SoftCloud: A Tool for Visualizing Software Artifacts as Tag Clouds

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Abstract—Software artifacts visualization helps software developers to manage the size and complexity of the software system. The tag cloud technique visualizes tags within the cloud according to their frequencies in software artifacts. A font size of the tag within the cloud indicates its frequency within a software artifact, while the color of a tag within the cloud uses just for aesthetic purposes. This paper suggests a new approach (SoftCloud) to visualize software artifacts as a tag cloud. The originality of SoftCloud is visualizing all the artifacts available to the software program as a tag cloud. Experiments have conducted on different software artifacts to validate SoftCloud and demonstrate its strengths. The results showed the ability of SoftCloud to correctly retrieve all tags and their frequencies from available software artifacts.

Keywords—Software engineering, software visualization, software artifacts, tag clouds.

أداة لتصوّر وثائق البرنامج على شكل سحابة العلامات
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المملوكة: نظم المعلومات الحاسوبية. تصور البرنامج، تصوّر وثائق البرنامج، ترقّبات
التصور المستندة إلى سحابة العلامات (tag cloud) تصور العلامات داخل السحابة وفقًا لفترة تكرارها في وثائق البرنامج.
يشير حجم خط العلامة (font size) داخل السحابة إلى تردد العلامة في وثيقة البرنامج. يستخدم لون العلامة (color) لتصوّر وثائق البرنامج على شكل SoftCloud. يقترح هذا البحث نهجًا جديداً لتصوّر وثائق البرنامج على شكل سحابة العلامات. تكمن أصالة SoftCloud في أنها تصور جميع الوثائق المتاحة لبرنامج على شكل سحابة العلامات للتحقق من صحة SoftCloud وإثبات قدرة البحث. أظهرت النتائج قدرة SoftCloud على استرداد جميع العلامات وتردادها بشكل صحيح من وثائق البرنامج المتاحة.

كلمات المقالة: جرد النقر، تصور البرمجيات، تصور وثائق البرنامج، سحابة العلامات.
1. Introduction

Tag cloud has become a widespread visualization and navigation technique in the software engineering domain (Emerson, 2014; Lohmann et al., 2009). Software artifacts visualization helps software developers to manage the complexity and size of the software system (Al-Msie’ddeen, 2019c). This study suggests a new approach called SoftCloud to visualize software artifacts as tag clouds. In general, the tag cloud is a visualization technique for the content of a particular document (Al-Msie’ddeen, 2019a). Tag cloud uses the font size to denote how often a particular tag has been repeated through documents, while the tag color is for decoration purposes only (Al-Msie’ddeen, 2019b).

Each tag in the cloud usually represents a single word, and tag importance has shown appropriate font color and size (Rinaldi, 2019). Most current studies use the static tag clouds to represent tags of the textual documents and web pages (Hearst and Rosner, 2008; Cui et al., 2010; García-Castro et al., 2009; Greene and Fischer, 2015). Current approaches that build the tag cloud from the software code are either incomplete (i.e., use either classes or methods) or do not perform pre-processing of the tag before adding it to the cloud (such as returning the English word to its root) (Emerson, 2014; Emerson et al., 2013a; Emerson et al., 2013b; Deaker et al., 2011; Cottrell et al., 2009; Anslow et al., 2008; Stocker, 2011; Martinez et al., 2016; Bajracharya et al., 2010). The literature has shown very limited work to mine tag cloud using different software artifacts (cf. Section 2). Figure 1 displays an example of a tag cloud — SoftCloud’s representation of the abstract text of this paper.

![Tag cloud - SoftCloud](image)

**Figure 1.** Tag cloud summarizing the abstract of this paper.

In this work, the software *artifacts* are any documents related to the software system. This paper considers any document resulting from the software development process as an artifact. Thus, the following documents are artifacts of the software: source code, commented code (i.e., Javadoc), design documents such as software architecture document (Rational software corp., 2001), and so on. Javadoc is a software artifact developed by software experts to summarize the software code (Kramer, 1999). SoftCloud considers all software identifier names (i.e., package, class, method, and attribute names) inside the code artifact.

