Putting Software Testing Terminology to the Test

M.A.Sc. Seminar

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Fall 2025

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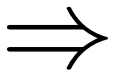
The Need for Standardized Terminology

- Engineering is applied science
- Scientific fields use precise terminology

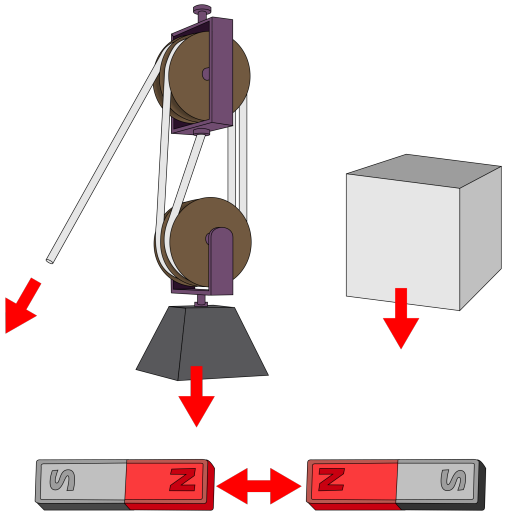


SOFTWARE ENGINEERING

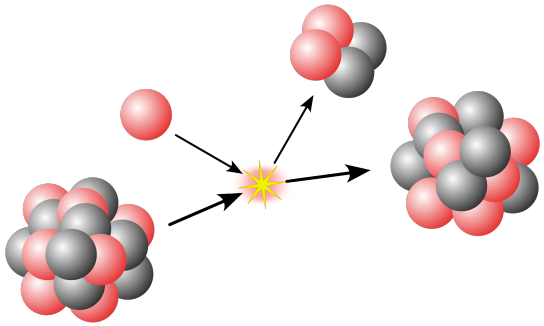
The Need for Standardized Terminology

- Engineering is applied science
- Scientific fields use precise terminology

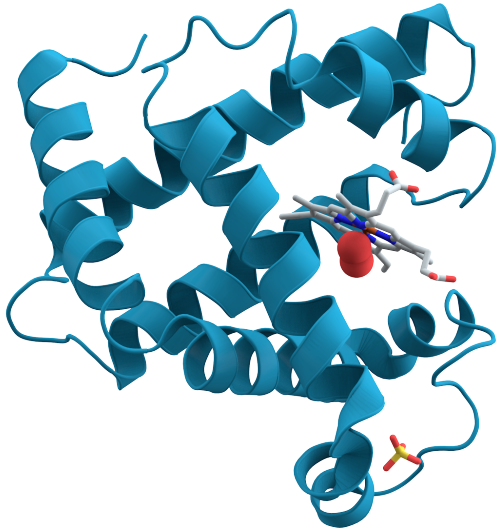
$\Rightarrow$ SOFTWARE ENGINEERING



Penubag and Ramey (2010)



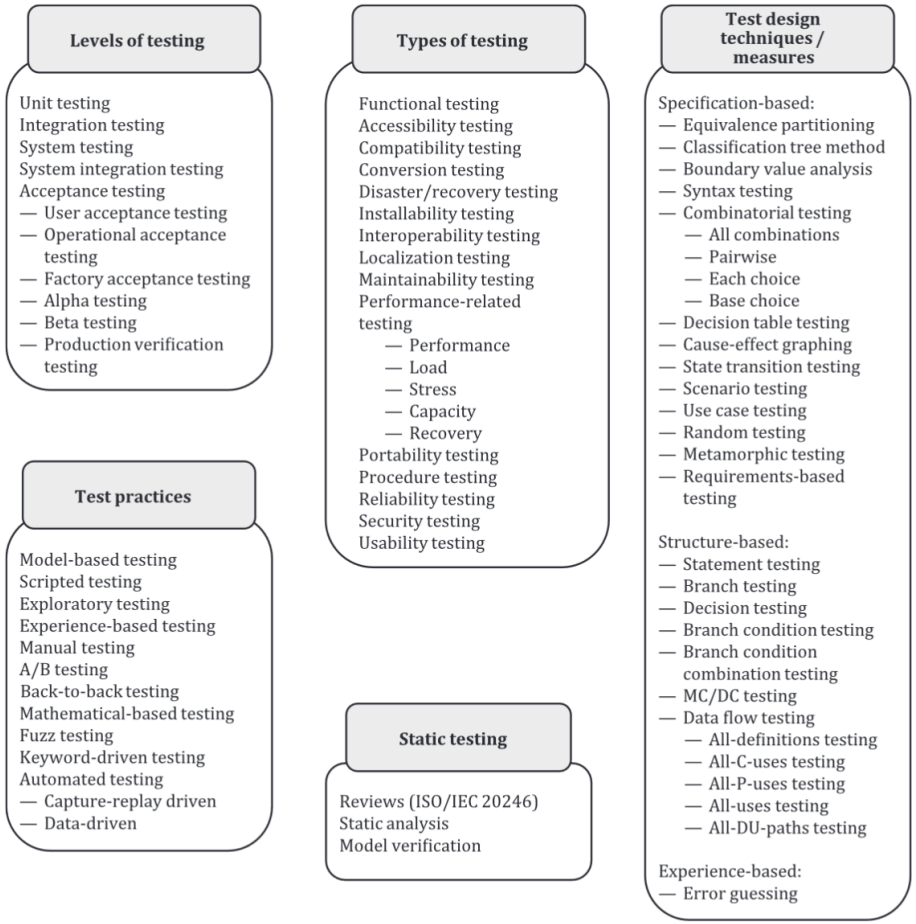
Kjerish (2016)



AzaToth (2008)

The Lack of Standardized Terminology

"The Problem"



(ISO/IEC and IEEE, 2022, Fig. 2)

