A Gamified Tool for Motivating Developers to Remove Warnings of Bug Pattern Tools

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***Abstract*—Static analysis tools such as bug pattern tools are useful to detect bugs early in software development. However, existing tools sometimes yield so many warnings that developers tend to ignore such warnings.**

To deal with this problem, we propose a gamified tool for motivating developers to remove such warnings. Our tool employs the gamification technique that calculates points by counting removed warnings with respect to each developer and each team. The points give developers the feedback and urge them to compete with each other. We confirmed that developers removed about 150% warnings with our tool in comparison with the case where they did not use our tool through an experiment.

I. Introduction

Bug pattern tools detect code fragments that seem to be faulty or to cause faults as warnings by analyzing source code. The automated detection can reduce costs of code inspection, and it can improve code quality. There are many existing tools, for example, FindBugs [1] and PMD [1] are bug pattern tools supporting Java.

Although the effectiveness of bug pattern tools has already been evaluated in various research studies [2], [3], [4], existing tools sometimes yield so many warnings that developers tend to ignore all the warnings [5], [6]. To deal with this problem, some researchers devote to improve the precision of the detection [7]. However, it is very difficult to remove all false positives.

As another approach, we propose a gamified tool, named Game-based Bug Catcher (GBC), for motivating developers to remove such warnings. GBC makes it more fun to remove warnings of FindBugs with a gamification technique. Gamification is defined as a technique to apply game design techniques to non-game experiences [8], [9]. GBC calculates points on the basis of the number of warnings developers removed. The points give developers the feedback and urge them to compete with each other.

We investigate two research questions (RQs) as follows:

- RQ1: Can we apply the gamification technique to existing bug pattern tools?
- RQ2: How effectively GBC can reduce warnings reported by FindBugs?

[1]PMD, http://pmd.sourceforge.net/.

```
1  String m(String s) {// NM_METHOD_NAMING_CONVENTION
2    int num = 2;
3    if (s.equals("EAGLES2014")) {
4      num = 1;
5    } else if (s.equals(null)) { // EC_NULL_ARG
6      num = 0;
7    }
8    String ret = null;
9    switch (num) {    // SF_SWITCH_NO_DEFAULT
10   case 1 :
11     ret = "Bug";  // SF_SWITCH_FALLTHROUGH
12   case 2 :
13     // SF_DEAD_STORE_DUE_TO_SWITCH_FALLTHROUGH
14     ret += "Pattern";
15   }
16   return ret;
17 }
```

Fig. 1. Sample Java code that contains five warnings

The contributions of this paper are:

- A gamified tool that motivates developers to remove warnings.
- Results of an experiment that indicate that our tool overall reduced warnings.

II. Problems in Existing Bug Pattern Tools

GBC uses FindBugs that is one of the most famous bug pattern tools supporting Java. FindBugs reports warnings that consist of the name, description, category, and rank. For example, Figure 1 shows source code that contains five warnings reported by FindBugs. Note that we add the names of warnings as comments in the source code.

The source code consists of 17 lines and surprisingly contains a warning per 3.4 lines. These warnings are able to be both true positives and false positives. When warnings occur in this frequency, a large project may bother with too many warnings. The source code is not real code, and this calculation cannot be directly applied to real software development, but it is still not a trivial example.

The problems of static analysis tools including bug pattern tools are found by various researchers. One of the most significant problems is too many warnings due to false positives as the example [7], [5], [6], [10], [11], [12]. To deal with the problem, there have already existed various approaches such as an improvement in the detection accuracy by enhancing

