

Self-verifiable Experimentation Pipelines

An Alternative to Research Artifact Descriptions

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We make the case for incorporating self-verifiable experimentation pipelines in journals and conferences as a way of streamlining the review process for code and data associated to academic articles.

on how to replicate results, including steps that detail how to install software and how to re-execute experiments and analysis contained in a paper.

1 Introduction

Reproducibility is the cornerstone of the scientific method. Yet, in computational and data science domains, a gap exists between current practices and the ideal of having every new scientific discovery be *easily* reproducible [1]. Advances in computer science (CS) and software engineering slowly and painfully make their way into these domains—even in CS research itself [2,3], paradoxically.

To address some of the reproducibility issues we face today, a growing number of CS conferences and journals incorporate an artifact evaluation process in which authors of articles submit artifact descriptions¹ that are tested by a committee, in order to verify that experiments presented in a paper can be re-executed by others. In short, an artifact description is a 2-3 page narrative

2 Self-verifiable Pipelines

An alternative to the manual creation and verification of an Artifact Description (AD) is to use a continuous integration (CI) service² such as Jenkins³ to ensure that the code (and data) associated to an article can be re-executed by others. If the execution and validation of an experimentation pipeline using a CI service, the URL pointing to the project on the CI server that holds execution logs, as well as the repository containing all the automation scripts, can potentially be used as an alternative to ADs. In other words, the repository containing the code for experimentation pipelines, and the associated CI project, serve both as a *Self-verifiable Experimentation Pipeline* (SEP). Thus, instead of submitting manually written ADs, authors can submit a link to the code repository where scripts for their pipelines reside, along with

¹<http://ctuning.org/ae/submission.html>

²<http://en.wikipedia.org/?curid=22903426>

³<https://jenkins.io>

a link to the CI server that executes them, and use this as the basis for evaluating the reproducibility of their work.

While automating the execution of a pipeline can be done in many ways, in order for this approach to serve as an alternative to ADs, there are five high-level tasks that SEPs must carry out in every execution:

1. **Code and data dependencies.**

Code must reside on a version control system (e.g. Github⁴, Gitlab⁵, etc.). If datasets are used, then they should reside in a dataset management system (Zenodo⁶, CKAN⁷, Data-packages⁸, etc.). The experimentation pipelines must obtain the code/data from these services on every execution.

2. **Setup.**

The pipeline should build and deploy the code under test. For example, if a pipeline is using containers or VMs to package their code, the pipeline should build the container/VM images prior to executing them. The goal of this is to verify that all the code and 3rd party dependencies are available at the time a pipeline runs, and that software can be build correctly.

3. **Resource allocation.**

If a pipeline requires a cluster or custom hardware to reproduce results, resource allocation must be done as part of the execution of the pipeline. This allocation can be static or dynamic. For example, if an experiment runs on custom hardware, the pipeline can statically

allocate (i.e. hardcode IP/hostnames) the machines where the code under study runs (e.g. GPU/FPGA nodes). Alternatively, a pipeline can dynamically allocate nodes on CloudLab [4], Grid500K [5], Chameleon [6], or a public cloud provider. These services typically offer infrastructure automation tools such as Geni-lib⁹ (Cloudlab), Enos [7] (Chameleon), SLURM [8] (HPC centers), or Terraform¹⁰ (AWS, GCP, etc.). All these tools can be used to automate infrastructure-related tasks.

4. **Environment capture.**

Capture information about the runtime environment. For example, hardware description, OS, system packages (i.e. software installed by system administrators), remote services (e.g. a scheduler). Many open-source tools can aid in aggregating this information such as SOSReport¹¹ or Factor¹².

5. **Validation.**

Scripts must verify that the output corroborates the claims made on the article. For example, the pipeline might check that the throughput of a system is within an expected confidence interval (e.g. defined with respect to a baseline obtained at runtime), or that a numerical computation is within some expected bounds.

A list of Popper [9] pipelines meeting the above criteria are available at Popper’s official documentation website¹³.

⁴<https://github.com>

⁵<https://gitlab.com>

⁶<https://zenodo.org>

⁷<https://ckan.org/>

⁸<https://frictionlessdata.io/data-packages/>

⁹<https://bitbucket.org/barnstorm/geni-lib>

¹⁰<https://terraform.io>

¹¹<https://github.com/sosreport/sos>

¹²<https://github.com/puppetlabs/facter>

¹³<http://bit.ly/popper-examples>

NOTE: A SEP is a set of high-level requirements, rather than a detailed list of low-level requisites. Consequentially, there are many alternatives to create a SEP. While the examples we link to are of Popper pipelines, this article has the intention to apply, in general, to any type of automated approach.

3 Review Process

We now illustrate how the peer-review process might work for a conference or journal that incorporates SEPs as a way of having authors demonstrate the reproducibility of their results. The process might look like this:

1. Authors create SEPs as part of their work.
2. Authors submit link(s) to the CI service that automatically executes the experimentation pipeline(s) associated to their submission.
3. Reviewers check logs of CIs to verify that the 5 components described in Section 2 are met.

Thus, incorporating SEPs to the peer-review process has two important outcomes:

1. **Better Experimentation Practices.** Authors that consider reproducibility as a first-class goal of their work increase the confidence in their results.
2. **Low-overhead Evaluation.** With SEPs, the burden of ensuring that a

pipeline can be re-executed by others relies on the authors, which leverage the CI service as that third-person ensuring the help of CI),

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