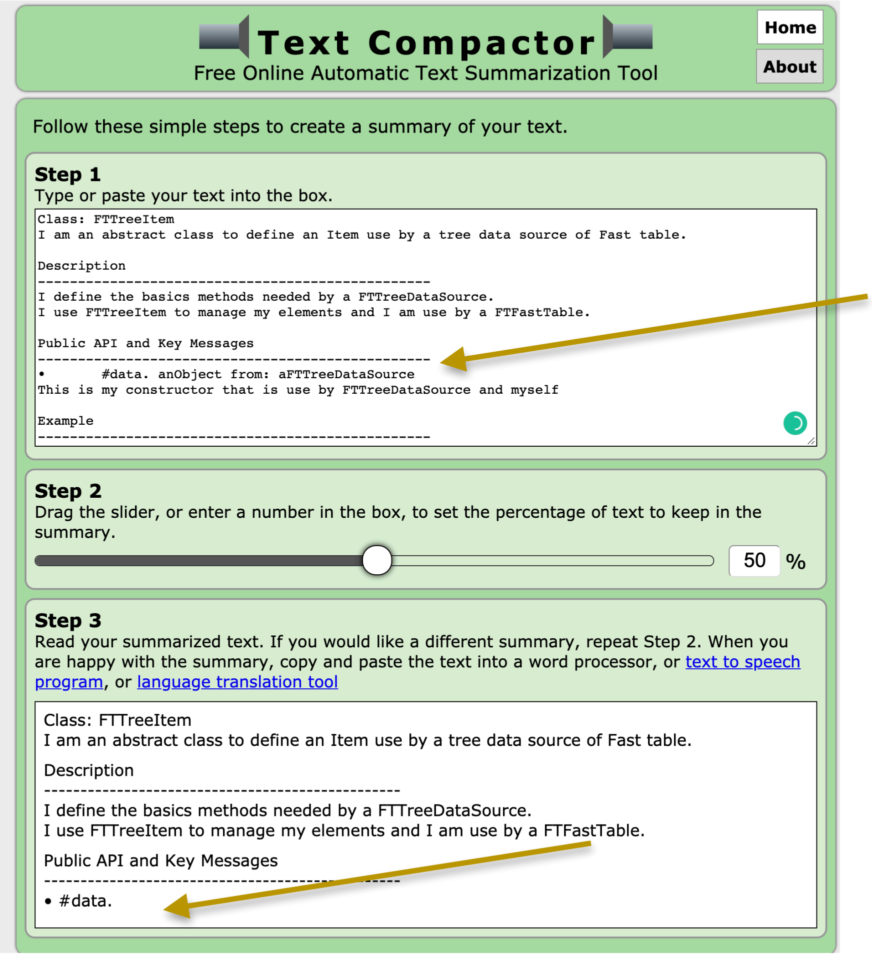


MILAN, Italy, April 18. **A small airplane crashed** into a government building in heart of Milan, **setting the top floors on fire**, **Italian police reported**. There were **no immediate reports on casualties** as rescue workers attempted to clear the area in the city's financial district. **Few de** ailab about it immediately set off fears that it **might be a terrorist act** akin to the Sept. 11 attacks in the United States. Those fears sent **U.S. stocks tumbling** to session lows in late morning trading.

Witnesses reported hearing a loud explosion fr office building, **which houses the administrative offices of the local** Lombardy region and sits next to the city's central train station. **Italian state television** said the crash put **a hole in the 25th floor of the Pirelli building**. News reports said smoke poured from the opening. Police and ambulances rushed to the building in downtown Milan. **No further details were immediately available**.

Comment summaries



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```
Class: FTTreeItem
I am an abstract class to define an Item use by a tree data source of Fast table.

Description
--------------------------------------------------
I define the basics methods needed by a FTTreeDataSource.
I use FTTreeItem to manage my elements and I am use by a FTFastTable.

Public API and Key Messages
--------------------------------------------------
•       #data. anObject from: aFTTreeDataSource
This is my constructor that is use by FTTreeDataSource and myself