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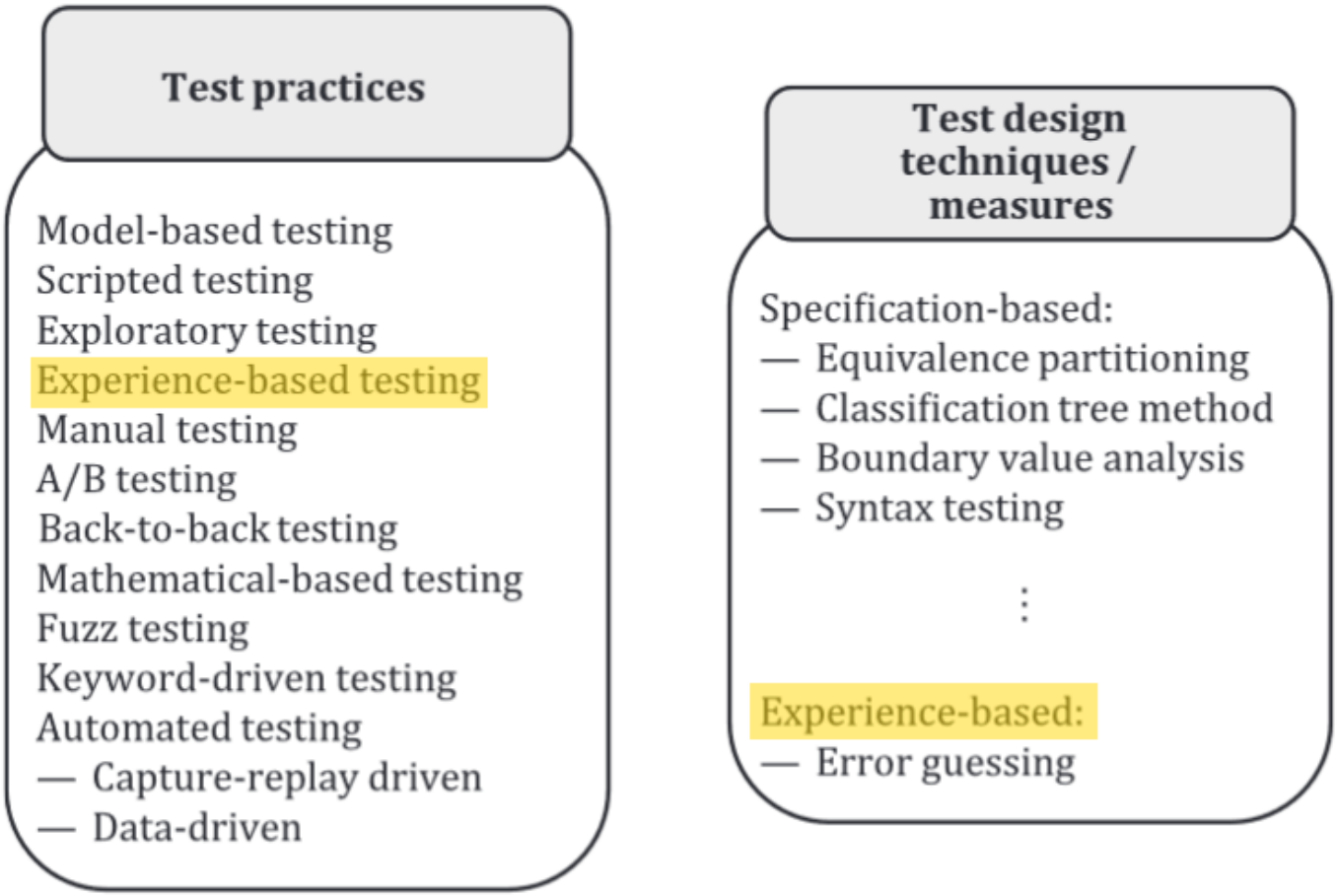
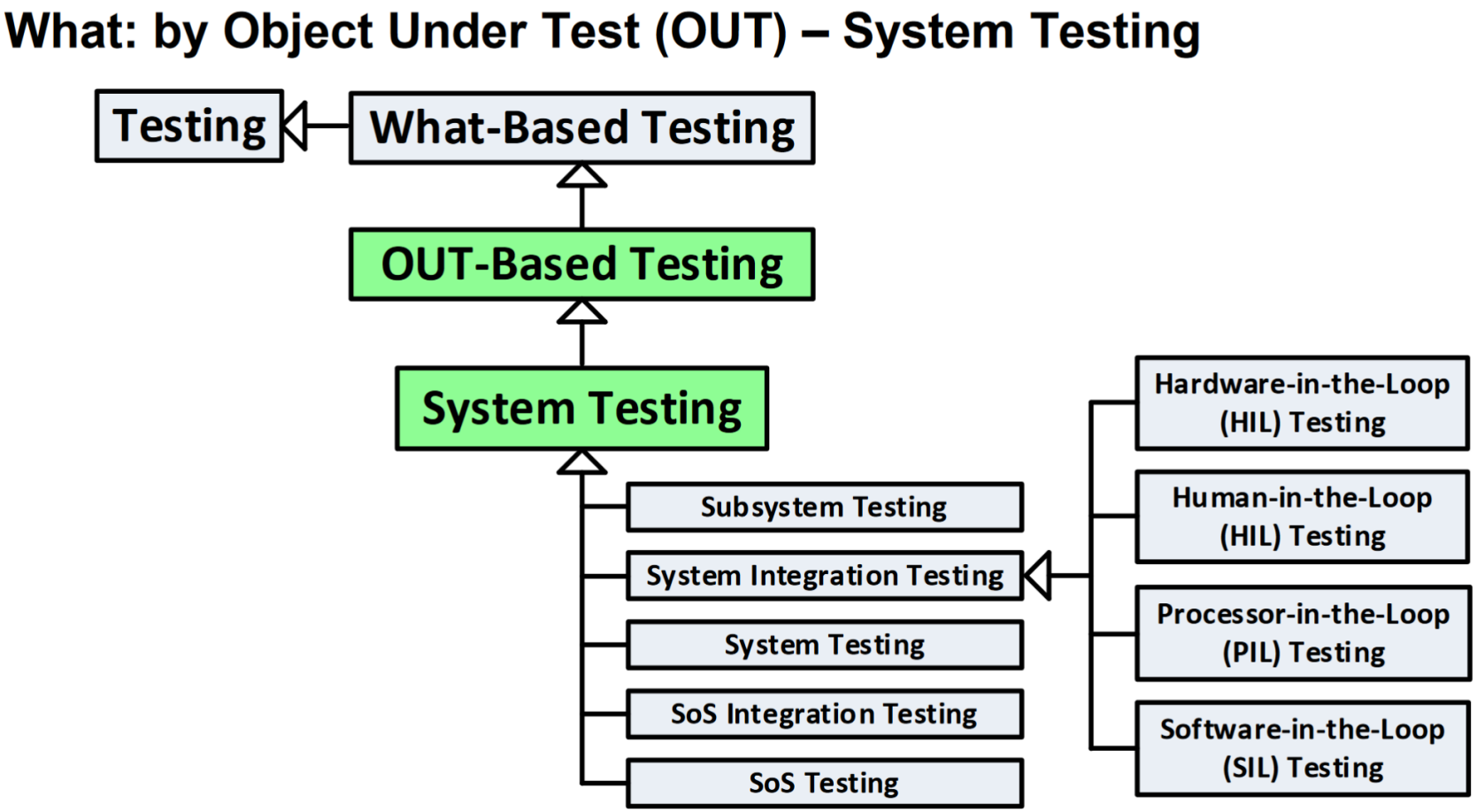


Adapted from (ISO/IEC and IEEE, 2022, Fig. 2)

The Lack of Standardized Terminology

"The Problem" (cont.)



(Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

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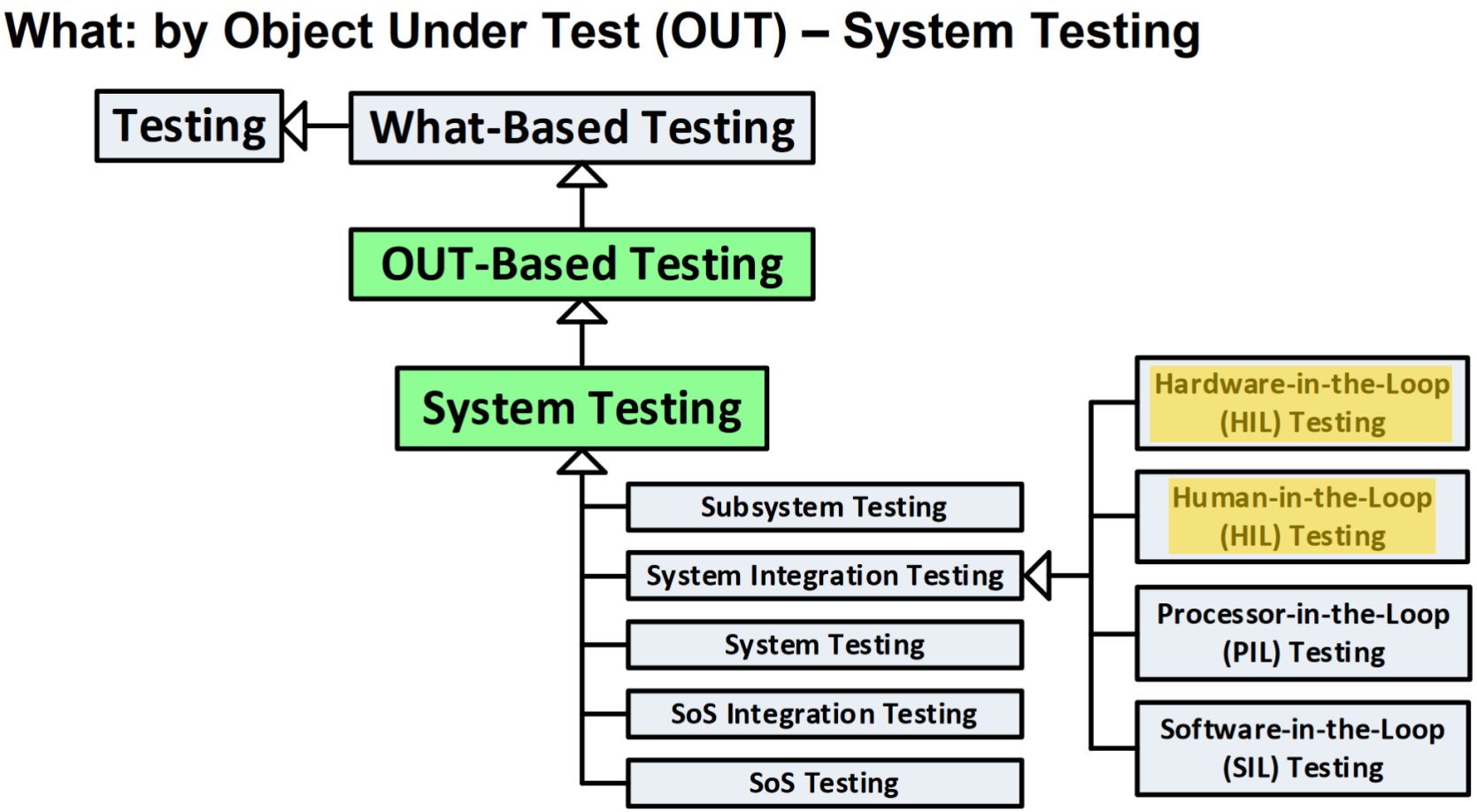

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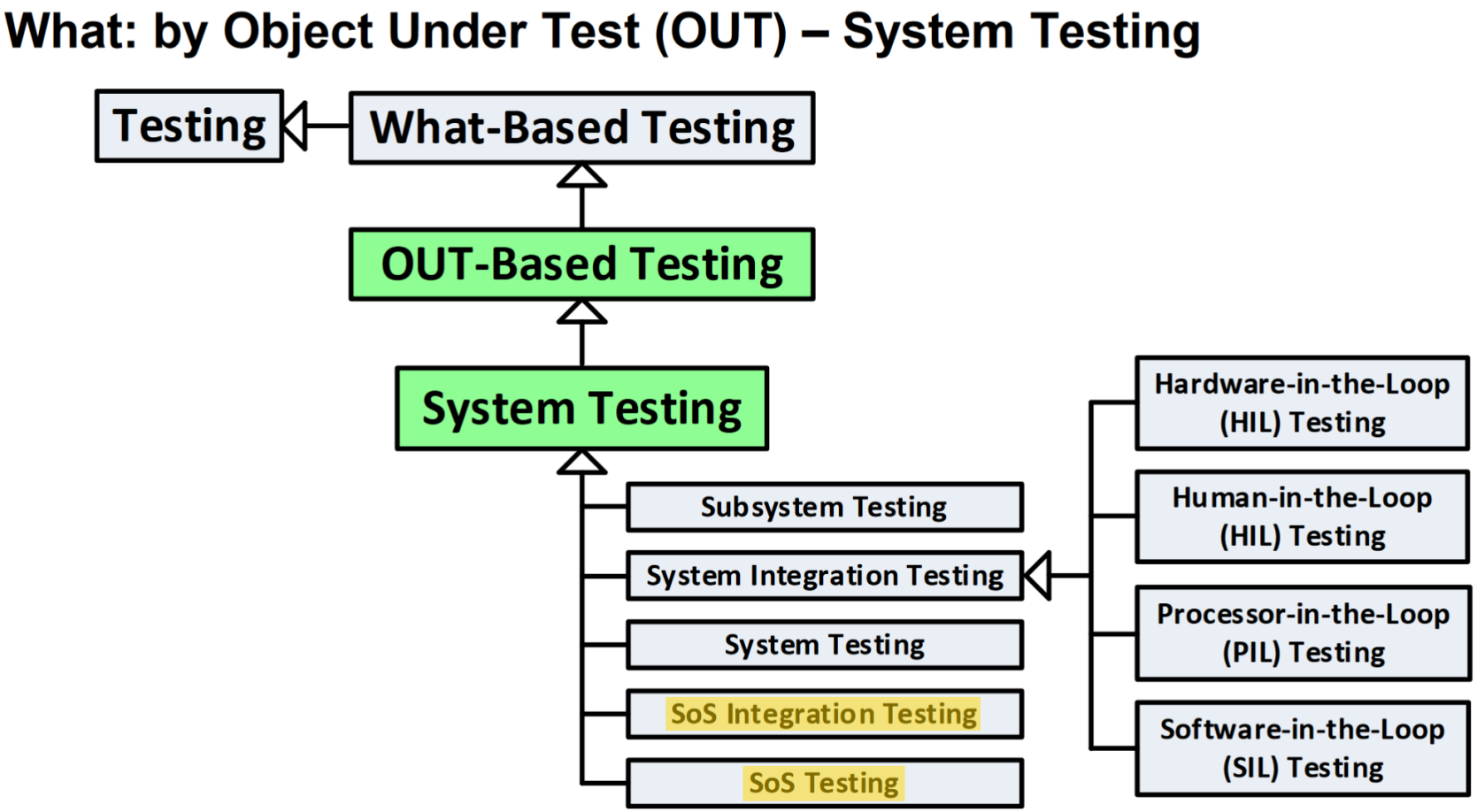