In this paper, tag cloud displays the most common tags across software artifacts. In the tag cloud, some tags appear in different font sizes. However, some tags appear important more than other tags. The number of times a tag repeats within a software artifact determines the font size of this tag in the cloud (Yonezawa et al., 2020). However, this allows the software developer to see the most common tags as well as the unique tags in the tag cloud.

SoftCloud accepts any software artifacts as input. However, based on its parser, SoftCloud extracts all software artifact words. After that, it divides words into their constituent words. Then, it obtains the word roots. Then, it determines the weight of each tag based on its frequency across software artifacts. After that, it arranges tags in standard form. Tags are arranged according to their frequency, random or alphabetical. Finally, SoftCloud produces the tag clouds as outputs (cf. Figure 2).
SoftCloud is detailed in the rest of this paper as follows. Section 2 discusses the related work. Section 3 describes the SoftCloud approach step-by-step. Section 4 presents the experiments were conducted to validate SoftCloud’s approach. Finally, section 5 concludes and provides future work of SoftCloud.

2. Related Work and Comparison with SoftCloud

This section presents the related work related to SoftCloud contributions. It also gives a concise summary of the diverse approaches and shows the need of suggesting SoftCloud’s approach.

In the software engineering field, industrial tools and academic research have not focused on tag clouds as a popular visualization technique. Few studies have proposed the idea of visualizing the software artifacts as a tag cloud (Emerson, 2014; Emerson et al., 2013a; Emerson et al., 2013b; Deaker et al., 2011; Cottrell et al., 2009; Anslow et al., 2008; Stocker, 2011; Martinez et al., 2016; Bajracharya et al., 2010).

This section is limited to providing works very close to the contributions of SoftCloud. In the related work, each approach receives one type of software artifact as input. There is no generic approach to dealing with different software artifacts. Some existing works deal only with one artifact, such as software code or Javadoc (Al-Msie’deen, 2019b; Al-Msie’deen, 2019c). The approach proposed in this study used different software artifacts as inputs. Besides, SoftCloud listing some user tasks on the tag cloud, such as: finding a particular tag, and finding the most common tags, and so on.

Anslow et al. (Anslow et al., 2008) used a tag cloud to visualize software classes. Cottrell et al. (Cottrell et al., 2009) proposed an approach to visualize software methods as tag clouds. Sourcecloud (Stocker, 2011) created a tag cloud for software classes. Al-Msie’deen (Al-Msie’deen, 2019c) used a tag cloud to visualize software source code, while, Al-Msie’deen (Al-Msie’deen, 2019b) visualized JavaDocs file as a tag cloud. Also, a tag cloud is used in the Sourcerer API Search (Bajracharya et al., 2010) to visualize the code repository. Table 1 presents a comparison between the selected tag cloud studies (i.e., small survey). The author evaluates the studied approaches according to the following criteria: inputs, outputs, cloud layout, and tag order.

| ID | Cl. Paper # | Packages | Classes | Attributes | Methods | JavaDocs | Code repositories | Specific text | Code blocks | Tag cloud | Block names | Code labels | Typewriter | Spiral | Alphabetical | Random | Frequency |
|----|-------------|----------|--------|------------|---------|----------|-------------------|--------------|------------|-----------|-------------|------------|------------|-------|--------------|--------|-----------|
| 1  | **          | **       | **     | **         | **      |          |                   |              |            |           |             |            |            |      |              |        |           |
| 2  |             |          |        |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 3  |             | **       | **     |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 4  |             | **       | **     |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 5  |             |          |        |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 6  |             | **       | **     |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 7  |             |          |        |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 8  |             | **       | **     |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |
| 9  |             | **       | **     |            |         |          |                   |              |            |           |             |            |            |      |              |        |           |

Table 1. Selected main studies related to SoftCloud.
The brief overview of the current approaches shows the need to suggest an approach to visualize different software artifacts as a tag cloud. SoftCloud’s approach deals with different software artifacts such as source code, design documents, and JavaDocs. On the other hand, SoftCloud’s approach performs preprocessing of the tag before adding it to the cloud, where it separates the words based on the camel-case splitting method, and then returns each word to its origin. Also, SoftCloud introduces some useful filters and user tasks (e.g., search tasks) within the cloud.