Example
--------------------------------------------------
```

Step 2
Drag the slider, or enter a number in the box, to set the percentage of text to keep in the summary.

50 %

Step 3
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Description

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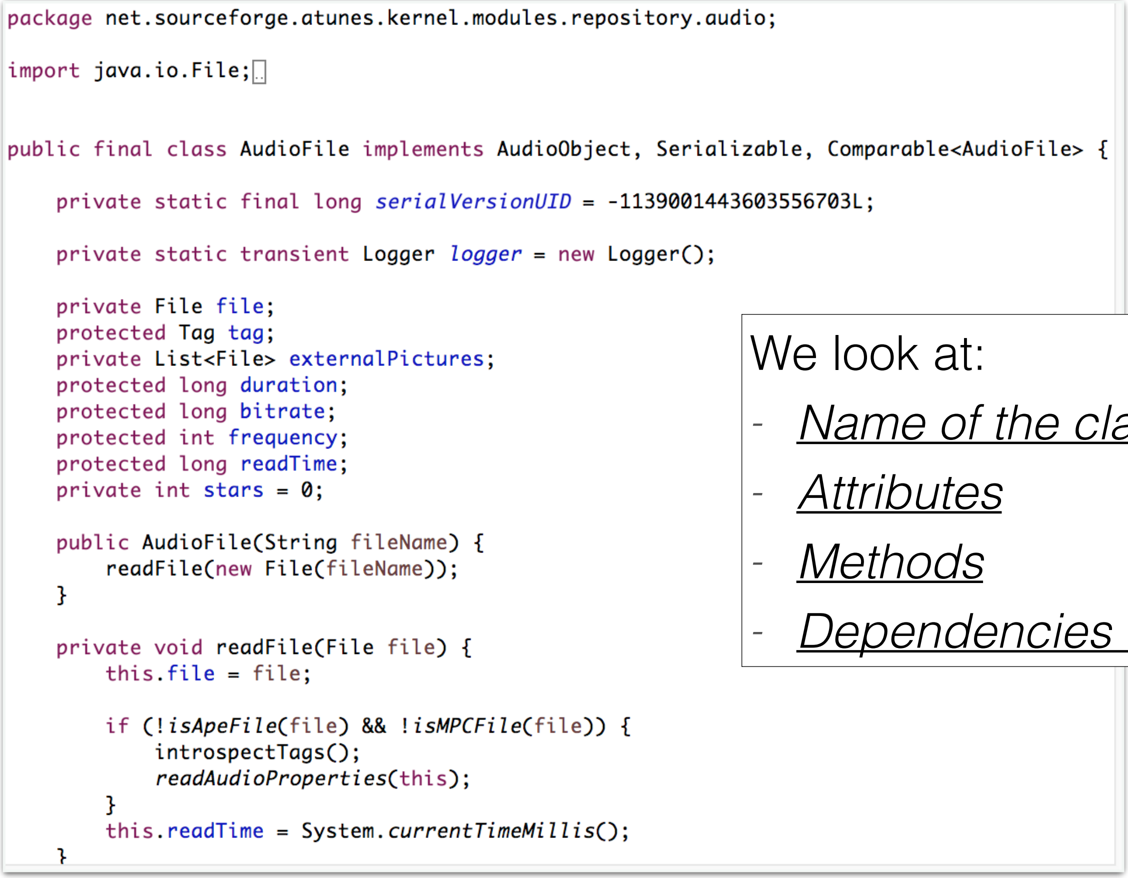
I use FTTreeItem to manage my elements and I am use by a FTFastTable.

Public API and Key Messages

- #data.

https://www.textcompactor.com/

Navigating classes



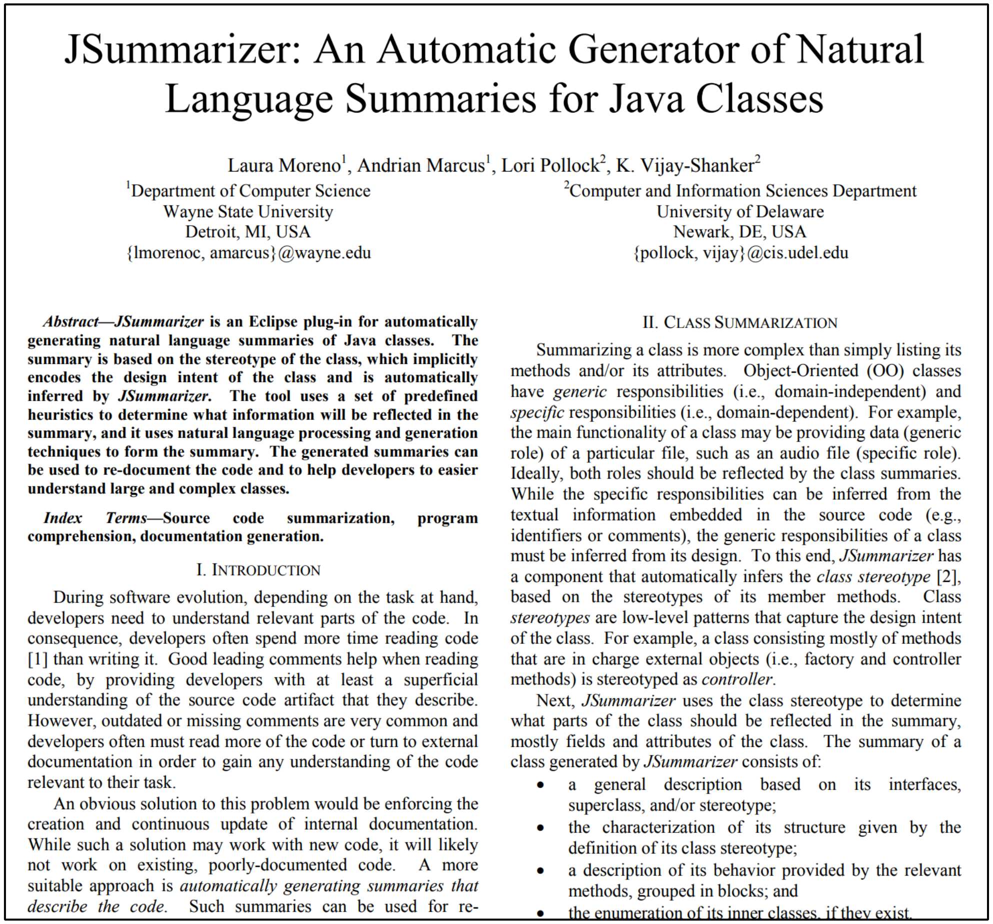
```
package net.sourceforge.atunes.kernel.modules.repository.audio;

import java.io.File;□


public final class AudioFile implements AudioObject, Serializable, Comparable<AudioFile> {

    private static final long serialVersionUID = -1139001443603556703L;

    private static transient Logger logger = new Logger();

    private File file;
    protected Tag tag;
    private List<File> externalPictures;
    protected long duration;
    protected long bitrate;
    protected int frequency;
    protected long readTime;
    private int stars = 0;

    public AudioFile(String fileName) {
        readFile(new File(fileName));
    }

    private void readFile(File file) {
        this.file = file;