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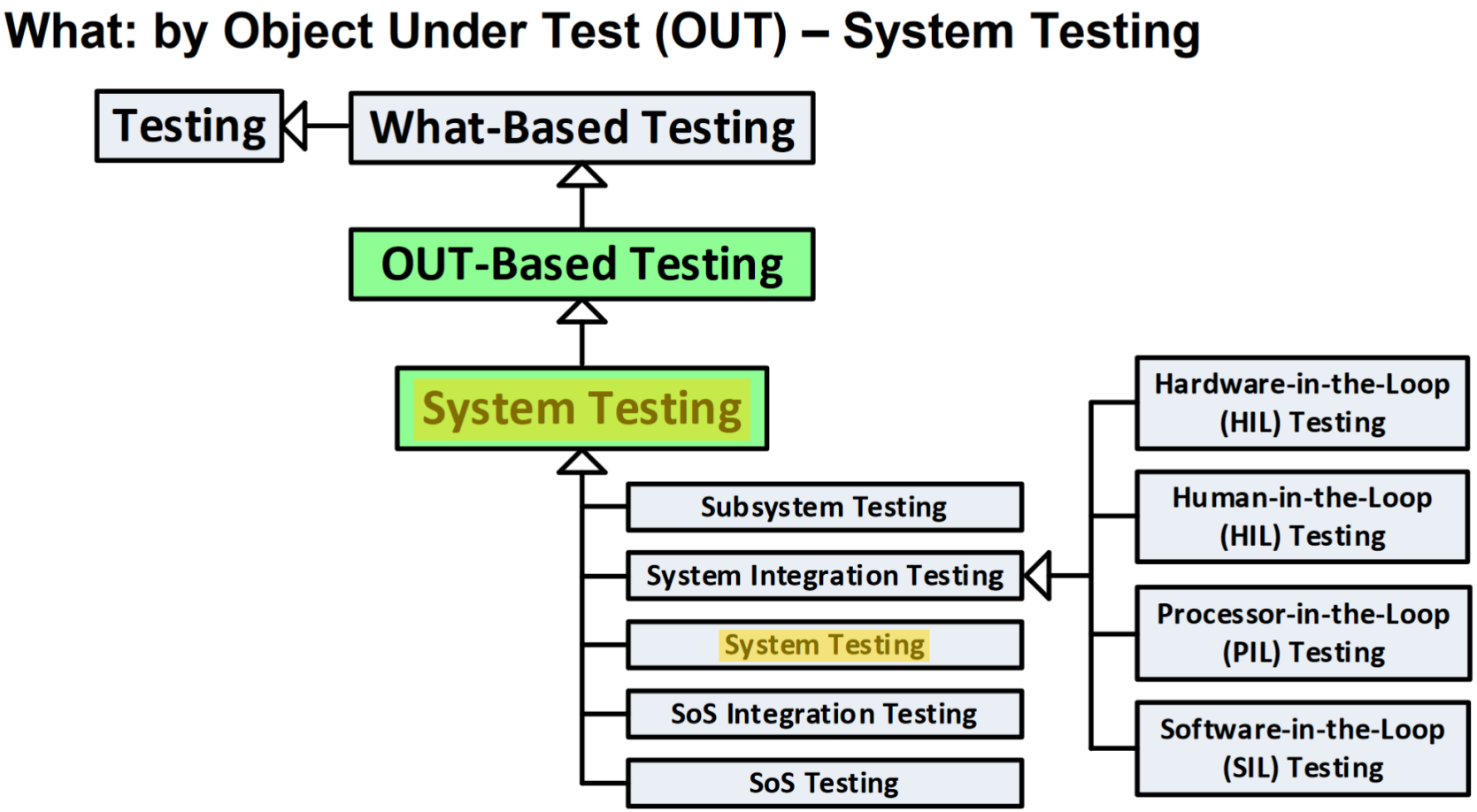

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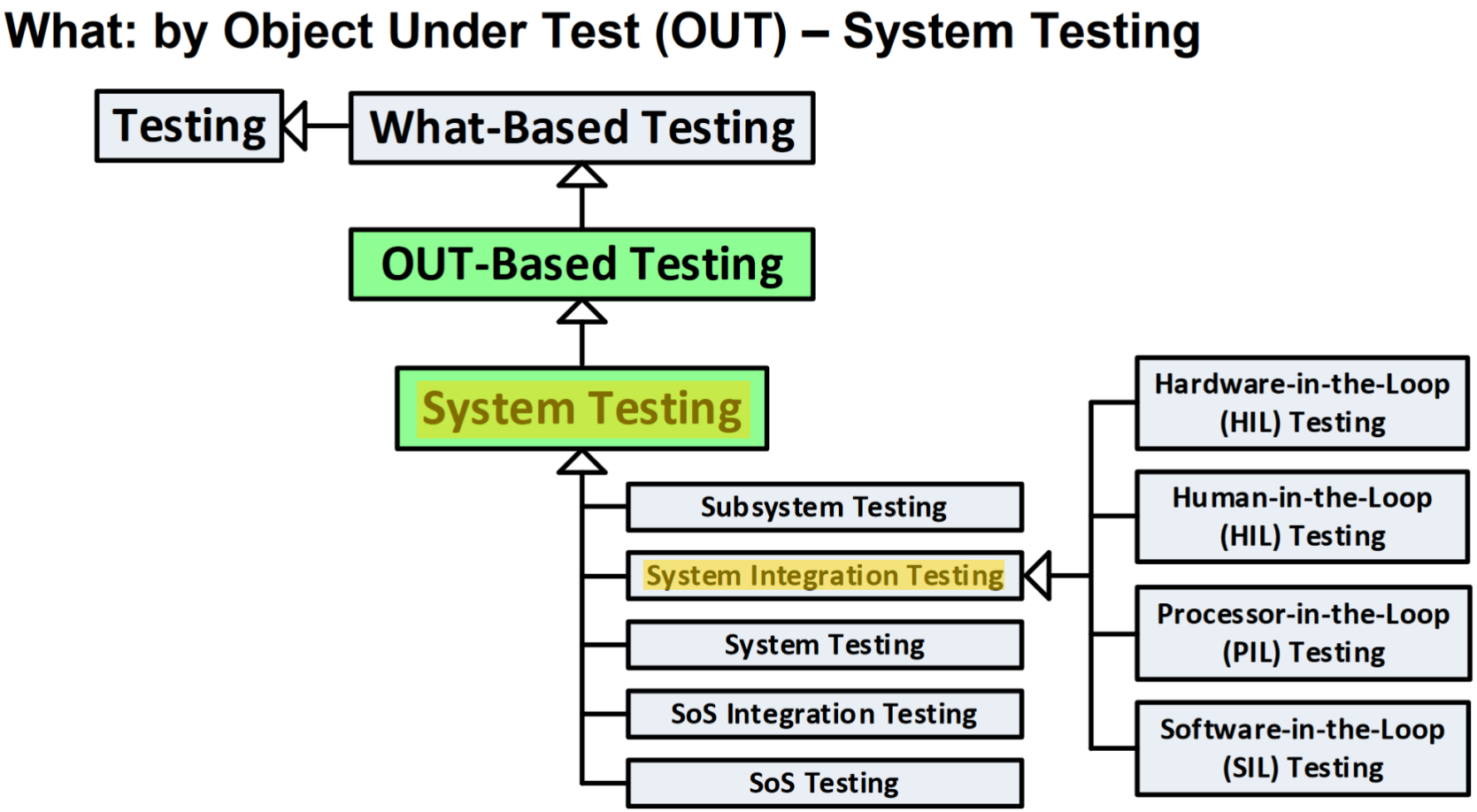