3. SoftCloud Step by Step

This section gives an overview of SoftCloud approach and describes the approach step-by-step.

The study presented in this paper exploits the tag cloud visualization technique and applies it to the software engineering domain. The originality of this approach is that it receives as inputs different software artifacts. Then, this approach generates the tag clouds to render the input information. SoftCloud’s approach is designed to deal with the software engineering datasets challenges (e.g., scale and complexity of software) using suitable visual mappings existing in tag clouds to render the dataset data.

To visualize a software dataset as a tag cloud, it is important to define visual characteristics that might influence perception within tag cloud such as cloud layout (e.g., typewriter), tag order (e.g., random), tag length (e.g., a variable number of letters or an equal number of letters), tag position, font size (also font family, style, size, and color), and cloud background color. In addition, it is important to choose visual characteristics that are suitable for data mapping, such as font size.

Dataset needs the necessary pre-processing procedure to prepare it. In the approach proposed in this paper, pre-processing is carried out by extracting the words of the available software artifacts. Then, the words have divided into their constituent words, and then each word is returned to its original. In conclusion, word repetition has counted throughout software artifacts, and at last, tags are arranged through the cloud using a specific order. An overview of SoftCloud’s approach is shown in Figure 2.
A tag cloud is a type of weighted list to visualize software artifact data (Jin, 2017), which gains growing attention and extra application opportunities in the software engineering field. As a demonstrative example, SoftCloud considers the source code of the Rhino software (Mozilla, 2012) and JavaDoc of NanoXML software (Scheemaecker, 2020). Rhino is an open-source application of JavaScript written completely in Java language. It is embedded in Java implementation to deliver scripting to end-users. J2SE 6 is used Rhino as the default Java scripting engine. NanoXML application is Java software for parsing XML documents. SoftCloud produces the artifact cloud in six phases are detailed below.

### 3.1. Mining Software Artifact Words

SoftCloud accepts the software artifact as input. Then, SoftCloud generates a words file as output. The words file contains all the words for the software artifact. Table 2 presents samples of words file contents of Rhino and NanoXML artifacts.

| Software artifact | Rhino code | NanoXML JavaDoc |
|-------------------|------------|-----------------|
|                   | org.mozilla.classfile | XMLParseException |
|                   | itsExceptionTableTop | class |
|                   | getClassName | summary |
|                   | addLoadConstant | package |
|                   | emptySubString | nanoxml |

SoftCloud considers the textual datasets (or words file), where the ideal datasets contain textual identifiers such as method names. The kind of dataset that would be ideal to show in a tag cloud is one that contains considerable amounts of textual information. Several datasets have contained this kind of information, in the form of identifiers, words, or labels. Software engineering datasets contain this type of data like package names and JavaDoc words.

### 3.2. Dividing Words to Their Constituent Words

SoftCloud divides the words extracted from the program's artifact into their constituent words. SoftCloud uses the camel-case splitting method to split artifact’s words based on
capital letters (e.g., A-Z), special characters (e.g., underscore), and numbers (e.g., 0-9). Each word is divided into words based on the camel-case rules (Al-Msie’deen et al., 2014b).

**Table 3.** Samples showing examples of dividing words using camel-case.

| NanoXML | JavaDoc words | Rhino identifier names |
|---------|---------------|------------------------|
| word1   | word2 | word3 | word4 | Identifier name | Words |
| NanoXML | nano  | x     | m     | 1  | org.mozilla | org mozilla |
| ParseException | parse | exception |    | itsFlags | its flags |
| getLocalizedMessage | get | localized | message | addField | add field |
| printStackTrace | print | stack | trace | putInt16 | put int |
| getLineNr | get | line | nr | unHex | un hex |
| fillInStackTrace | fill | in | stack | trace | find_split | find split |

The Camel-case method is easy and widely used for dividing words (Al-Msie’deen et al., 2014a). For instance: `getMaximumInterpreterStackDepth` identifier name has split into `get`, `maximum`, `interpreter`, `stack`, and `depth`. Table 3 presents samples of word splitting from Rhino and NanoXML software.