        if (!isApeFile(file) && !isMPCFile(file)) {
            introspectTags();
            readAudioProperties(this);
        }
        this.readTime = System.currentTimeMillis();
    }
```

We look at:

- *Name of the class*
- *Attributes*
- *Methods*
- *Dependencies between classes*

https://github.com/larsb/atunesplus/blob/master/aTunes/src/main/java/net/sourceforge/atunes/kernel/modules/repository/audio/AudioFile.java

Java class summaries



JSummarizer: An Automatic Generator of Natural Language Summaries for Java Classes

Laura Moreno[1], Andrian Marcus[1], Lori Pollock[2], K. Vijay-Shanker[2]

[1]Department of Computer Science
Wayne State University
Detroit, MI, USA
{lmorenoc, amarcus}@wayne.edu

[2]Computer and Information Sciences Department
University of Delaware
Newark, DE, USA
{pollock, vijay}@cis.udel.edu

***Abstract*—*JSummarizer* is an Eclipse plug-in for automatically generating natural language summaries of Java classes. The summary is based on the stereotype of the class, which implicitly encodes the design intent of the class and is automatically inferred by *JSummarizer*. The tool uses a set of predefined heuristics to determine what information will be reflected in the summary, and it uses natural language processing and generation techniques to form the summary. The generated summaries can be used to re-document the code and to help developers to easier understand large and complex classes.**

***Index Terms*—Source code summarization, program comprehension, documentation generation.**

I. Introduction

During software evolution, depending on the task at hand, developers need to understand relevant parts of the code. In consequence, developers often spend more time reading code [1] than writing it. Good leading comments help when reading code, by providing developers with at least a superficial understanding of the source code artifact that they describe. However, outdated or missing comments are very common and developers often must read more of the code or turn to external documentation in order to gain any understanding of the code relevant to their task.

An obvious solution to this problem would be enforcing the creation and continuous update of internal documentation. While such a solution may work with new code, it will likely not work on existing, poorly-documented code. A more suitable approach is *automatically generating summaries that describe the code*. Such summaries can be used for re-

II. Class Summarization

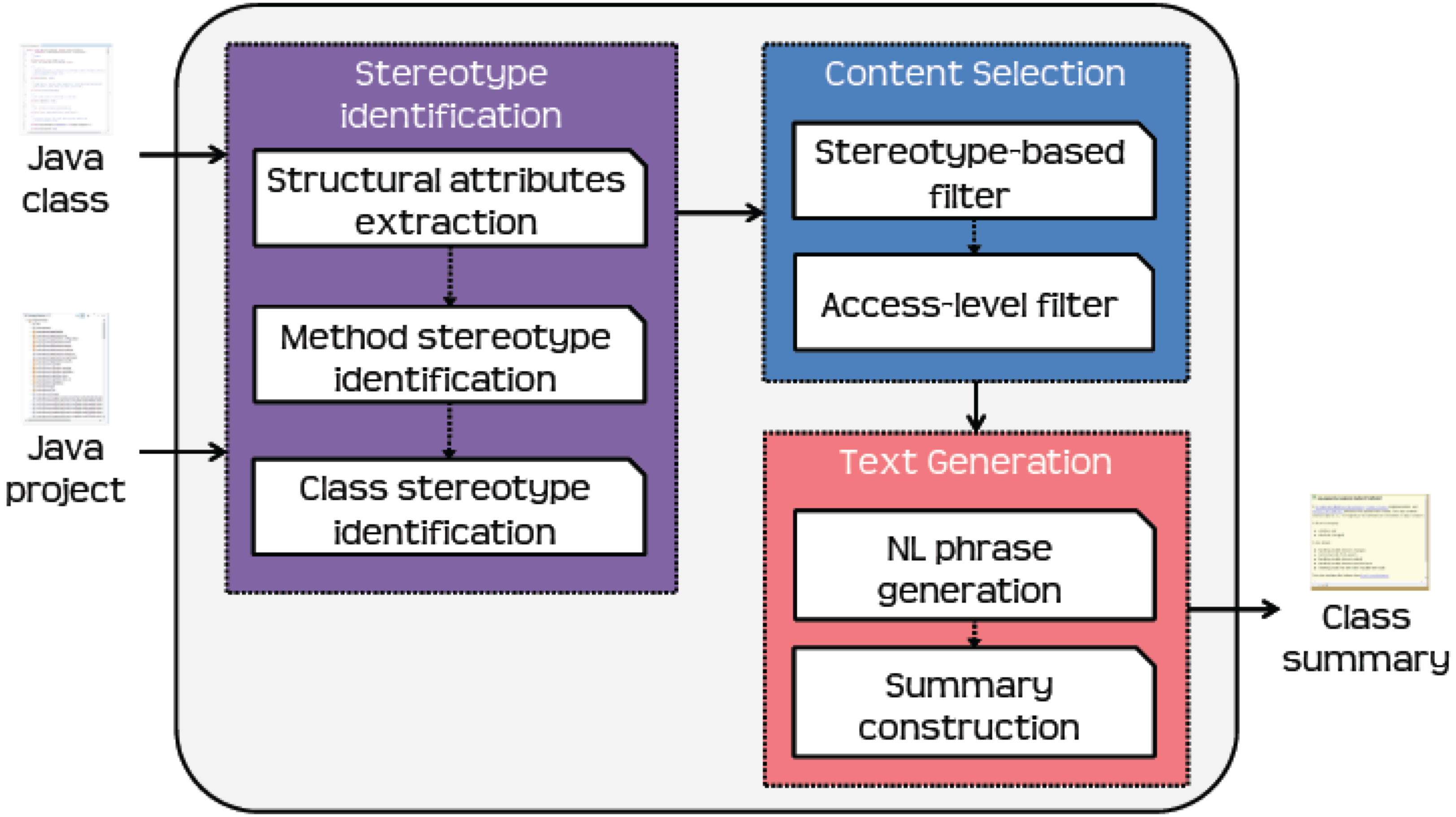