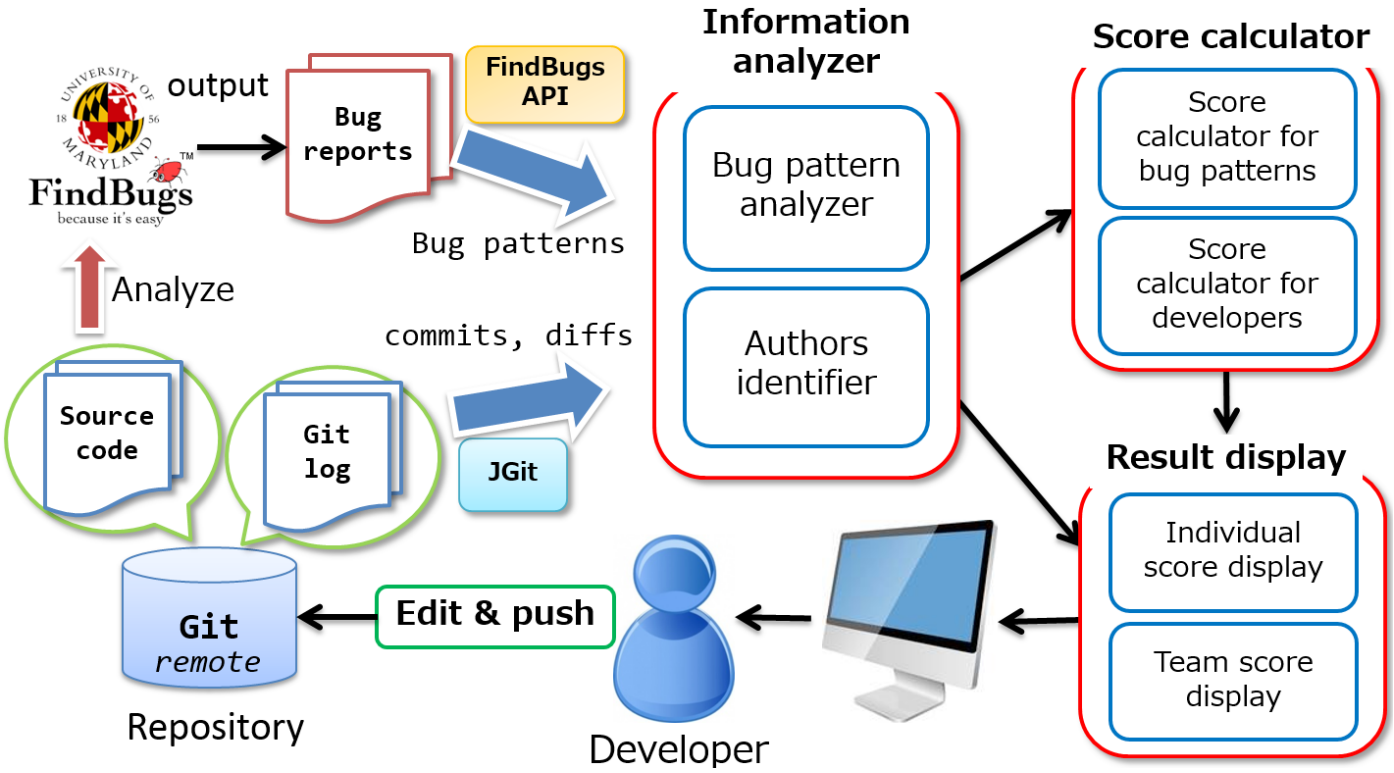

Fig. 2. Overview of GBC

algorithms or by combining multiple tools [7]. Although these approaches partially alleviate the problem, it is very difficult to remove false positives completely.

III. Gamified Tool for Motivating Developers to Remove Warnings

We developed GBC for motivating developers to remove warnings as another approach to deal with the problem. Figure 2 shows the overview of GBC. GBC finds who wrote the code fragments corresponding to each warning and who fixed the code fragments to remove corresponding warnings. GBC calculates points by counting removed or added warnings with respect to each developer and team.

GBC consists of three components: the information analyzer, score calculator, result display. The information analyzer consists of the bug pattern analyzer and author identifier. The bug pattern analyzer analyzes warnings reported by FindBugs and understands which bug patterns each warning corresponds to. The author identifier identifies who wrote or fixed the code fragment corresponding to each bug pattern. The score calculator consists of the two score calculators for bug patterns and developers. The score calculators calculate the point of each warning and the total point of each developer, respectively. The result display consists of the individual score display and team score display. The score displays show the point of each developer and the point of each team, respectively. Figure 3 shows the individual score display.