### 3.3. Stemming Words to Their Roots

*Stemming* is the text normalization (or called word normalization) technique, in the field of software engineering word normalization is used to prepare words for more processing. Stemming is a way of stripping attaches from words to form the word root (e.g., protected to protect). The word root generated by SoftCloud does not have to be the real word itself. Stemmer is used in SoftCloud to return the word to its word root. In SoftCloud, stemming was performed through *WordNet* (Fellbaum, 1998). SoftCloud relies on WordNet dictionary to swap English words with their roots or stems (Princeton university, 2010).

**Table 4.** Examples of returning English words to their roots or origins.

| Rhino code words | NanoXML JavaDoc words |
|------------------|-----------------------|
| Identifier word | Root or stem | JavaDoc word | Root or stem |
| synchronized | synchronize | indicates | indicate |
| interfaces | interface | extends | extend |
| reserved | reserve | thrown | throw |
| parameters | parameter | parsing | parse |
| arguments | argument | occurred | occur |

In SoftCloud, stemming is a method of changing an artifact word to its root. The word root is the final form of the word that will appear in the cloud as a tag. SoftCloud stemmer accepts as an input English word and generates as output word root (or tag). For instance, the words `parsing`, `parses`, and `parsed` all have the same root/stem which is `parse`. Sometimes, the WordNet may not be dependable in all cases to return word root. In this case, SoftCloud returns the word itself as being the root of the word. Table 4 shows examples of the word stems from Rhino and NanoXML software artifacts.

### 3.4. Determining the Weight of Tag

In SoftCloud, tag weight gives a sign about tag frequency across software artifact words. In this stage, a weight is assigned to each tag based on its occurrences in software artifact words. Table 5 displays examples of tags and their weights from Rhino and NanoXML software artifacts.
Table 5. Examples of tags and their weights from Rhino and NanoXML artifacts.

| Rhino code tags | Weight | NanoXML JavaDoc tags | Tag | Weight |
|-----------------|--------|----------------------|------|--------|
| Activation      | 20     | Exception            | 10   |
| Adapter         | 24     | From                 | 2    |
| Add             | 134    | Get                  | 4    |
| And             | 35     | Java                 | 7    |
| Arg             | 12     | Line                 | 6    |

In fact, the number of times a tag is repeated is a very important indication of the importance of this tag in the software artifact. For instance, in drawing shapes software (Al-Msie’ddeen, 2019c), the shape tag arose thirteen times across software source code, so the given weight of this tag is thirteen. The font size for the tag in the mined cloud is the number of times the tag is repeated throughout the software artifact document. Tags that appear with a large font size are more important than others.

3.5. Arranging Tags in Standard Form

SoftCloud uses typewriter-style to arrange tags in the cloud from left to right and from top to bottom. SoftCloud displays tags in the cloud in alphabetical order (i.e., a-z). Software developer looks more able to find tags in alphabetically ordered clouds (Al-Msie’ddeen, 2019c). Table 6 shows examples of tags in alphabetical order.

Table 6. Examples of tags in alphabetical order.

| Rhino code tags | NanoXML JavaDoc tags |
|-----------------|----------------------|
| Mozilla         | Xxmlend              |
| Classfile       | Xop                  |
| Class           | Xor                  |
| File            | Year                 |
| Writer          | Yield                |
| Acc             | Z                    |
| Public          | Zero                 |
| Unordered tags  | Tags in alphabetical order |
| Unordered tags  | Tags in alphabetical order |

| Rhino code tags | NanoXML JavaDoc tags |
|-----------------|----------------------|
| Mozilla         | Nano                |
| Classfile       | X                   |
| Class           | M                   |
| File            | L                   |
| Writer          | Class               |
| Acc             | Z                   |
| Public          | Exception           |

On the other hand, SoftCloud allows the developer to arrange the tags according to their frequency. Tags have arranged within the cloud from the highest to lowest frequency. If some tags are equal in frequency, then SoftCloud sorts these tags alphabetically. Figure 3 shows the generated tag cloud after applying the frequency order filter.

Figure 3. A tag cloud produced from JavaDoc of XMLParseException class of NanoXML.

In this cloud, tags appear according to their importance. The most important tags appear first in the cloud. The tag cloud in Figure 3 shows that the most common tag in the JavaDoc
of XMLParseException class is an exception. The most common tags have been displayed in larger fonts.