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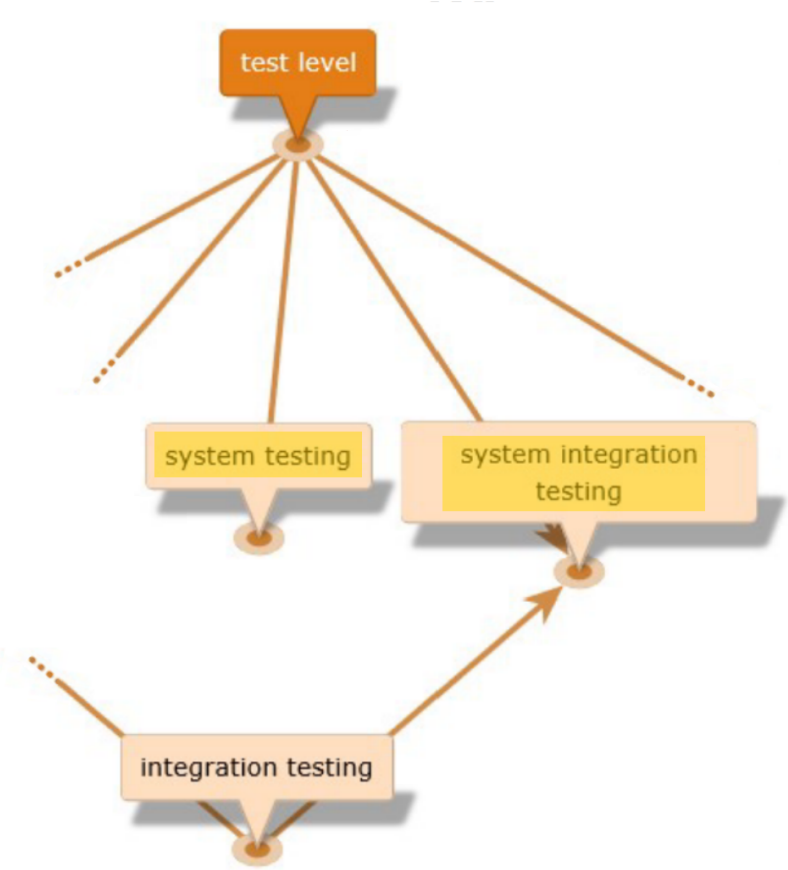
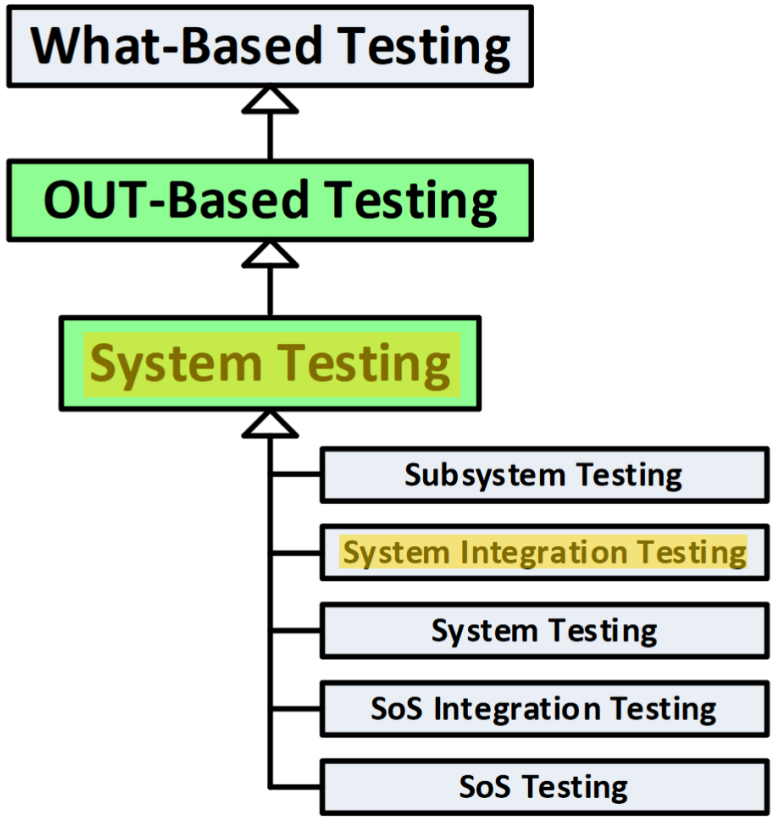


Adapted from (Hamburg and Mogyorodi, 2024)



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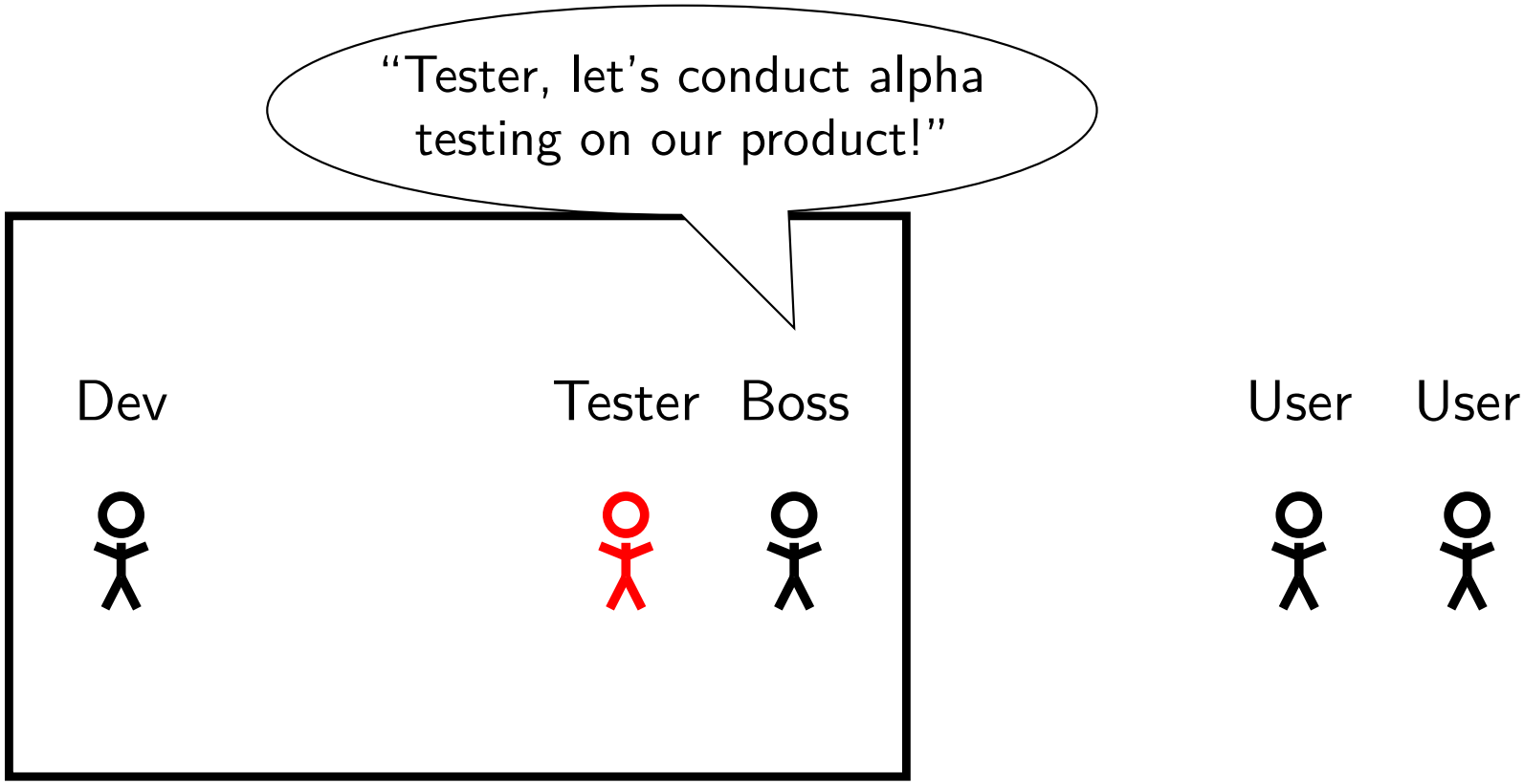

