

# Patterns for making sense of bug data / Patterns for cleaning and analyzing bug data

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*Index Terms*—TODO; TODO; TODO; TODO

## I. INTRODUCTION

Someone said that data analysis is easy, the hard part is cleaning the data. This is true also of bug databases. You deal with data that may be incomplete, inconsistent, or just plain wrong [cite Bird, Aranda etc.]. Without proper guidance, it is easy to get lost. We hope to provide some hints for those adventurous enough to analyse bug data, by suggesting some filtering, and also general analyses that support more specific analyses.

Conventions: lines beginning with > denote R code.

## II. DATA

The R snippets refer to data extracted from Bugzilla databases. Other databases may have different schemas, so the scripts may need to be adapted.

Tables: `bugs_activity` (we'll call it `changes`), `bugs`, `longdescs` (we'll call it `comments`) Let's assume that we have imported such tables as a R data frame.

```
> head(events)
```

...

To ensure reproducibility, the full source code for this paper, together with data sets, is available at ...

### III. PATTERNS

The format we use is:

Write a short story referencing the patterns, that shows how one typically uses them

#### IV. PATTERN CLUSTER: GATHER

### A. Grab the Release Dates

## Problem

## How to discover the release dates?

## Context

releases are important events. They help to determine phases in the software lifecycle. The activity in a project that is near release date may be different from the activity in regular periods. For example, in Eclipse/Platform, verifications are much more frequent just before a release.

### Solution

project websites do not usually keep info about all the previous releases. Fetch previous versions of the sites using The Internet Archive, [archive.org](https://archive.org). Other solution is look for tags in the version control system.

## V. PATTERNS CLUSTER: CLEAN

### A. Look Out For Mass Edits

## Problem

Discover changes to bug reports that were the result of a mass edit.

## Context

Changes to a bug report often the result of an effort made by developers to triage, fix or verify a bug. Such efforts take time. It is expected, for example, that a bug status is only changed to **VERIFIED** after a developer spends some time creating test scenarios, running the software, inspecting the source code changes etc.

However, on some bug data sets, one can find hundreds or thousands of bugs that are changed by the same developer within minutes or hours. These are mass edits and should not be interpreted as a burst of productivity. For example, if a developer changes the status of a thousand bug reports `VERIFIED` within a few hours, it does not mean that he verified a thousand bugs — that would be humanly impossible. More often than not, it just means that the repository needed some cleanup, by marking old bugs as `VERIFIED` to help developers keep track of current problems.

When analyzing bug data, mass edits should be identified and removed from the data set, as they may distort the results.

## Solution

Mass edits are characterized by a large number of changes of the same type (e.g., marking a bug report as **VERIFIED** or changing a target milestone) made by a single developer in a short period of time. Often such changes are accompanied by a comment that is the same for all changes in the mass edit.

There are at least three solutions to find mass edits: two based on number of changes over time, and one based on developer comments. Before applying a solution, a type of change must be chosen. In the following examples, it is assumed that we are interested in mass verifications, i.e., mass edits that change a bug status to **VERIFIED**, but the solutions apply to other types of change as well.

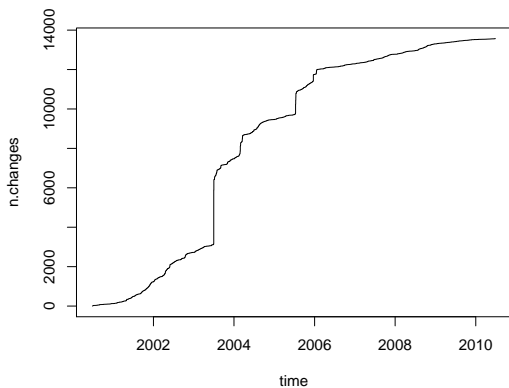
*Solution 1: plot the accumulated number of verifications over time and look for steep ascents.* The first solution is more visual, exploratory. Select only the changes that update the bug status to verified, along with the time of the change. Sort the changes by time and then plot the accumulated number of changes over time as a line chart.

The line is always increasing, but periods with many changes will stand out as steep ascents. Examine your vertical axis to assess whether such ascents represent a large number of changes (e.g., thousands). If this is the case, then it is likely that the changes were caused by a mass edit.