Summarizing a class is more complex than simply listing its methods and/or its attributes. Object-Oriented (OO) classes have *generic* responsibilities (i.e., domain-independent) and *specific* responsibilities (i.e., domain-dependent). For example, the main functionality of a class may be providing data (generic role) of a particular file, such as an audio file (specific role). Ideally, both roles should be reflected by the class summaries. While the specific responsibilities can be inferred from the textual information embedded in the source code (e.g., identifiers or comments), the generic responsibilities of a class must be inferred from its design. To this end, *JSummarizer* has a component that automatically infers the *class stereotype* [2], based on the stereotypes of its member methods. Class *stereotypes* are low-level patterns that capture the design intent of the class. For example, a class consisting mostly of methods that are in charge external objects (i.e., factory and controller methods) is stereotyped as *controller*.

Next, *JSummarizer* uses the class stereotype to determine what parts of the class should be reflected in the summary, mostly fields and attributes of the class. The summary of a class generated by *JSummarizer* consists of:

- a general description based on its interfaces, superclass, and/or stereotype;
- the characterization of its structure given by the definition of its class stereotype;
- a description of its behavior provided by the relevant methods, grouped in blocks; and
- the enumeration of its inner classes, if they exist.

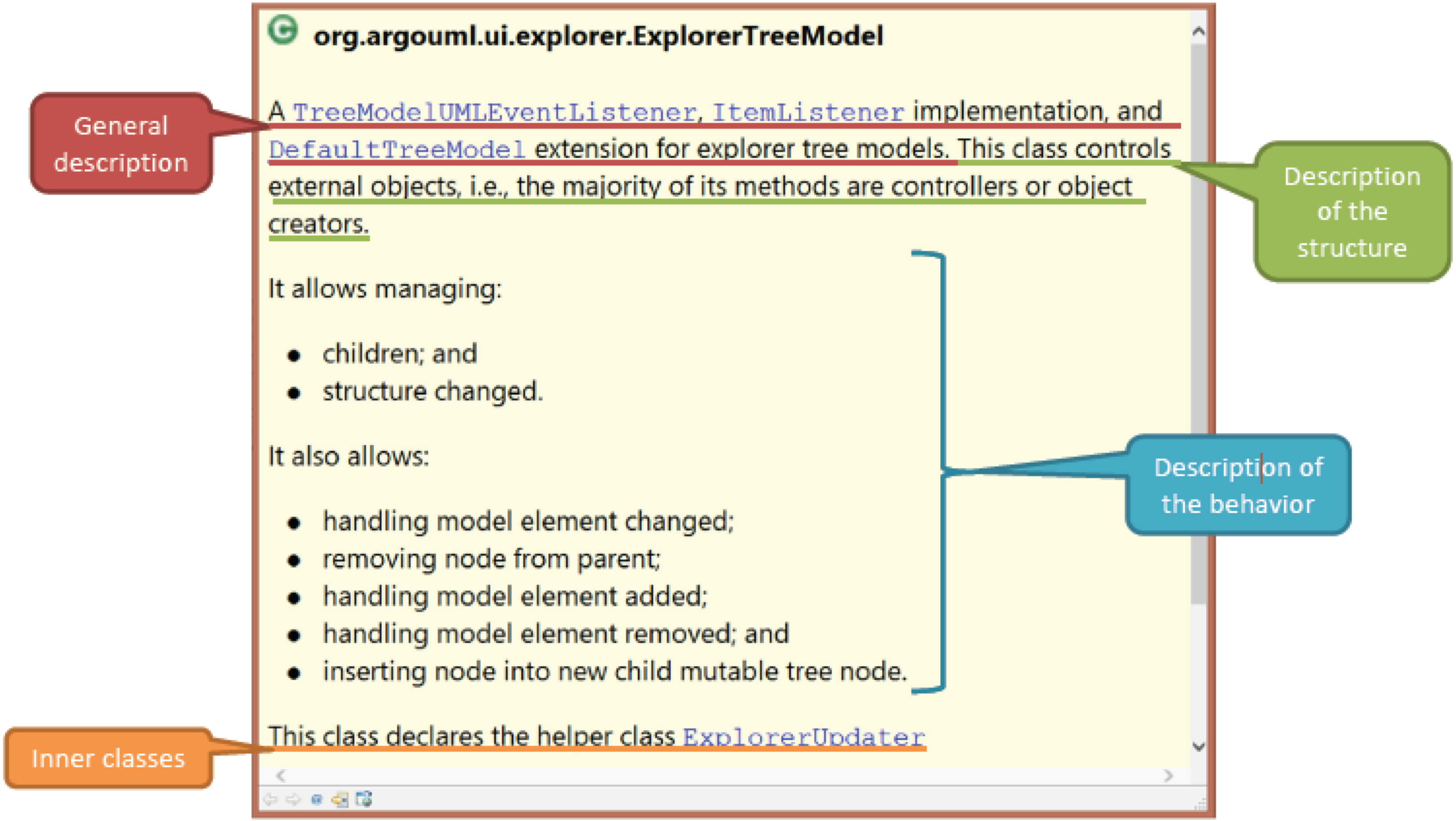
- Generate class summaries
- Decide the information to generate
- Gather the heuristics
- Generate the info

Workflow



JSummarizer: An automatic generator of natural language summaries for Java classes by Moreno

Summary



org.argouml.ui.explorer.ExplorerTreeModel

A TreeModelUMLEventListener, ItemListener implementation, and DefaultTreeModel extension for explorer tree models. This class controls external objects, i.e., the majority of its methods are controllers or object creators.

It allows managing:

- children; and
- structure changed.

It also allows:

- handling model element changed;
- removing node from parent;
- handling model element added;
- handling model element removed; and
- inserting node into new child mutable tree node.

This class declares the helper class ExplorerUpdater

Questions when summarizing classes

- What information to include in the summaries?
- How much information to include in the summaries?
- How to generate and present the summaries?

Content adequacy vs. expressiveness

- Missing some information
- Not easy to understand

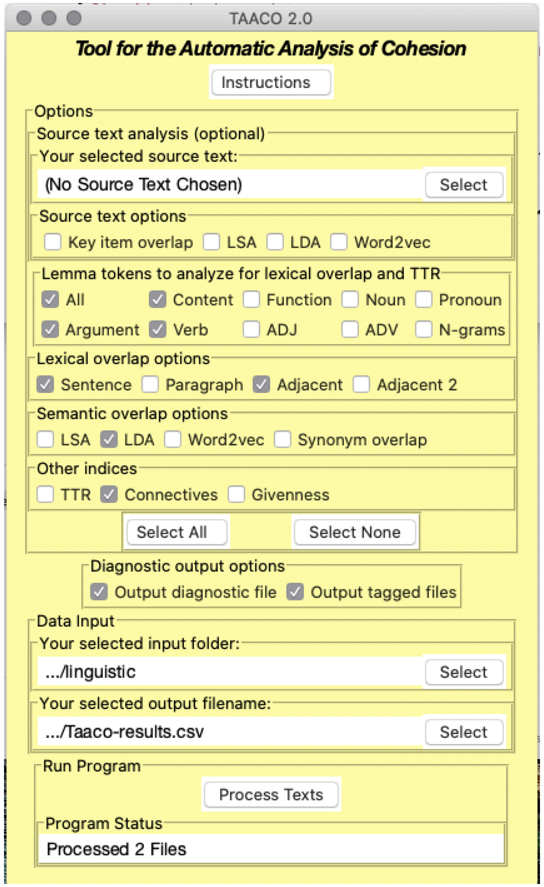
To overcome these limitations…

Researchers proposed to detect source code descriptions from external sources:

- Mailing list and issue trackers
- StackOverflow discussions

Linguistic Analysis

Linguistic analysis for English



Tool for the Automatic Analysis of Cohesion

Options

Source text analysis (optional)

Your selected source text: (No Source Text Chosen)

Source text options: □ Key item overlap □ LSA □ LDA □ Word2vec

Lemma tokens to analyze for lexical overlap and TTR: ☑ All ☑ Content □ Function □ Noun □ Pronoun ☑ Argument ☑ Verb □ ADJ □ ADV □ N-grams