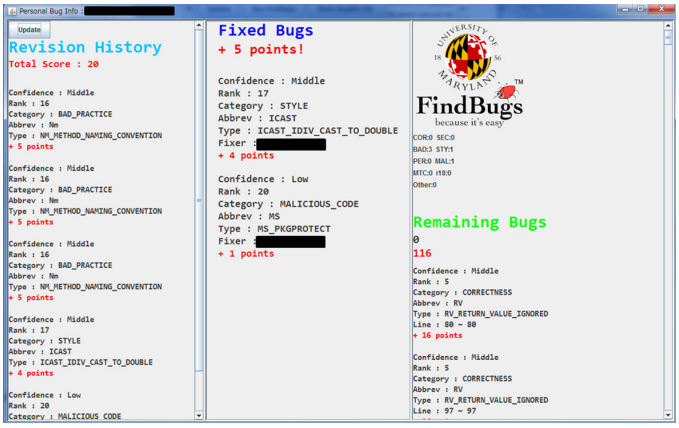

Fig. 3. Screenshot of individual score display

A. Bug Pattern Analysis using FindBugs and Git

We employed FindBugs to detect code fragments corresponding to bug patterns. We also employed Git [2] to identify who wrote or fixed the code fragments. Git is a famous version control system that stores edit histories. GBC identifies an author of each commit by analyzing the edit histories. Then, GBC collects each set of warnings in two versions using FindBugs and detects which warnings are added or removed by analyzing the difference of the two sets of warnings.

[2]Git, http://git-scm.com/.

B. Introduction of Gamification Technique

Gamification techniques can motivate users by adding game elements in non-game contexts. For example, Foursquare [3] uses gamification techniques. Foursquare provides a feature that shares the locations where users checked in. Foursquare gives users badges by referring to the number of the locations and the kinds of the locations. Users are motivated to use Foursquare frequently to collect badges.

Gamification techniques began to be applied to various fields including software engineering [13], [14], [15]. We implemented the calculator components that analyze the rank of bug patterns. FindBugs gives each bug pattern the rank that indicates how serious the bug pattern is. We define a point of a bug pattern as $21-rank$ because the rank is an integer between 0 and 21. When a developer removes a warning corresponding to a bug pattern, he/she gets the point of the bug pattern. The team point is the summation of the points of the team members. In this way, GBC encourages developers to compete with each other, thus, GBC motivates developers to remove warnings.

IV. Evaluation

To investigate RQ1 and RQ2, we conducted an experiment. We gathered six bachelor or master students who studied computer science.

A. Experimental Setup

The experiment uses two open source software (OSS) programs, namely, bukkit [4] (S_A) and twitter4j-core [5] (S_B), as subject programs. bukkit is a server program for a famous game software Minecraft. twitter4j-core is a core library for handling Twitter API from Java programs. bukkit and twitter4j-core have 26,917 and 18,123 lines of code, respectively.

We conducted the experiment with the following steps.

1) We divide the six students into two groups (G_A and G_B).
2) We deploy the two OSS programs in our Git repository. The students acquire them and put them on their local machines.
3) G_A removes warnings in S_A with GBC within 30 minutes. We handle GBC to show the point information in another display. In contrast, G_B removes them without GBC within 30 minutes.
4) After the task for S_A, G_A removes warnings in S_B without GBC within 30 minutes. In contrast, G_B removes them with GBC within 30 minutes.

B. Results

Table I shows the results of the experiment. The columns of "Group", "OSS", "GBC", "Total", "Removed", and "Ratio" indicate that the group which removed warnings, the name of the OSS program where they removed warnings, whether they removed warnings with GBC or without GBC, the total number of the warnings that FindBugs reported, the number of the warnings removed by the corresponding group, and the ratio of the removed warnings.

Figures 4 and 5 show the numbers of removed warnings with respect to each group. We cannot compare the results of G_A and G_B because they have not the same skills. Thus, we compare the results in the same group.

TABLE I. Removed warnings of FindBugs with or without GBC

Group	OSS	GBC	Total	Removed	Ratio
G_A	S_A	Yes	168	26	15.48%
	S_B	No	150	13	8.67%
G_B	S_A	No	168	41	24.40%
	S_B	Yes	150	59	39.33%