Here is the R code. Assume that **changes** is the list of changes to bug reports in NetBeans/Platform.

### Center figure

```
> ver <- subset(changes, field == "bug_status"
+   & new.value == "VERIFIED")
> ver <- ver[order(ver$time), ]
> ver$n.changes <- 1:nrow(ver)
> with(ver, plot(n.changes ~ time, type="l"))
```



In the chart, some line segments are almost vertical (e.g., the line between 2002 and 2004). Such segments mark dates when there were mass edits.

*Solution 2: count the number of changes per user per day.* Then, sort by number of changes, from highest to lowest, and select pairs (user, date) with a high number of

changes. The changes that match the selected pairs (user, date) are likely to be mass edits.

Here is the R code for the solution. Assume that **ver** holds the data that was computed in the previous solution. The counts are computed using the **count** function from the package **plyr** and assigned to the variable **cnt**. Here, the highest six counts are shown.

```
> library(plyr)
> ver$date <- as.Date(ver$time)
> cnt <- count(ver, c("date", "user"))
> cnt <- cnt[order(cnt$freq, decreasing=T), ]
> head(cnt)
```

date	user	freq
2003-07-01	17822	2706
2003-07-02	17822	531
2005-07-12	182	444
2005-12-20	182	313
2004-02-27	182	199
2005-07-13	182	182

*Solution 3: count the number of changes per user per day with the same comment.* Same as before, except that the comment is taken into account. For optimization purposes, the comment text can be replaced by its MD5 hash (or another hash function).

Here is the R code. Assume that we have a **comments** data frame. First, merge it with **ver** to select only comments related to verifications. Then, do the counting as usual. Here, the 6 records with higher counts are shown.

```
> library(plyr)
> full <- merge(ver, comments)
> cnt <- count(full, c("date", "user",
+   "comment.md5"))
> cnt <- cnt[order(cnt$freq, decreasing=T), ]
> head(cnt[, c("date", "user", "freq")])
```

date	user	freq
2003-07-01	17822	1703
2003-07-01	17822	972
2003-07-02	17822	447
2005-07-12	182	437
2005-12-20	182	209
2005-07-13	182	181

## Discussion

The first solution to find mass edits is more visual, but less accurate, as it does not take into account the user who made the changes, and also more subjective. The second solution is numeric and takes into account the users, but does not distinguish regular changes and mass edits if they were made by the same user in the same day. The third solution addresses this problem, but is more computationally intensive, as it involves user's comments.

## Examples

For example, at MSR 2012, Souza et al. [2] used the first two solutions. They used the first solution to build the chart shown in their paper's Figure 2. Then, they used the

second solution to find change bursts with more than 50 changes by the same user on the same day. Such changes were considered mass edits and consequently discarded.

#### **Related Patterns**

How many changes in a day are considered normal and how many indicate mass edits? Be sure to [Choose a Suitable Threshold]. After finding mass edit candidates, it is a good idea to [Read the Fine Comments] to gain more confidence that the changes resulted from a mass edit.

#### *B. Meet the teams / Know your subjects*

##### **Problem**

How to discover developers' roles?

##### **Context**

Some developers are triagers, other are "fixers", there are also QA experts. When studying human factors, it is important to know that developers are not all equal and have different roles.

##### **Solution**

Analyze their activity in the bug tracking system, specially the status changes. Count the relative number of activities. Plot distribution of ratios. After discovering a group of developers with a specific role, see if the group is responsible for most of that activity in the project.

##### **Related Patterns**

Be sure to Choose a Suitable Threshold.

#### *C. Old Wine Tastes Better*

(aka Let them mature / give 'em some time)

##### **Problem**

how to avoid analysing bugs that are not accurate

##### **Context**

it may be the case that a bug is later discovered to be invalid, or a fix is reopened, but you may not know this and consider the bug as valid or fixed, because you do not have enough history.

##### **Solution**

Discard newer bugs, that do not have enough history. Plot the distribution of bug durations (from open to last activity, or from open to a specific activity that you are interested as an outcome variable). (in my case, I discovered that more than 90% are reopened within 1 year, so it is probably safe to discard bugs that are newer than 1 year).