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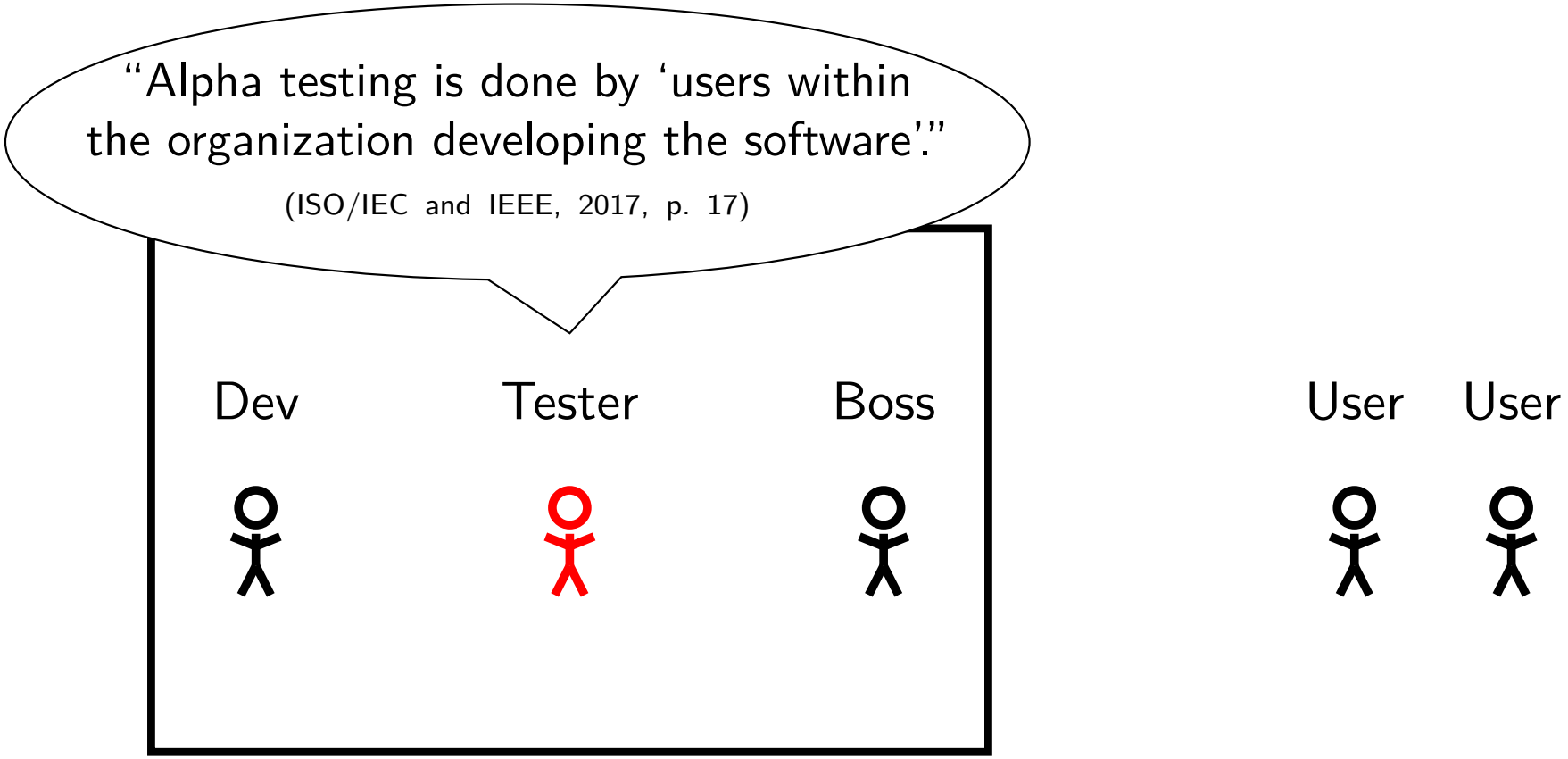

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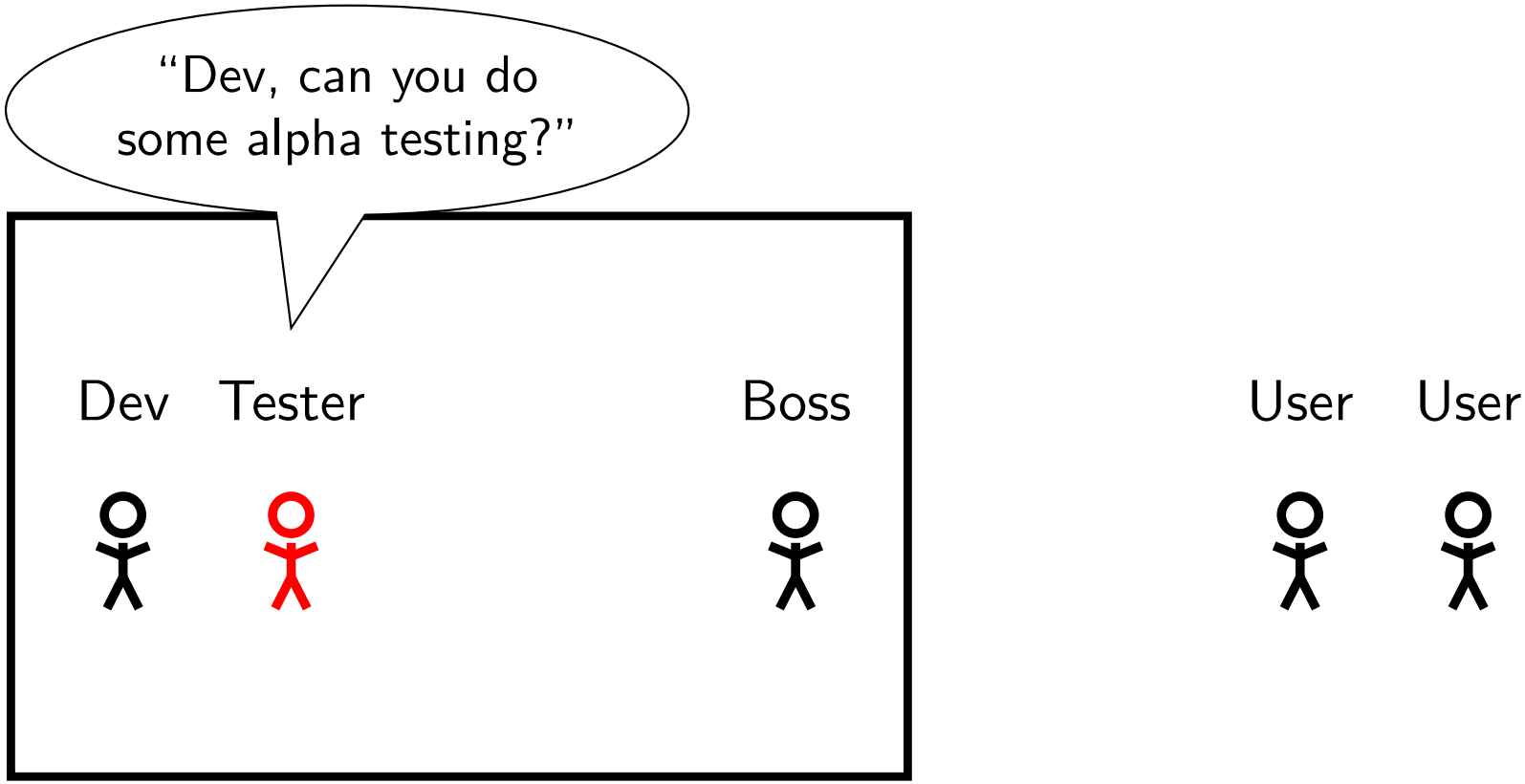