### 3.6. Producing Software Artifact Cloud

In SoftCloud, the dataset is extracted first from the software artifact. Then the dataset words are divided into their constituent words. After that, each word is returned to its root. Later, the weights are determined for the tags, and then the software engineer determines the appropriate arrangement of the tags in the cloud. Finally, the cloud has been created. As an example, SoftCloud uses the JavaDoc for XMLParseException class of NanoXML software. Table 7 shows JavaDoc of XMLParseException class.

| Table 7. JavaDoc of XMLParseException class of NanoXML (Scheemaeker, 2020) |
|---|
| **Class Summary** |
| Package nanoxml/XMLParseException |
| public class XMLParseException |
| extends java.lang.RuntimeException |
| An XMLParseException is thrown when an error occurs while parsing an Xml string. |
| **Field Summary** |
| static int No_Line, indicates that no line number has been associated with this exception. |
| **Constructor Summary** |
| XMLParseException(java.lang.String name, int lineNr, java.lang.String message), creates an exception. |
| XMLParseException(java.lang.String name, java.lang.String message), creates an exception. |
| **Method Summary** |
| int getLineNr(), Where the error occurred, or No_Line if the line number is unknown. |
| **Methods inherited from class java.lang.Throwable** |
| fillStackTrace, getLocalizedMessage, getMessage,.printStackTrace, printStackTrace, printStackTrace, toString |
| **Methods inherited from class java.lang.Object** |
| clone, equals, finalize, getClass, hashCode, notify, notifyAll, wait, wait, wait |

Figure 4 shows a tag cloud extracted from JavaDoc of XMLParseException class of NanoXML (cf. Table 7). This cloud contains all tags of JavaDoc. The number next to each tag is an indication of how often that tag is repeated within the software artifact. The mined tag cloud shows the rarest tags such as when and unknown.

![Tag cloud - SoftCloud](image)

**Figure 4.** A tag cloud generated from JavaDoc of XMLParseException class.

SoftCloud contains several features to allow data exploration such as filtering data and handling large scale data. These features are the most important to software engineering.
datasets. SoftCloud prototype is formed to extract tag clouds from different software artifacts. SoftCloud prototype is available at author page (Al-Msie’deen, 2021a).

4. Experimentation

This section presents the experiments conducted in this research to display its soundness and presents different software artifacts. Also, it shows the obtained results for some artifacts and presenting the threats to the validity of SoftCloud. Figure 5 shows mined tag cloud from Rhino software. SoftCloud algorithms need 22697 ms to generate tag cloud from Rhino artifact. The most common tags (resp. the rarest tags) across Rhino artifacts are presented in Table 8.

| The most common tags | The rarest tags |
|----------------------|----------------|
| Tag                  | Frequency      | Tag          | Frequency |
| Get                  | 510            | Zone         | 2          |
| Id                   | 444            | Collect      | 1          |
| Set                  | 172            | W            | 4          |
| Name                 | 168            | After        | 3          |
| Class                | 159            | Yield        | 6          |

The number of tags across Rhino code is equal to 1095.
The execution time of SoftCloud in ms is equal to 22697.

The success of a SoftCloud is measured by three metrics: precision, recall, and F-Measure (Al-Msie’deen, 2019b). Precision and recall give a value of one, if the tag and its frequency in the cloud are the same as tag frequency in the software artifact. F-Measure gives a value of one in cases where both precision and recall are one (Al-Msie’deen, 2014). SoftCloud evaluation metrics have values between zero and one.

For a specific tag within the cloud, a precision metric is a percentage of correctly retrieved tag frequencies to the total number of retrieved tag frequencies (cf. equation in Table 9), whereas recall metric is the percentage of correctly retrieved tag frequencies to the total number of relevant tag frequencies. The F-Measure metric combines recall and precision in one value (Al-Msie’deen, 2014). An example of the calculation of these three metrics are presented in Table 9.

Figure 5. A tag cloud generated from Rhino artifact.

An illustrative example is introduced in Table 9 to show: 1) how to calculate these measures for a trace tag from JavaDoc of XMLParseException class (cf. Table 7), and 2) the
equation of each measure. Moreover, 3) how to compute these measures based on some samples (not related to SoftCloud experimentation).