Lexical overlap options: ☑ Sentence □ Paragraph ☑ Adjacent □ Adjacent 2

Semantic overlap options: □ LSA ☑ LDA □ Word2vec □ Synonym overlap

Other indices: □ TTR ☑ Connectives □ Givenness

Diagnostic output options: ☑ Output diagnostic file ☑ Output tagged files

Data Input

Your selected input folder: .../linguistic

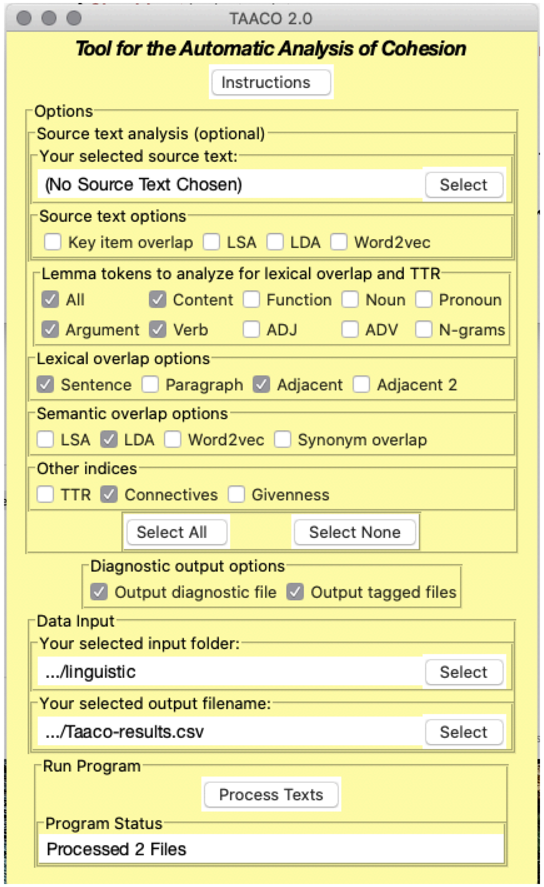
Your selected output filename: .../Taaco-results.csv

Run Program

Program Status: Processed 2 Files

TAACO

Linguistic analysis for English



TAACO 2.0

Tool for the Automatic Analysis of Cohesion

Options

Source text analysis (optional)

Your selected source text:

(No Source Text Chosen)

Source text options

□ Key item overlap □ LSA □ LDA □ Word2vec

Lemma tokens to analyze for lexical overlap and TTR

☑ All ☑ Content □ Function □ Noun □ Pronoun

☑ Argument ☑ Verb □ ADJ □ ADV □ N-grams

Lexical overlap options

☑ Sentence □ Paragraph ☑ Adjacent □ Adjacent 2

Semantic overlap options

□ LSA ☑ LDA □ Word2vec □ Synonym overlap

Other indices

□ TTR ☑ Connectives □ Givenness

Diagnostic output options

☑ Output diagnostic file ☑ Output tagged files

Data Input

Your selected input folder:

.../linguistic

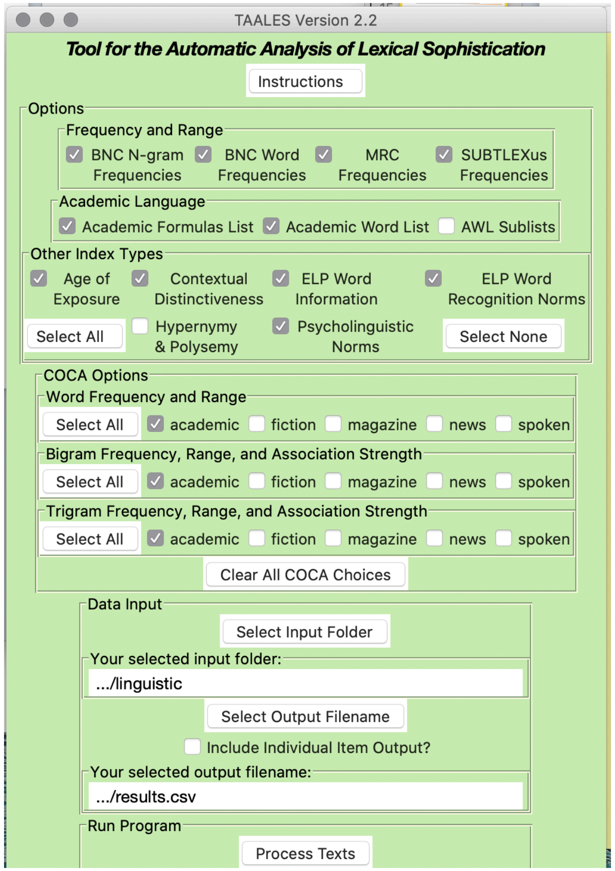
Your selected output filename:

.../Taaco-results.csv

Run Program

Program Status

Processed 2 Files



TAALES Version 2.2

Tool for the Automatic Analysis of Lexical Sophistication

Options

Frequency and Range

☑ BNC N-gram Frequencies ☑ BNC Word Frequencies ☑ MRC Frequencies ☑ SUBTLEXus Frequencies

Academic Language

☑ Academic Formulas List ☑ Academic Word List □ AWL Sublists

Other Index Types

☑ Age of Exposure ☑ Contextual Distinctiveness ☑ ELP Word Information ☑ ELP Word Recognition Norms

□ Hypernymy & Polysemy ☑ Psycholinguistic Norms

COCA Options

Word Frequency and Range

☑ academic □ fiction □ magazine □ news □ spoken

Bigram Frequency, Range, and Association Strength

☑ academic □ fiction □ magazine □ news □ spoken

Trigram Frequency, Range, and Association Strength

☑ academic □ fiction □ magazine □ news □ spoken

Data Input

Your selected input folder:

.../linguistic

□ Include Individual Item Output?

Your selected output filename:

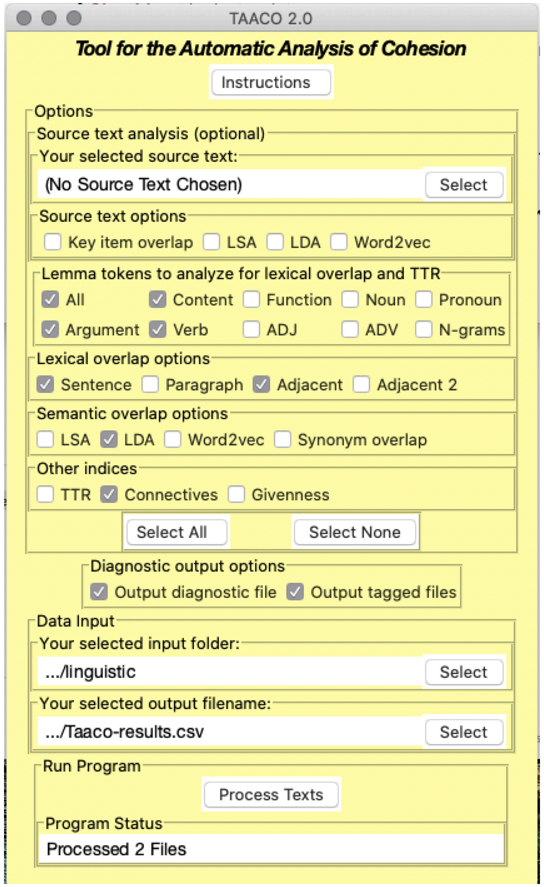
.../results.csv

Run Program

TAACO

TAALES

Linguistic analysis for English



TAACO 2.0

Tool for the Automatic Analysis of Cohesion

Instructions

Options

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Source text options

□ Key item overlap □ LSA □ LDA □ Word2vec

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Semantic overlap options

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Other indices

□ TTR ☑ Connectives □ Givenness

Select All Select None

Diagnostic output options

☑ Output diagnostic file ☑ Output tagged files

Data Input

Your selected input folder:

.../linguistic Select

Your selected output filename:

.../Taaco-results.csv Select

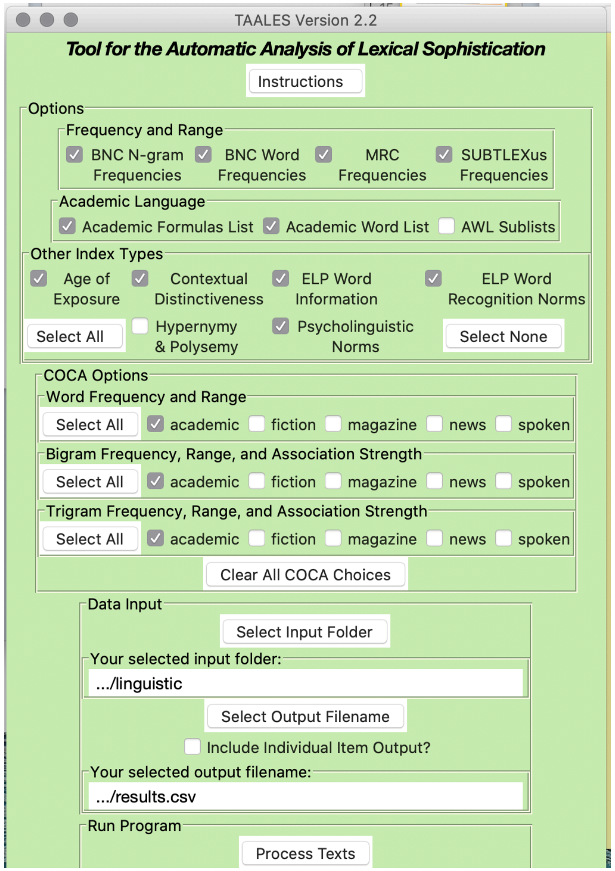
Run Program

Process Texts

Program Status

Processed 2 Files

TAACO



TAALES Version 2.2

Tool for the Automatic Analysis of Lexical Sophistication

Instructions

Options

Frequency and Range

☑ BNC N-gram Frequencies ☑ BNC Word Frequencies ☑ MRC Frequencies ☑ SUBTLEXus Frequencies

Academic Language

☑ Academic Formulas List ☑ Academic Word List □ AWL Sublists

Other Index Types

☑ Age of Exposure ☑ Contextual Distinctiveness ☑ ELP Word Information ☑ ELP Word Recognition Norms

Select All □ Hypernymy & Polysemy ☑ Psycholinguistic Norms Select None

COCA Options

Word Frequency and Range

Select All ☑ academic □ fiction □ magazine □ news □ spoken

Bigram Frequency, Range, and Association Strength

Select All ☑ academic □ fiction □ magazine □ news □ spoken

Trigram Frequency, Range, and Association Strength

Select All ☑ academic □ fiction □ magazine □ news □ spoken

Clear All COCA Choices

Data Input

Select Input Folder

Your selected input folder:

.../linguistic

Select Output Filename

□ Include Individual Item Output?

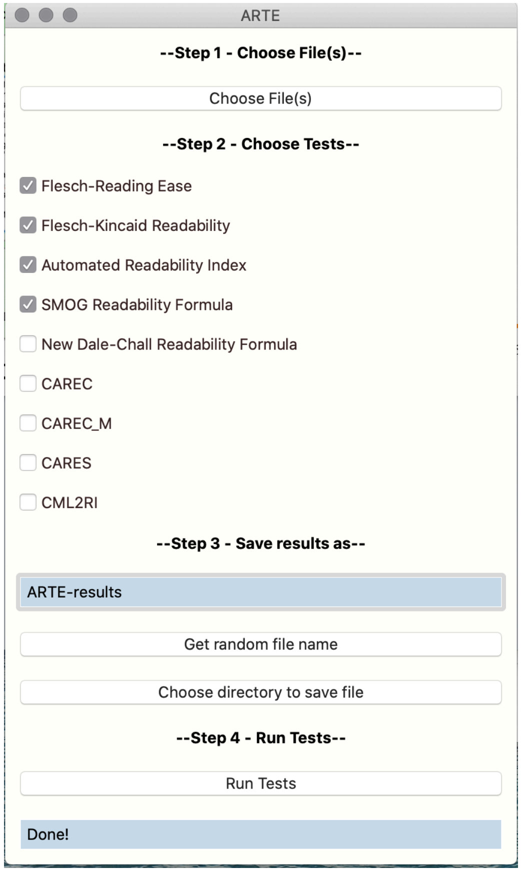
Your selected output filename:

.../results.csv

Run Program

Process Texts

TAALES



ARTE

--Step 1 - Choose File(s)--

Choose File(s)

--Step 2 - Choose Tests--

☑ Flesch-Reading Ease

☑ Flesch-Kincaid Readability

☑ Automated Readability Index

☑ SMOG Readability Formula

□ New Dale-Chall Readability Formula

□ CAREC

□ CAREC_M

□ CARES

□ CML2RI

--Step 3 - Save results as--

ARTE-results

Get random file name

Choose directory to save file

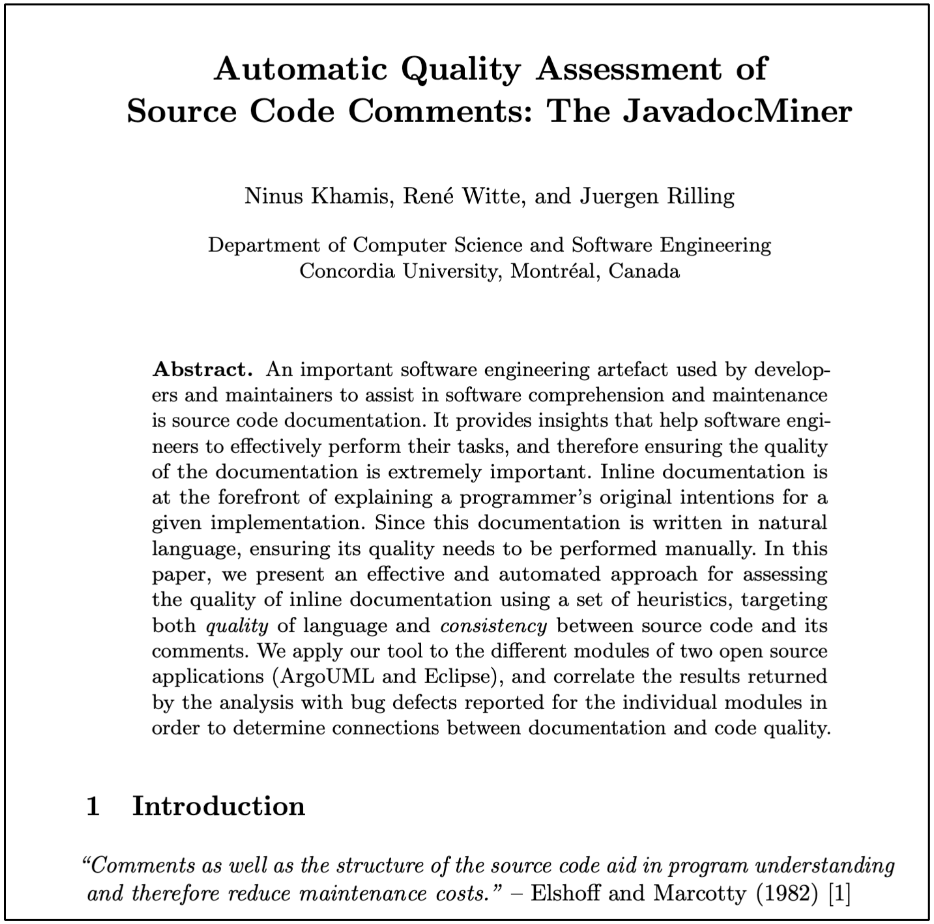
--Step 4 - Run Tests--

Run Tests

Done!

ARTE

Style analysis of Java comments



Automatic Quality Assessment of Source Code Comments: The JavadocMiner

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Department of Computer Science and Software Engineering
Concordia University, Montréal, Canada

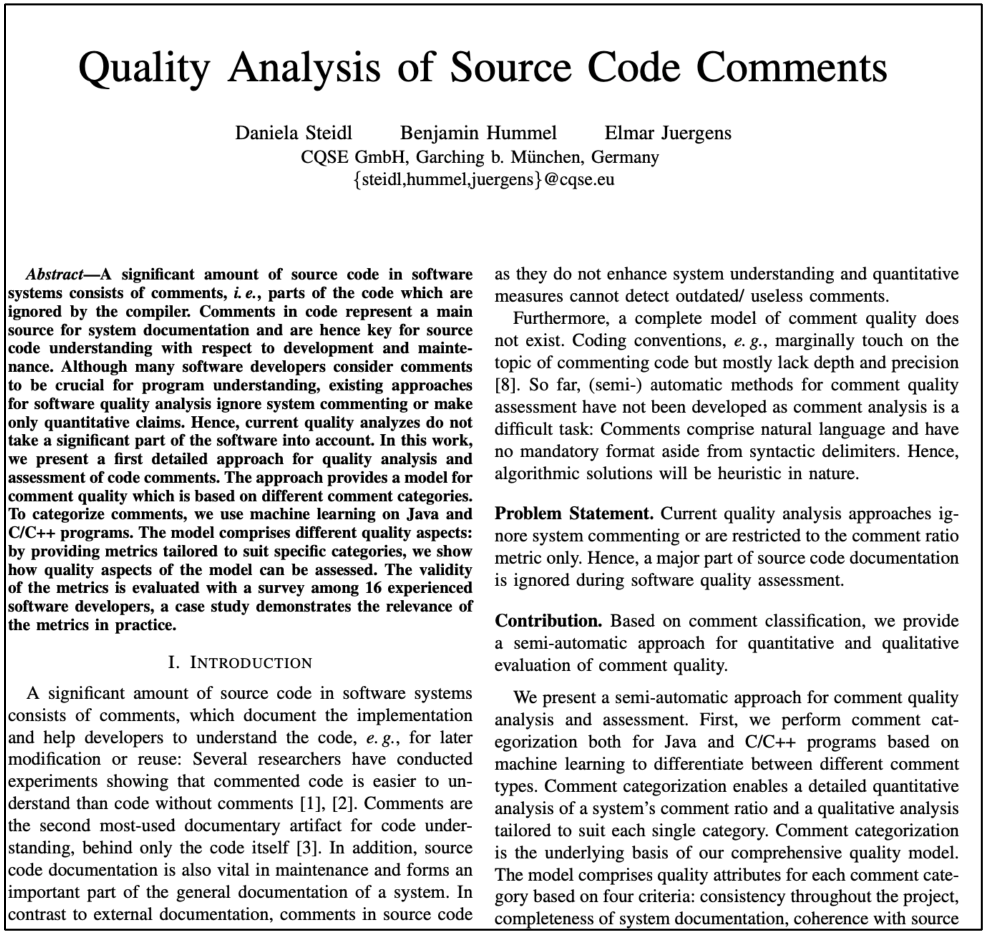
Abstract. An important software engineering artefact used by developers and maintainers to assist in software comprehension and maintenance is source code documentation. It provides insights that help software engineers to effectively perform their tasks, and therefore ensuring the quality of the documentation is extremely important. Inline documentation is at the forefront of explaining a programmer's original intentions for a given implementation. Since this documentation is written in natural language, ensuring its quality needs to be performed manually. In this paper, we present an effective and automated approach for assessing the quality of inline documentation using a set of heuristics, targeting both *quality* of language and *consistency* between source code and its comments. We apply our tool to the different modules of two open source applications (ArgoUML and Eclipse), and correlate the results returned by the analysis with bug defects reported for the individual modules in order to determine connections between documentation and code quality.