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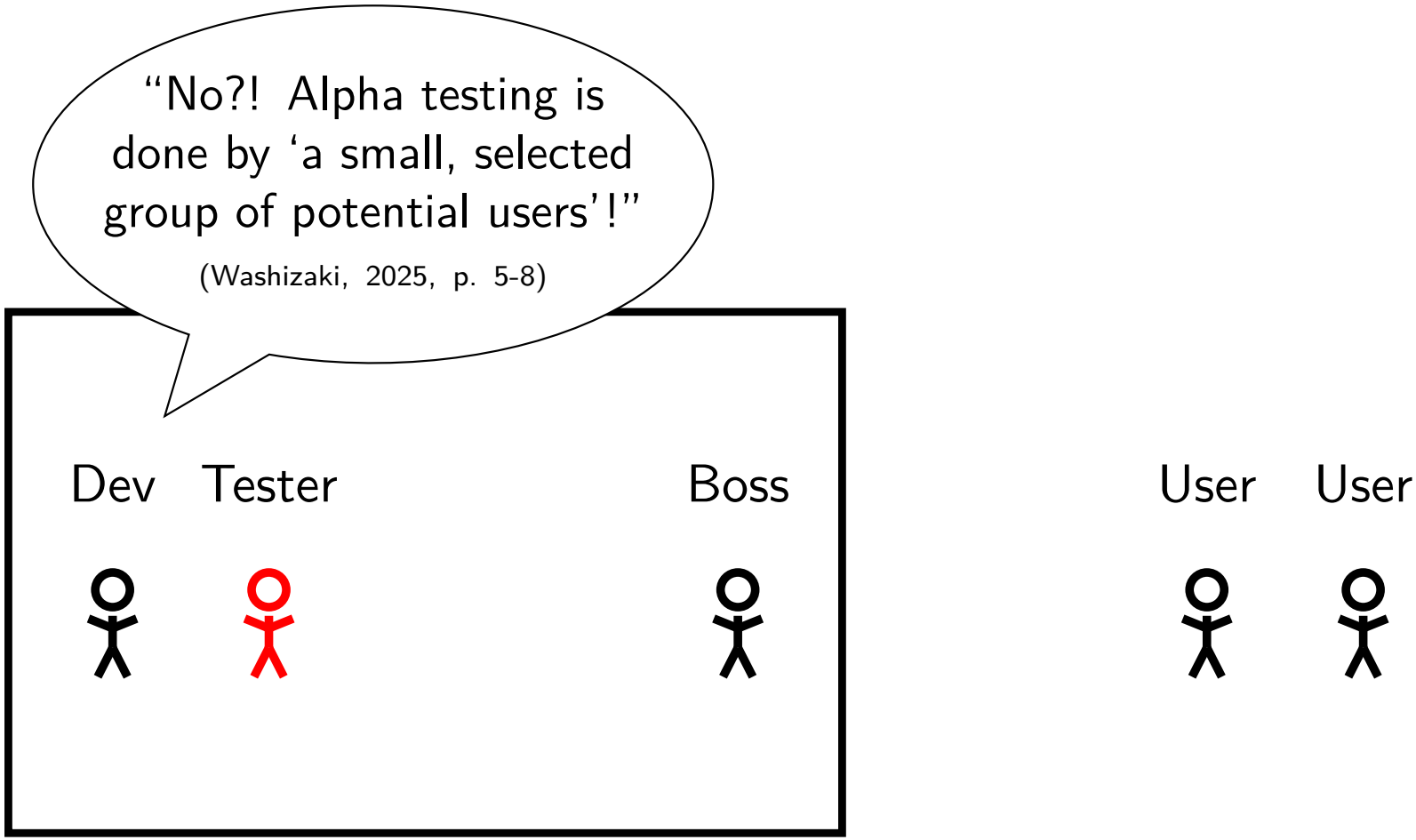

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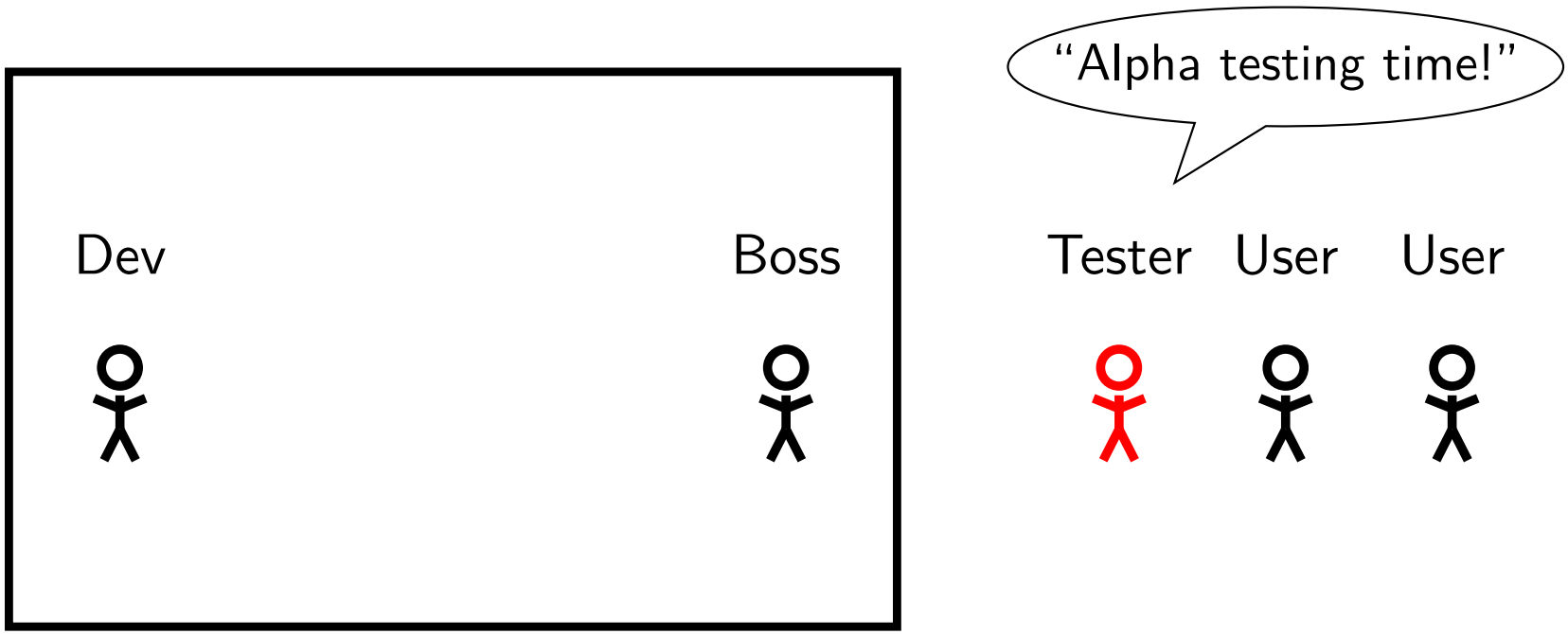