**Table 9.** Standard SoftCloud evaluation metrics: precision, recall, and F-Measure.

| Tag  | relevant tag frequency | correctly retrieved tag frequencies | retrieved tag frequencies |
|------|------------------------|-----------------------------------|--------------------------|
| Trace| 4                      | 4                                 | 4                        |

| Metric | Precision | Recall | F-Measure |
|--------|-----------|--------|-----------|
| Value  | 1         | 1      | 1         |

**Precision** = \(|\{\text{relevant tag frequencies}\} \cap \{\text{retrieved tag frequencies}\}| / |\{\text{retrieved tag frequencies}\}|

**Recall** = \(|\{\text{relevant tag frequencies}\} \cap \{\text{retrieved tag frequencies}\}| / |\{\text{relevant tag frequencies}\}|

**F-Measure** = \(2 \times [(\text{Precision} \times \text{Recall}) / (\text{Precision} + \text{Recall})]

| Tag  | relevant tag frequency | correctly retrieved tag frequencies | retrieved tag frequencies |
|------|------------------------|-----------------------------------|--------------------------|
| Notify| 100                    | 50                                | 150                      |

| Metric | Precision | Recall | F-Measure |
|--------|-----------|--------|-----------|
| Value  | 0.3       | 0.5    | 0.4       |

| Tag  | relevant tag frequency | correctly retrieved tag frequencies | retrieved tag frequencies |
|------|------------------------|-----------------------------------|--------------------------|
| Wait | 70                     | 70                                | 100                      |

| Metric | Precision | Recall | F-Measure |
|--------|-----------|--------|-----------|
| Value  | 0.7       | 1      | 0.8       |

Low precision (e.g., precision = 0.1) leads to low trust in the proposed system (i.e., too much noise). On the other hand, low recall (e.g., recall = 0.1) leads to unawareness and inefficiency of the suggested approach (i.e., too many missing frequencies for the tag). Table 10 summarizes the obtained results of some tags from Rhino and NanoXML software artifacts.

**Table 10.** Tags mined from Rhino and NanoXML software artifacts.

| Software | Tag | Tag within the cloud | Tag within the artifact | SoftCloud evaluation metrics |
|----------|-----|----------------------|------------------------|-----------------------------|
| Rhino    | A   | 37                   | 37                     | Precision: 1  Recall: 1  F-Measure: 1 |
|          | And | 35                   | 35                     | Precision: 1  Recall: 1  F-Measure: 1 |
|          | Arg | 12                   | 12                     | Precision: 1  Recall: 1  F-Measure: 1 |
| NanoXML  | Get | 4                    | 4                      | Precision: 1  Recall: 1  F-Measure: 1 |
|          | X   | 7                    | 7                      | Precision: 1  Recall: 1  F-Measure: 1 |
|          | An  | 5                    | 5                      | Precision: 1  Recall: 1  F-Measure: 1 |

Results display that precision value is one of all mined tags. Thus, all frequencies of the retrieved tag are relevant. Recall metric value equals one of all mined tags. Hence, all relevant tag frequencies are retrieved. F-Measure value equals one of all mined tags. Consequently, all relevant tag frequencies are recovered, and only the relevant tag frequencies are recovered. The results demonstrate the efficiency and ability of SoftCloud to accurately retrieve the correct frequency of tags from software artifacts. Figure 6 shows the tag cloud generated from the source code summarization of the draw method from drawing shapes software (Al-Msie’ddeen and Blasi, 2019).
I have implemented numerous tag cloud layouts. Tags are positioned one at a time within the cloud, with the chosen order (e.g., alphabetical order). SoftCloud layouts are typewriter and spiral layout. In typewriter layout tags are positioned left to right, jumping to a new line once the next tag cannot be positioned on the existing line. While, in a spiral layout the first tag is positioned in the middle of the cloud, with consecutive tags are being positioned around it in a spiral style. Figure 7 expresses the same data set in Figure 6 with a spiral layout chosen. This layout is less appropriate for some tasks, including discovering a particular tag or emphasizing its absence.

