

# A New Taxonomy of Software Testing Approaches

Seeking More Standardized Standards

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#### Goal

Taxonomy of software testing approaches

- Should be systematic, rigorous, and "complete"
- Application: **automatically generating test cases** in Drasil [1]
- The underlying domain should drive the scope and prerequisites for generated test cases

#### Problem

Existing software testing taxonomies are inadequate; for example:

- Tebes et al. (2020) mainly focus on parts of the testing process (e.g., test goal, testable entity)
- ROoST, by Souza et al. (2017), is an ontology, and as such, prioritizes organizing testing approaches over defining them
- Unterkalmsteiner et al. (2014) provide a foundation for classification but not its results

### Methodology

Since a taxonomy doesn't already exist, we should create one!

- Started from **established standards and resources**, such as IEEE [2, 3, 4] and SWEBOK [5]
- Relevant information (currently 190 testing approaches, 85 software qualities, and their definitions) is then collected and organized into spreadsheets
- We will iterate this process until we encounter diminishing returns, implying that something approaching a **complete taxonomy** has emerged!
- Since there are many standardized documents about software testing (or software in general), this should be trivial, no?

## In Our Experience...

#### Levels of testing

Unit testing Integration testing System testing System integration testing Acceptance testing

- User acceptance testing Operational acceptance
- Factory acceptance testing
- Alpha testing
- Beta testing
- Production verification
- testing

#### Test practices

Model-based testing Scripted testing **Exploratory testing** Experience-based testing Manual testing A/B testing Back-to-back testing Mathematical-based testing Fuzz testing Keyword-driven testing Automated testing — Capture-replay driven Data-driven

#### Types of testing

Accessibility testing Compatibility testing Conversion testing Disaster/recovery testing Installability testing Interoperability testing Localization testing Maintainability testing

Functional testing

testing Performance

Performance-related

- Load Stress
- Capacity Recovery

Portability testing Procedure testing Reliability testing Security testing Usability testing

#### Static testing

Reviews (ISO/IEC 20246) Static analysis Model verification

Figure 1: Classification of some "test approach choices" [2, p. 22].

#### Test design techniques / measures

Specification-based:

- Equivalence partitioning Classification tree method
- Boundary value analysis Syntax testing
- Combinatorial testing
- All combinations Pairwise
- Each choice Base choice
- Decision table testing Cause-effect graphing
- State transition testing
- Scenario testing Use case testing
- Random testing Metamorphic testing
- Requirements-based
- Structure-based:
- Statement testing Branch testing Decision testing
- Branch condition testing Branch condition combination testing
- MC/DC testing Data flow testing — All-definitions testing
- All-C-uses testing All-P-uses testing All-uses testing

All-DU-paths testing

Experience-based:

Error guessing

## Information often appears logical, but this often breaks down. For example, the classification of test approaches in Figure 1 reveals the following ambiguities:

- Experience-based testing is both a test design technique and a test practice
- What distinguishes the following pairs is unclear:
  - Disaster/recovery testing and recovery testing
  - Branch condition testing and branch condition combination testing

## More Examples

Despite [2] being a software testing standard, it leaves much unstandardized (see Figure 2).

- Most (55 out of 99) testing approaches from [2] do not have a definition!
- Eight of these were (at the very least) described in the previous version of this standard [4]
- Nine were present in the same way in another IEEE standard [3] before this one was published

However, existence does not imply usefulness; see Figure 3 for some good (bad?) examples.

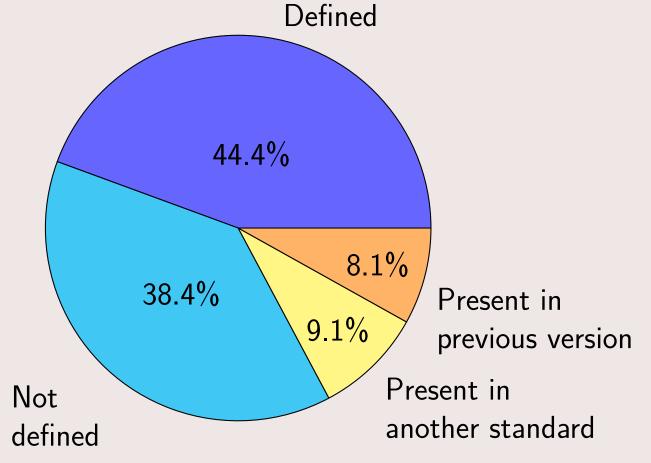


Figure 2: Breakdown of testing approach definitions in [2].

#### software element

1. system element that is software cf. system element, software/system element

event sequence analysis **1.** per

operable 1. state of

1. mechanism or piece of equipment designed to serve a purpose or perform a function

Figure 3: Less-than-helpful definitions [3, pp. 421, 170, 136, 301 (counterclockwise from top)]. Note: "equipment" is not defined, and "mechanism" is only defined as how "a function ...transform[s] input into output" [p. 270].

This problem extends to definitions of testing approaches. For example, SWEBOK V4 says "scalability testing evaluates the capability to use and learn the system and the user documentation." It also focuses on the system's effectiveness in supporting user tasks and the ability to recover from user errors" [5, p. 5-9]. This definition seems to be an amalgamation of the definitions of usability, recovery, and potentially functional testing. What's more, SWEBOK's definition of elasticity testing cites a single source [5, p. 5-9] that doesn't contain the words "elasticity" or "elastic"!

Even when the general idea behind an approach is understood, discrepancies can still arise. While alpha testing is quite common and understood, there is disagreement on who performs it:

- "users within the organization developing the software" [3, p. 17],
- "a small, selected group of potential users" [5, p. 5-8], or
- "roles outside the development organization" [6].

## Conclusions & Future Work

- Current software testing taxonomies are incomplete, inconsistent, and/or incorrect
- For one to be useful, it needs to be built systematically from a large body of established sources
- We will continue investigating how the literature defines and categorizes software testing approaches to analyze any discrepancies and structure these ideas coherently
- Hopefully, this leads to a **centralized**, **consistent taxonomy** that can grow alongside the literature as the field of testing advances

#### References

- [1] J. Carette, S. Smith, J. Balaci, T.-Y. Wu, S. Crawford, D. Chen, D. Szymczak, B. MacLachlan, D. Scime, and M. Niazi, "Drasil," Feb. 2021
- [2] ISO/IEC and IEEE, "ISO/IEC/IEEE International Standard Systems and software engineering –Software testing –Part 1: General concepts," ISO/IEC/IEEE 29119-1:2022(E), Jan. 2022.
- [3] ISO/IEC and IEEE, "ISO/IEC/IEEE International Standard Systems and software engineering-Vocabulary," ISO/IEC/IEEE 24765:2017(E), Sept. 2017.
- [4] ISO/IEC and IEEE, "ISO/IEC/IEEE International Standard Systems and software engineering -Software testing -Part 1: General concepts," ISO/IEC/IEEE 29119-1:2013, Sept. 2013
- Jan. 2024. [6] M. Hamburg and G. Mogyorodi, editors, "ISTQB Glossary, v4.3," 2024.

[5] H. Washizaki, ed., Guide to the Software Engineering Body of Knowledge, Version 4.0.

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