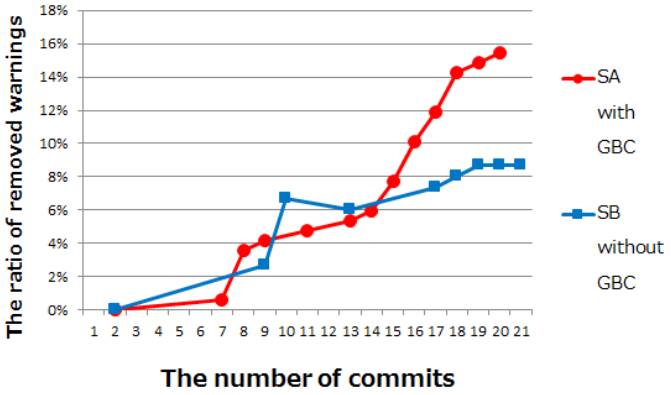

Fig. 4. Experiment results of G_A

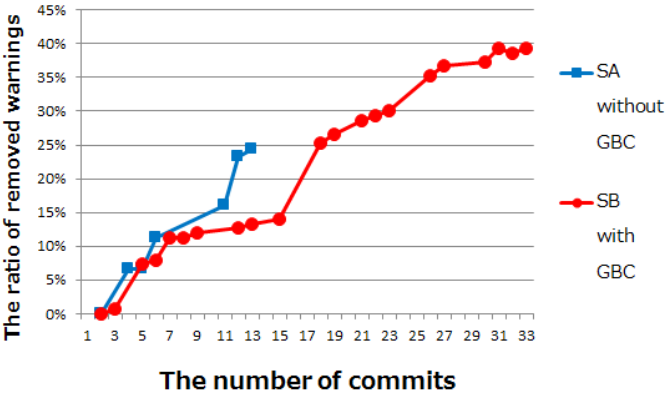

Fig. 5. Experiment results of G_B

The results show that both G_A and G_B with GBC removed more warnings than the case where they removed warnings without GBC. They also show that the ratios of removed warnings with GBC are bigger than the case where they removed warnings without GBC. Thus, we can conclude that GBC motivated developers to remove warnings, and we can answer yes to RQ1.

We also collected information from the six students through interviews and questionnaires. Five of them said that removing warning with GBC is better than removing warning without GBC. In the interview, a student said that he tried to fix source code aggressively because GBC motivated him to remove warnings. Another student said that he prioritized the number

[3] Foursquare, https://ja.foursquare.com/.
[4] https://github.com/Bukkit/Bukkit
[5] https://github.com/yusuke/twitter4j

of removed warnings rather than the correctness and accuracy because GBC urged to remove warnings quickly. For the case where they did not use GBC, a student said that he did not want to remove them because it was a tedious task to remove warnings. In contrast, another student said that he could concentrate on removing warnings because a factor such as GBC did not urge him to compete with others. Overall, GBC is effective to motivate developers to remove warnings, but we should keep in mind that our gamification technique were not effective to all students who do not like the competition.

V. Threats to Validity

Some students have not strong skills of FindBugs and Git. They may learn something through the experiment, and it may have an affect on the results. However, both groups removed more warnings when they used GBC. Thus, we can ignore such learning.

The experiment setting has two differences from real software development. 1) The examinees removed warnings in the OSS programs that they did not write. 2) The examinees removed warnings within only 30 minutes. To validate GBC more carefully, we plan to apply GBC to a long-term software development.

VI. Related work

Thung et al. compares three static analysis tools, FindBugs, PMD, and Jlint in terms of false negatives [5]. They applied the three tools to three OSS programs and found that FindBugs and PMD are more effective to prevent false negatives than Jlint. However, there are still false detection problems in all the three tools.

Nanda et al. developed a new tool that executes multiple static analysis tools to deal with the costs of selecting tools and the problem of too many warnings [7]. Their tool collects feedback from users to improve the detection accuracy. In contrast, our approach motivates developers to remove warnings instead of the improvement in the detection accuracy.

Singer et al. proposed a gamified tool that adds gamification techniques into Git to motivate developers to commit change history more frequently [13]. Their tool observes commits and reports the summary of the commits on Web pages and e-mails. They confirmed that their tool can successfully motivate developers due to the competition, but the competition bothered some developers. Our approach employs similar gamification techniques, and we got similar experimental results.

VII. Conclusion

Bug pattern tools are effective but have some problems. One of the most significant problems is that they yield sometimes too many warnings to make developers hesitate to remove them. To deal with the problem, we propose a gamified tool, named GBC, to motivate developers to remove warnings of FindBugs. GBC urges developers to remove warnings through the competition by counting the number of removed warnings with respect to each developer and team. We conducted the experiment and confirmed that developers removed more warnings when they used GBC.

In future work, we will add other gamification techniques not related to the competition into GBC because there are some people who do not like the competition. We also plan to conduct a more realistic and long-term experiment similar to real software development to deal with threats to validity.

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