The software architecture document is one of the software’s artifacts. This document is a design document. Figure 9 represents the tag cloud generated from a software architecture document of the collegiate sports paging system (Rational software corp., 2001).
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Figure 9. Tag cloud summarizing architecture document of collegiate sports paging system.

The user of SoftCloud has the choice of filtering the tag text to a fixed number of letters (e.g., 10 letters). This filter has two aims (cf. Figure 10), to exploit available space in the cloud, and to minimize any side effect a larger number of letters in a tag may have on user awareness (i.e., eye attention).

Figure 10. A tag cloud generated by using fixed number filter.

The threat to the validity of SoftCloud is that the existing prototype considers only a Java code artifact. Moreover, when a software engineer uses mixture words inside software artifacts (e.g., ScTStandardS) the camel-case splitting method cannot deal with it (or should be enhanced with other methods). The WordNet dictionary may not be dependable in all cases to reveal the word root. Currently, SoftCloud is missing some filters, for instance, it does not filter tag names that are textually similar.

5. Conclusion and Future Directions of SoftCloud

This paper proposed a new approach to visualize software artifacts as a tag cloud. However, SoftCloud has executed on different software artifacts. Such as rhino, nanoXML, drawing shapes, interactive multimedia magazines, and collegiate sports paging software artifacts. The results were showed that all tags and their occurrences are mined correctly from software artifacts. However, the mined tag clouds have shown the most common and rarest tags. Also, Tags have been arranged randomly, alphabetically, or according to their frequency. Also, Tags within the cloud are filtered based on their frequency or length. Besides, Clouds have been organized according to a typewriter or spiral layout. For future work, some user
tasks will be added to the cloud and use new cloud layouts. Finally, there is an urgent need for a comprehensive survey providing all studies related to the tag cloud techniques in the software engineering domain.

References

Al-Msie’ddeen, R. (2008). A requirement model of local news WEB/WAP application for rural communities. Master thesis, Universiti Utara Malaysia, Kedah Darul Aman, Malaysia.

Al-Msie’ddeen, R. (2014). Reverse Engineering Feature Models from Software Variants to Build Software Product Lines. PhD thesis, Montpellier 2 University, France.

Al-Msie’ddeen, R. (2018). Automatic labeling of the object-oriented source code: The Lotus approach. Science International-Lahore, 30(1):45–48.

Al-Msie’ddeen, R. (2019a). Object-oriented Software Documentation. LAP LAMBERT Academic Publishing.

Al-Msie’ddeen, R. (2019b). Tag clouds for software documents visualization. JOIV, 3(4):361–364.

Al-Msie’ddeen, R. (2019c). Tag clouds for the object-oriented source code visualization. ETASR, 9(3):4243–4248.

Al-Msie’ddeen, R. (2021a). Softcloud prototype. Softcloud.

Al-Msie’ddeen, R. (2021b). Requirements specification of interactive multimedia magazine for IT news in Jordan. Unpublished/ in Press.

Al-Msie’ddeen, R. and Blasi, A. (2021). Software evolution understanding: automatic extraction of software identifiers map for object-oriented software systems. Journal of Communications Software and Systems, 17(1): 20–28.

Al-Msie’ddeen, R. and Blasi, A. (2019). Supporting software documentation with source code summarization. IJAS, 6(1): 59-67.

Al-Msie’ddeen, R., Huchard, M., Seriai, A., Urtado, C., and Vauttier, S. (2014a). Automatic documentation of [mined] feature implementations from source code elements and use-case diagrams with the REVPLINE approach. SEKE, 24(10):1413–1438.

Al-Msie’ddeen, R., Seriai, A., Huchard, M., Urtado, C., and Vauttier, S. (2014b). Documenting the mined feature implementations from the object-oriented source code of a collection of software product variants. SEKE, pages 138–143.

Alfrijat, A. M. and Al-Msie’ddeen, R. (2010). A requirement model of local news WEB/WAP application for rural community. Advances in Computer Science and Engineering, 4(1):37–53.

Anslow, C., Noble, J., Marshall, S., and Tempero, E. D. (2008). Visualizing the word structure of java class names. 23rd Annual ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages, and Applications, pages 777–778. ACM.

