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# Dissection on Java Organs in GitHub Repositories

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**ABSTRACT** Organ transplantation has brought convenience for software reuse and evolution since it was proposed. However, studies about mature, high-quality organs are still insufficient. It is still unclear about the detailed characteristics of organs in open-source environment. In this paper, we look deep into organs obtained from software evolution processes of ten large-scale Java repositories hosted on GitHub, aiming at providing practical information for utilizing organs in open-source environment. We found that 1) commits use *add* as a keyword in their comments possess the most organs, occupying 38% of the total amount, but commits with the keyword *fix* possess the highest locating accuracy (about 57%); 2) developers prefer to add new classes when they bring new functionalities to the projects in that the proportion of *Class Level Organs* is 40%, more than *Statement Level Organs* and *Function Level Organs* (35% and 25%, respectively); 3) nearly 70% of the total amount are *cross-file organs* with the median of the number of files each organ spans reaching 3 and the average of this value being around 4; 4) a small number (0.55%) of organs are *multi-commit*; 5) more than 40% of code reuse in open-source software can be finished by organ transplantation. Based on our findings, we highlight implications for future studies and design the mode of using organs to conduct code reuse.

**INDEX TERMS** organ transplantation, code reuse, GitHub repository, commits, software evolution, code clone

## I. INTRODUCTION

Software reuse, which refers to creating software systems utilizing existing software rather than building them from scratch [1, 2], brings great convenience for software development and maintenance. Components, which are considered as the basic unit in software [3], have been studied well during the years and provided endorsement for reuse technologies [4, 5, 6] such as extending the functionality of a specific system using existing code.

For achieving the same goal, Mark Harman et al. [7] transplanted code from other systems and named these code Organ, referring to all code associated with the feature of interest. New ideas have been brought to reuse since then: organs may provide greater convenience than components since they are more flexible according to the definitions. If one programmer is interested with just an if conditional branch to guarantee the condition whereas the whole class is reused, it is then nothing to do with convenience and concision. Later on, Harman's study was extended by creating a tool named

*CodeCarbonCopy* (CCC) [8] and transplanting call graph and layout features [9]. Despite the satisfying results they got, their practices in this area are restricted to a small-scale and specific experimental context: donors of the experiments in [7] and [8] are all pre-prepared applications, leading to a small number of organs (5 and 7, respectively). Organ transplantation based on large-scale dataset was not involved in their experiments.

In our previous study [10], we made the first attempt to extract and transplant organs from open-source communities, aiming at remedying the problem of lacking of organs. We firstly proposed the idea that mining organs from the evolution process of open-source projects by concentrating on the contents of commits. We then put forward a strategy for transplantation and made some manual experiments in which satisfactory results were achieved. The main lack of this study was that we did not study organs comprehensively: we only considered potential organs in *adding commits* (i.e., commits with *add* as a keyword) and we also ignored some special cases

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