

Department of Computer Science,
University of Saskatchewan

July 22, 2020

The Guest Editors

Journal of Systems and Software

Re: Submitting an extended version of our earlier work

Dear Guest Editors,

We would like to submit an extended version of our earlier work on ranking some existing good clone detection tools based on their capability to predict co-change candidates during software evolution. Our earlier work titled as “**Evaluating Performance of Clone Detection Tools in Detecting Cloned Cochange Candidates**” was published in IEEE 14th International Workshop on Software Clones (IWSC), 2020. In that work, we evaluated the performance of six good clone detection tools based on detecting cloned co-change candidates. Our goal was to practically verify whether a tool which is good in detecting cloned fragments from software systems, also good in detecting cloned co-change candidates or not. The key points of our earlier published paper are:

- Used six open-source software systems as subject systems.
- Evaluated the performance of six clone detection tools.
- We also investigated and reported two possible reasons for the difference in the performance of clone detection tools while we are using them to predict co-change fragments.

We have considered doing the following improvements for extending the paper to be submitted for publication on the Journal of Systems and Software (Special Issue on Software Clones).

- ✓ We have added two additional research questions (RQ3, RQ4) to find a more specific reason for the variation of the performance by clone detectors in detecting co-change candidates.
- ✓ We have also increased the generalizability of the previous study by adding two more software systems as subject systems and six more clone detection tool implementations.
- ✓ Our overall investigation has been upgraded from 6X6 to 12X8 (Clone detector X Subject Systems).
- ✓ Besides, the number of clone fragments detected and the line covered in the source file by those fragments, our extended investigation shows that the type of detected clones and underlying source code processing techniques also have some impact on the performance of detecting cloned co-change candidates.

In the following paragraphs, we describe a few more steps we performed to extend our earlier work.

- ✓ **Adding more clone detectors in the study:** In the earlier implementation, we have applied six clone detection tools, five of them (Deckard, ConQAT, iClones, NiCad, and SimCAD) have been reported as very good tools for detecting Type-1, 2, 3 clones. We added one text similarity-based tool (Simian) as the sixth tool in the earlier implementation. To extend the work, we added six additional implementations of clone detection techniques by using three additional tools. New tools added are CloneWorks, CCFinder, and Duplo. CloneWorks have been reported as a fast and flexible clone detector for large-scale near-miss clone detection experiments. CloneWorks provides options to modify its configuration files which have effects on the source code processing mechanism while detecting the clones. This is important to target specific types (1, 2, or 3) of clone by using this clone detection tool. We have applied four types of different configuration files to detect Type-3 pattern, Type-3 Token, Type-2 Blind, and Type-1 clones by using CloneWorks tool. This provided four additional sets of detected clone result. CCFinder is known as a multilinguistic token-based code clone detection technique for large scale source code. Inclusion of CCFinder enriched the variation of detected clone fragments in the extended study. To make more comparison of the performance of type-1 clones in detecting co-change candidates we added Duplo in our study.
- ✓ **Adding more subject systems:** In the earlier version of the study, we added six software systems four of them are written in Java and two of them are written in C programming language. To increase the generalizability of the study we have added two more software systems written in C having diverse size and application domain from the other six systems.
- ✓ **Additional two research questions:** Our earlier investigation evaluated only two research questions to find the comparison scenario of clone detectors in detecting co-change candidates and reasons behind these performance variations of those tools. We have added two more research questions in the extended study to find out the relation of the types of clone and source code processing techniques while detecting the clone as the additional reasons for these difference in performance.
- ✓ **Updating different sections in the paper to incorporate our new findings:** We have updated different sections such as Abstract, Introduction, Methodology, Experimental Result, Discussion, Conclusion and Future Works by adding our new findings from our extended research.

We believe that our extended version contains at least 60% more content than our earlier work.

Sincerely,
 Md Nadim
 Manishankar Mondal, and
 Chanchal K. Roy