Bajracharya, S. K., Ossher, J., and Lopes, C. V. (2010). Searching API usage examples in code repositories with sourcerer API search. In Proceedings of 2010 ICSE Workshop on Search-driven Development: Users, Infrastructure, Tools and Evaluation, pages 5–8. ACM.

Cottrell, R., Goyette, B., Holmes, R., Walker, R. J., and Denzinger, J. (2009). Compare and contrast: Visual exploration of source code examples. International Workshop on Visualizing Software for Understanding and Analysis, pages 29–32. IEEE Computer Society.

Cui, W., Wu, Y., Liu, S., Wei, F., Zhou, M. X., and Qu, H. (2010). Context-preserving, dynamic word cloud visualization. IEEE Computer Graphics and Applications, 30(6):42–53.

Deaker, C., Churcher, N., and Irwin, W. (2011). Tag clouds in software visualisation. Technical report TR-COSC 01/11, pages 1–8. Department of cs, University of Canterbury.
Emerson, J. (2014). Tag clouds in software visualisation. Master thesis, University of Canterbury.

Emerson, J., Churcher, N., and Cockburn, A. (2013a). Tag clouds for software and information visualisation. In Proceedings of the 14th Annual ACM SIGCHI NZ conference on Computer-Human Interaction, pages 1:1–1:4. ACM.

Emerson, J., Churcher, N., and Deaker, C. (2013b). From toy to tool: Extending tag clouds for software and information visualisation. In 22nd Australian Conference on Software Engineering (ASWEC 2013), pages 155–164. IEEE Computer Society.

Feinberg, J. (2013). Wordle - Beautiful word clouds. Wordle.

Fellbaum, C. (1998). WordNet: an electronic lexical database. Cambridge, MA: MIT Press. pages 449.

García-Castro, L. J., Hepp, M., and Castro, A. G. (2009). Tags4tags: using tagging to consolidate tags. In Database and Expert Systems Applications, pages 619–628. Springer.

Greene, G. J. and Fischer, B. (2015). Interactive tag cloud visualization of software version control repositories. VISSOFT 2015, pages 56–65. IEEE Computer Society.

Hearst, M. A. and Rosner, D. K. (2008). Tag clouds: Data analysis tool or social signaller?. In Hawaii International Conference on Systems Science, page 160. IEEE Computer Society.

Jin, Y. (2017). Development of Word Cloud Generator Software Based on Python. 13th Global Congress on Manufacturing and Management, pages 788-792. Elsevier BV.

Kramer, D. (1999). API documentation from source code comments: a case study of JavaDoc. Annual international conference on Documentation, pages 147–153. ACM.

Lohmann, S., Ziegler J., Tetzlaff, L. (2009). Comparison of Tag Cloud Layouts: Task-Related Performance and Visual Exploration. In Human-Computer Interaction - International Conference. pages 392–404. Springer.

Martinez, J., Ziadi, T., Bissyande, T. F., Klein, J., and Traon, Y. L. (2016). Name suggestions during feature identification: the variclouds approach. In Proceedings of the 20th International Systems and SPLC, pages 119–123. ACM.

Mozilla. (2012). Rhino - Mozilla | MDN. Rhino.

Princeton University. (2010). About WordNet. WordNet.

Rational Software Corp. (2001). Collegiate sports paging system - software architecture document - version 1.0. Software architecture document.

Rinaldi, A. (2019). Web Summarization and Browsing Through Semantic Tag Clouds. Int. J. Intell. Inf. Technol. 15(3): pages 1-23.

Salman, H. E., Seriai, A., Dony, C., and Al-Msie’deen, R. (2012). Recovering traceability links between feature models and source code of product variants. In VARY ’12, pages 21–25. ACM.

Scheemaeker, M. D. (2020). NanoXML 2.2.1. Nanoxml.

Stocker, M. (2011). Tag cloud visualization for source code. Sourcecloud.

Yonezawa, T., Wang, Y., Kawai, Y., and Sumiya, K. (2020). Dynamic Video Tag Cloud: A Cooking Support System for Recipe Short Videos. In 25th International Conference on Intelligent User Interfaces, pages 122-123. ACM.

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