
Quality Characteristics for Software in HPC Environments: A Systematic Literature Review

deRSE25

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IT Center



Motivation

Why *quality characteristics*?

- ▶ FAIR criteria for research software translate to qualities

“R: Software is both usable (can be executed) and reusable (can be understood, modified, built upon or incorporated into other software).”

FAIR4RS Principles [Barker et al. 2022]

Why *software in HPC environments*?

- ▶ HPC system capabilities are needed by scientists across all domains
- ▶ Quality is important because of expensive runs
- ▶ Unique challenges like hardware heterogeneity

Goals

1. Investigate existing research on the topic
2. Find out which quality characteristics are important
3. Compare to quality characteristics from software in general

Systematic Literature Review - Search

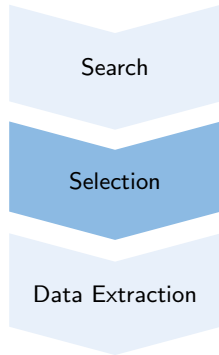


$\left(\begin{array}{c} \text{"software quality"} \\ \text{or} \\ \text{"code quality"} \\ \text{or} \\ \text{"software sustainability"} \\ \text{or} \\ \text{"software engineering" and ("quality" or "sustainability")} \end{array} \right) \text{ and } \left(\begin{array}{c} \text{"hpc"} \\ \text{or} \\ \text{"high performance comput*"} \\ \text{or} \\ \text{"high-performance comput*"} \end{array} \right)$

- ▶ Applied to different indices
 - ▶ Scopus
 - ▶ BASE (Bielefeld Academic Search Engine)
 - ▶ dblp computer science bibliography
- ▶ Executed in August, 2024

[Kitchenham and Charters 2007]

Systematic Literature Review - Selection

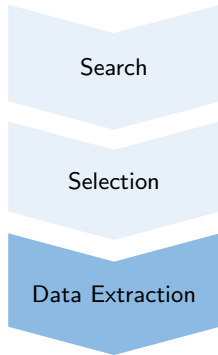


Inclusion criteria	Exclusion criteria
<ol style="list-style-type: none">1. Quality refers to an application software2. Software is intended to be executed in an HPC environment3. Characteristics of software quality are defined and analyzed	<ol style="list-style-type: none">1. Not in English language2. Duplicate3. Pre-print of an included publication4. Not in continuous full-text format5. Primarily about teaching the topics

► 29 included publications

[Kitchenham and Charters 2007]

Systematic Literature Review - Data Extraction

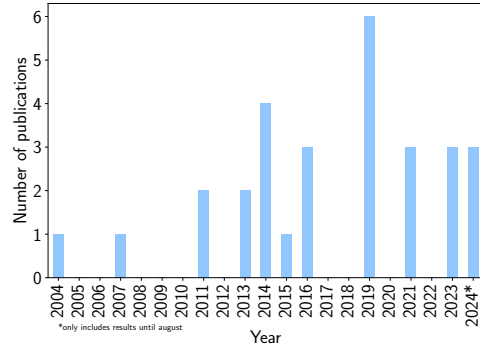
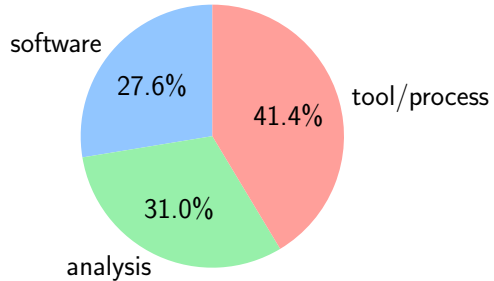


- ▶ General data
title, authors, publication venue, publication year, DOI, references,
application domain
- ▶ Quality characteristics and trade-offs between them
- ▶ Category
 - ▶ Tool and/or process
to measure or improve software quality aspects
 - ▶ Software
including a description of how software quality is approached
 - ▶ Analysis
of software quality, for example, the current state

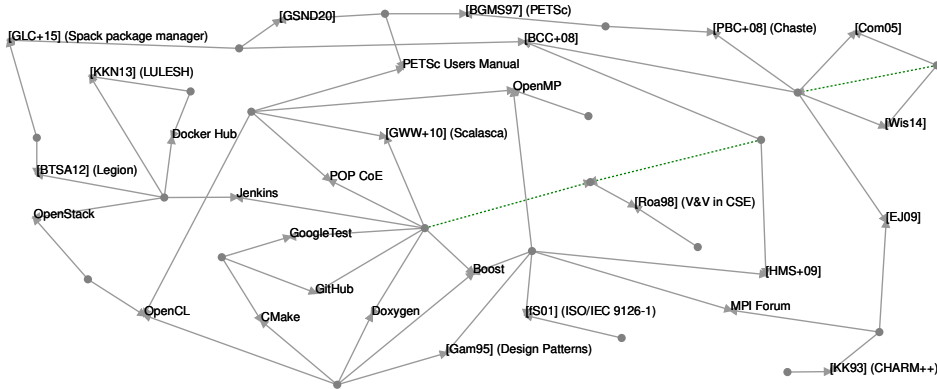
[Kitchenham and Charters 2007]