1 Introduction

"Comments as well as the structure of the source code aid in program understanding and therefore reduce maintenance costs." – Elshoff and Marcotty (1982) [1]

- Metric-based methods
- Comment too short, too long
- Check documentable items (tags)
- Readability

Style analysis of Java comments



Quality Analysis of Source Code Comments

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CQSE GmbH, Garching b. München, Germany
{steidl,hummel,juergens}@cqse.eu

***Abstract*—A significant amount of source code in software systems consists of comments, *i. e.*, parts of the code which are ignored by the compiler. Comments in code represent a main source for system documentation and are hence key for source code understanding with respect to development and maintenance. Although many software developers consider comments to be crucial for program understanding, existing approaches for software quality analysis ignore system commenting or make only quantitative claims. Hence, current quality analyzes do not take a significant part of the software into account. In this work, we present a first detailed approach for quality analysis and assessment of code comments. The approach provides a model for comment quality which is based on different comment categories. To categorize comments, we use machine learning on Java and C/C++ programs. The model comprises different quality aspects: by providing metrics tailored to suit specific categories, we show how quality aspects of the model can be assessed. The validity of the metrics is evaluated with a survey among 16 experienced software developers, a case study demonstrates the relevance of the metrics in practice.**

I. Introduction

A significant amount of source code in software systems consists of comments, which document the implementation and help developers to understand the code, *e. g.*, for later modification or reuse: Several researchers have conducted experiments showing that commented code is easier to understand than code without comments [1], [2]. Comments are the second most-used documentary artifact for code understanding, behind only the code itself [3]. In addition, source code documentation is also vital in maintenance and forms an important part of the general documentation of a system. In contrast to external documentation, comments in source code as they do not enhance system understanding and quantitative measures cannot detect outdated/ useless comments.

Furthermore, a complete model of comment quality does not exist. Coding conventions, *e. g.*, marginally touch on the topic of commenting code but mostly lack depth and precision [8]. So far, (semi-) automatic methods for comment quality assessment have not been developed as comment analysis is a difficult task: Comments comprise natural language and have no mandatory format aside from syntactic delimiters. Hence, algorithmic solutions will be heuristic in nature.