##### **Related Patterns**

Be sure to Choose a Suitable Threshold.

#### *D. Choose a Suitable Threshold*

#### *E. Don't be confused*

##### **Problem**

confusion variables affect outcomes.

##### **Context**

##### **Solution**

use mosaic plots. use correlation matrices. Consequences: mosaic plots are easy to read with two variables, barely readable with 3 or 4, but start to become confusing with 5 or more.

#### *F. Count 'em all*

##### **Problem**

How to know if your variables are associated?

##### **Solution**

count the cases. Built a contingency table. After that you can use Fisher's exact test to assess association.

##### **Related Patterns**

[Classify] your data (make sure your [data is classified])

### VI. PATTERN CLUSTER: ANALYZE

#### *A. Read the Fine Messages*

(aka Read the Fine Comments)

##### **Problem**

How to know if a specific status change really represents what you think it represents?

##### **Context**

a specific status change may have different meanings on different projects. For example, when a bug is marked as FIXED, does it mean that a patch was submitted? That the fix is available in the version control system?

##### **Solution**

don't be afraid and read the comments of a few cases in which that status change occurs. Specially comments of bugs that are exceptional in one way or another.

##### **Related Patterns**

it is more productive to read comments that are related. You may want to [Classify] your data before .

#### *B. Know Your Project*

##### **Problem**

##### **Context**

when you do not know your project, you run the risk of making wrong assumptions about the data.

##### **Solution**

read developer documentation on the website. You may find guidelines, well defined roles and processes. Seek material in developer conferences.

##### **Examples**

eclipsecon, the talk "eclipse way". NetBeans docs talk about quality engineers.

#### *C. Know their aliases/names*

##### **Problem**

how to discover the multiple identities of a developer?

##### **Solution**

use the methods proposed by Bird et al. in Mining Email Social

#### *D. Eavesdropping*

(aka Be a regular reader/listener)

##### **Problem**

how to detect what is not explicit in the bug metadata?

##### **Solution**

do a text search. Maybe use regular patterns.

##### **Examples**

verification techniques reported by developers.

##### **Related Patterns**

read the fine comments.

### *E. This Case is Classified*

(aka Classify your Cases / Make your cases classified / Separate the wheat from the chaff)

#### **Problem**

How to avoid analysing cases that you are not interested in?

#### **Context**

#### **Solution**

create scripts to automate the classification and enrich your data with derived observations.

#### **Related Patterns**

after classifying the cases, [Read the Fine Comments] of each class and verify if the classification is adequate

### *F. Triangulate / Check*

Check your inferences by reading a sample of the data.

### *G. Explore*

Read some data to get the idiosyncrasies of each project. See Read the Fine Comments, Know Your Project, Eavesdropping.

### *H. Choose a suitable time grain*

day? week? month? release?

### *I. Future Perfect*

When making predictions based on temporal data, you usually train your models on the available data, and then asks the question: how would the model perform on future data. The problem, of course, is that future data does not exist yet. A sensible approach to overcome this problem is to split your data set in two parts: earlier data and more recent data. The second part, recent data, represents the future from the point of view of an observer that only knows the earlier data. This way, you can train your model on the first part of the data and test it on the second part.

### *J. Estimate time-related metrics*

- tempo de correcao - tempo de verificacao - tempo de latencia - etc.

Voce nao tem os dados exatos, tem que fazer simplificacoes, definir janelas razoaveis, definir intervalos de interesse.

### REFERENCES

- [1] C. Bird, A. Bachmann, E. Aune, J. Duffy, A. Bernstein, V. Filkov, and P. Devanbu, "Fair and balanced?: bias in bug-fix datasets," in *European Soft. Eng. Conf. and Symposium on the Foundations of Soft. Eng.*, ser. ESEC/FSE '09. ACM, 2009.
- [2] R. Souza and C. Chavez, "Characterizing verification of bug fixes in two open source ides." in *MSR*, M. Lanza, M. D. Pent, and T. Xi, Eds. IEEE, 2012, pp. 70–73. [Online]. Available: <http://dblp.uni-trier.de/db/conf/msr/msr2012.html#SouzaC12>