[Lummerzheim 2025b]

General Results

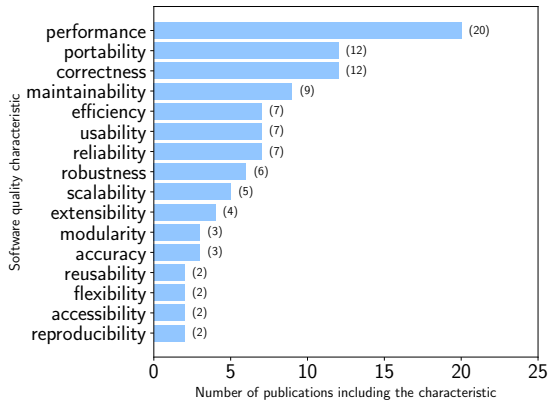


Connections



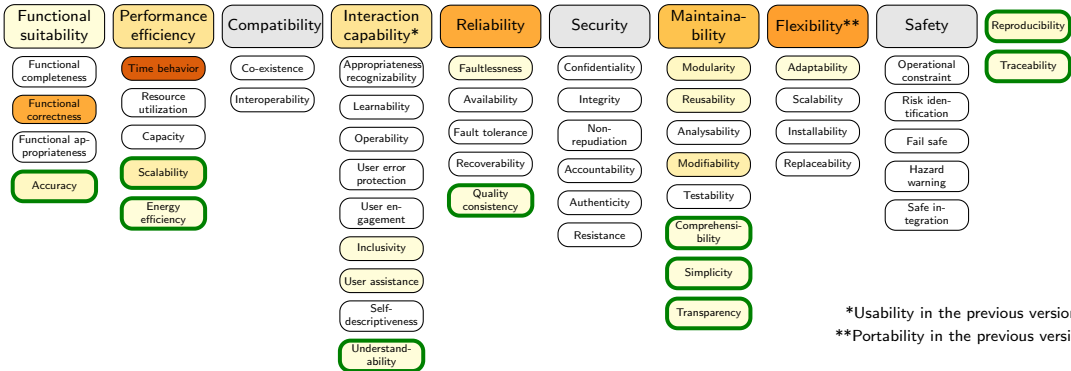
[Lummerzheim 2025a] interactive version: <https://slr-hpc-software-quality-794fea.pages.git.nrw/>

Quality Characteristics

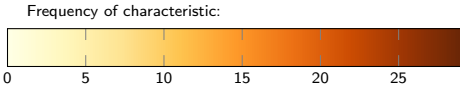


- ▶ Trade-offs mainly between performance-related and other characteristics
- ▶ Characteristics included once: comprehensibility, traceability, simplicity, transparency, functionality, sustainability, quality consistency, stability, expandability, understandability, adaptivity, development effort, energy efficiency, result consistency

Comparison to SQuaRE (ISO/IEC 25010:2023)[International Organization for Standardization 2023]



*Usability in the previous version
 **Portability in the previous version



Newly added characteristic:

Conclusion

- ▶ Software quality in HPC has specific criteria and commonalities with (research) software in general

Outlook

- ▶ Extract and evaluate used metrics
- ▶ Complement with studies using other methodologies
- ▶ Create a template for software quality documentation






Questions?

Contact

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Thank you for your attention.

References

-  Barker, Michelle et al. (Oct. 2022). "Introducing the FAIR Principles for research software". In: *Scientific Data* 9.1. DOI: 10.1038/s41597-022-01710-x.
-  International Organization for Standardization (2023). *Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Product quality model*. URL: <https://www.iso.org/standard/78176.html>.
-  Kitchenham, Barbara and Stuart M. Charters (2007). *Guidelines for performing Systematic Literature Reviews in Software Engineering*. Tech. rep. Evidence-Based Software Engineering (EBSE). URL: <https://www.researchgate.net/publication/302924724>.
-  Lummerzheim, Camilla (2025a). *Code for "Quality Characteristics for Software in HPC Environments: A Systematic Literature Review"*. DOI: 10.5281/ZENODO.14899735.
-  Lummerzheim, Camilla (2025b). *Data for "Quality Characteristics for Software in HPC Environments: A Systematic Literature Review"*. en. DOI: 10.5281/ZENODO.14898873.