Problem Statement. Current quality analysis approaches ignore system commenting or are restricted to the comment ratio metric only. Hence, a major part of source code documentation is ignored during software quality assessment.

Contribution. Based on comment classification, we provide a semi-automatic approach for quantitative and qualitative evaluation of comment quality.

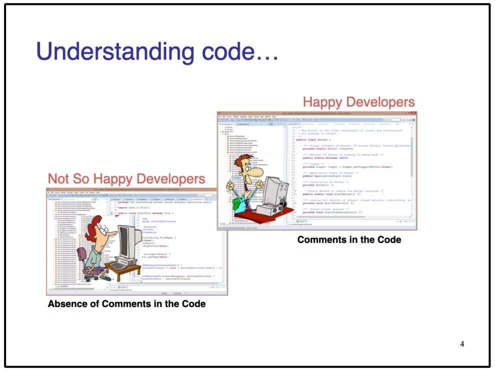
We present a semi-automatic approach for comment quality analysis and assessment. First, we perform comment categorization both for Java and C/C++ programs based on machine learning to differentiate between different comment types. Comment categorization enables a detailed quantitative analysis of a system's comment ratio and a qualitative analysis tailored to suit each single category. Comment categorization is the underlying basis of our comprehensive quality model. The model comprises quality attributes for each comment category based on four criteria: consistency throughout the project, completeness of system documentation, coherence with source

- Metric-based method
- Check whether comments are similar to method names

Future work

- Evaluate if a comment is good or not
- Detect inconsistent comments
- Propose refactoring of comments

Summary



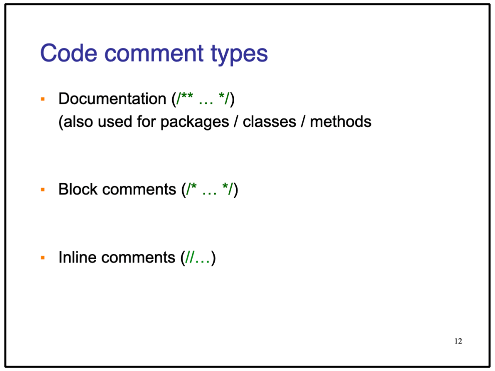
Understanding code…

Happy Developers

Not So Happy Developers

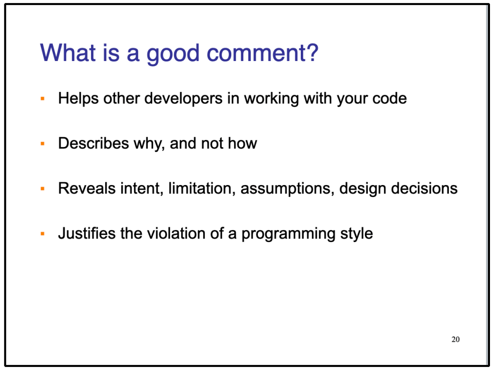
Comments in the Code

Absence of Comments in the Code



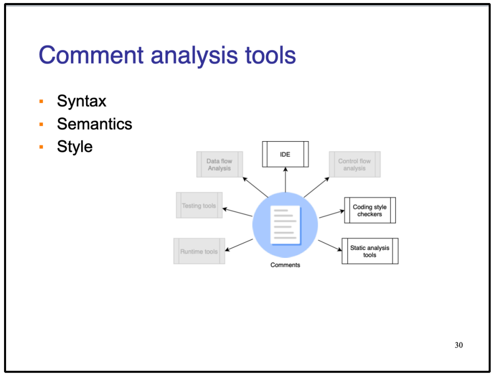
Code comment types

- Documentation (/** … */)
  (also used for packages / classes / methods
- Block comments (/* … */)
- Inline comments (//…)



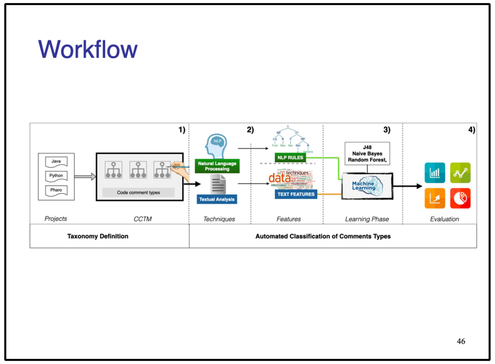
What is a good comment?

- Helps other developers in working with your code
- Describes why, and not how
- Reveals intent, limitation, assumptions, design decisions
- Justifies the violation of a programming style

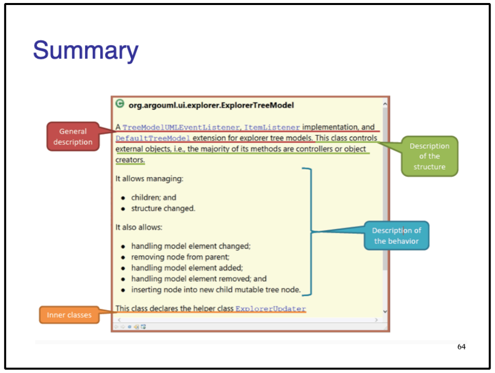


Comment analysis tools

- Syntax
- Semantics
- Style



Workflow



Summary

org.argouml.ui.explorer.ExplorerTreeModel

A TreeModelUMLEventListener, ItemListener implementation, and DefaultTreeModel extension for explorer tree models. This class controls external objects, i.e., the majority of its methods are controllers or object creators.

It allows managing:

- children; and
- structure changed.

It also allows:

- handling model element changed;
- removing node from parent;
- handling model element added;
- handling model element removed; and
- inserting node into new child mutable tree node.

This class declares the helper class ExplorerUpdater

General description

Description of the structure

Description of the behavior

Inner classes