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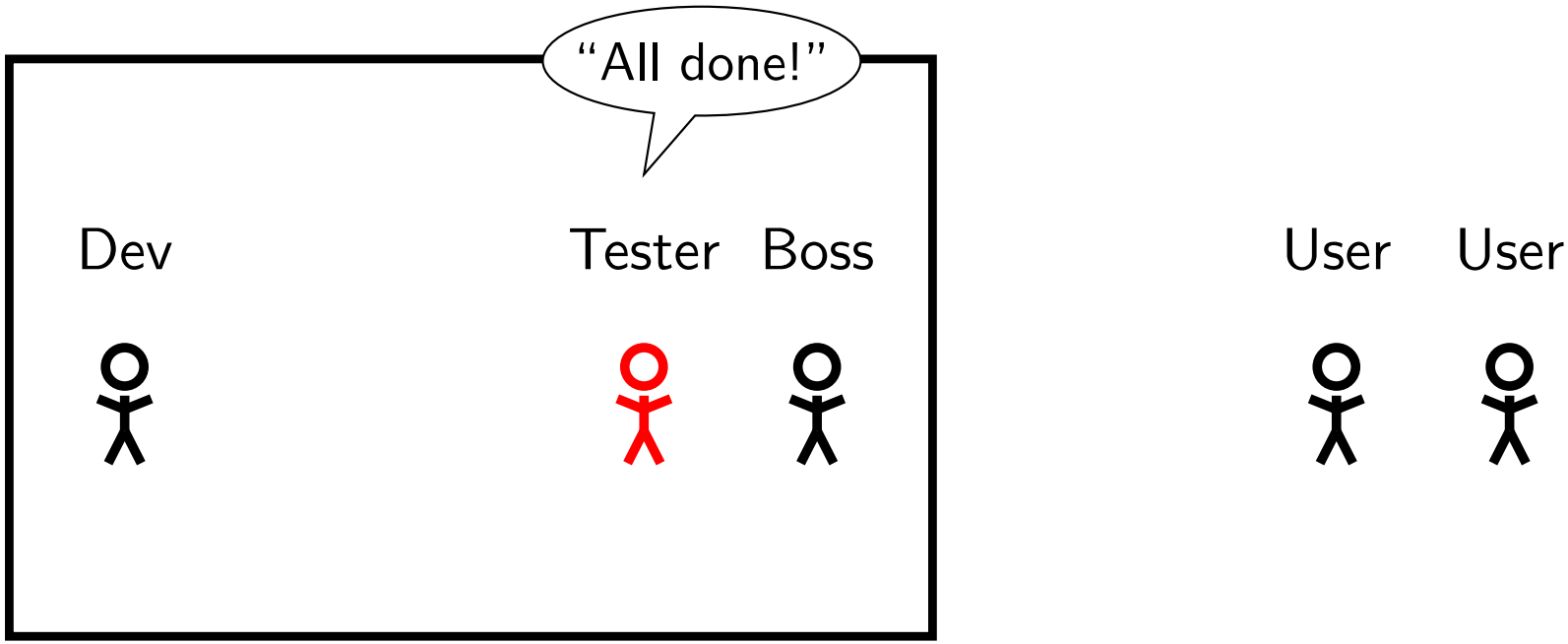

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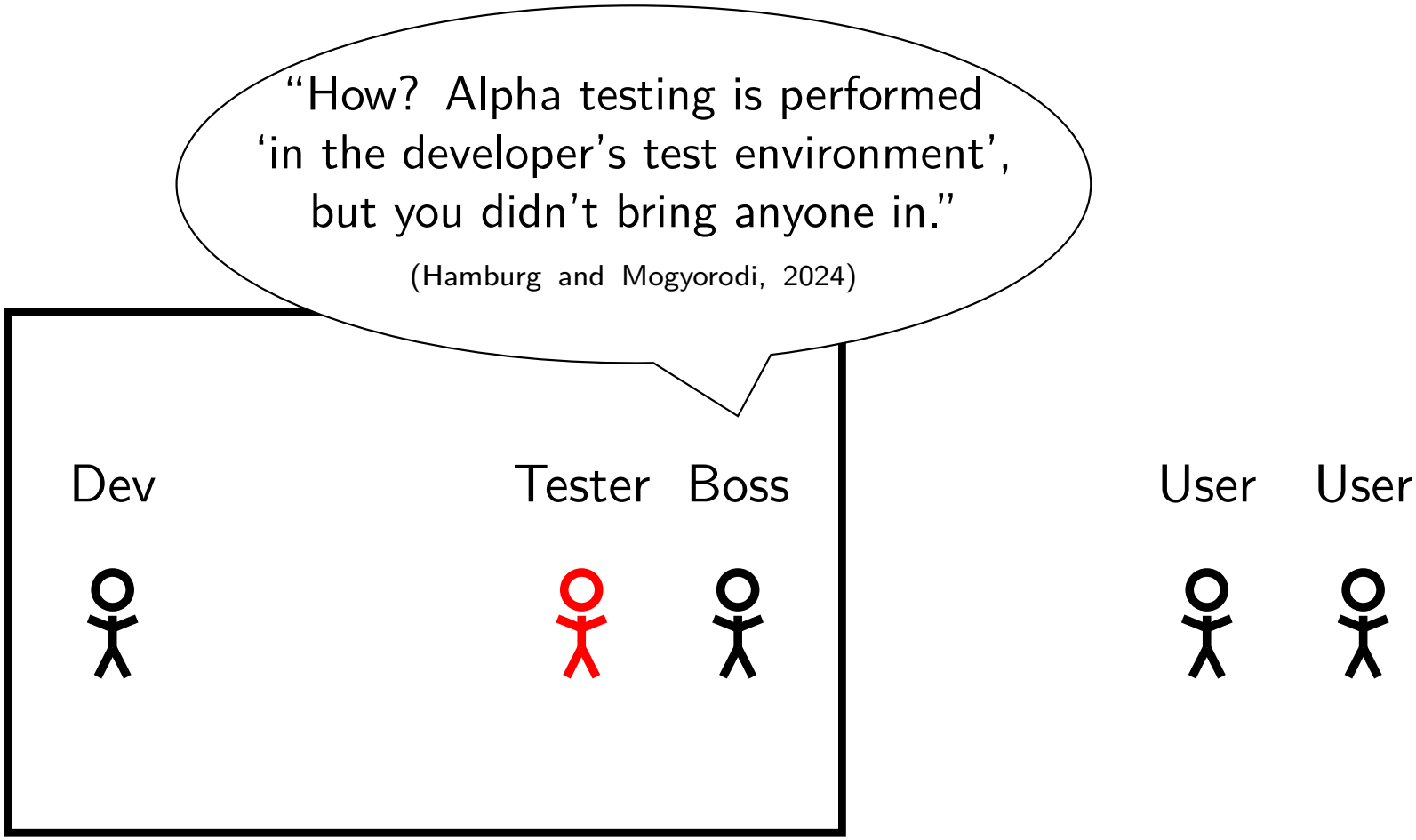
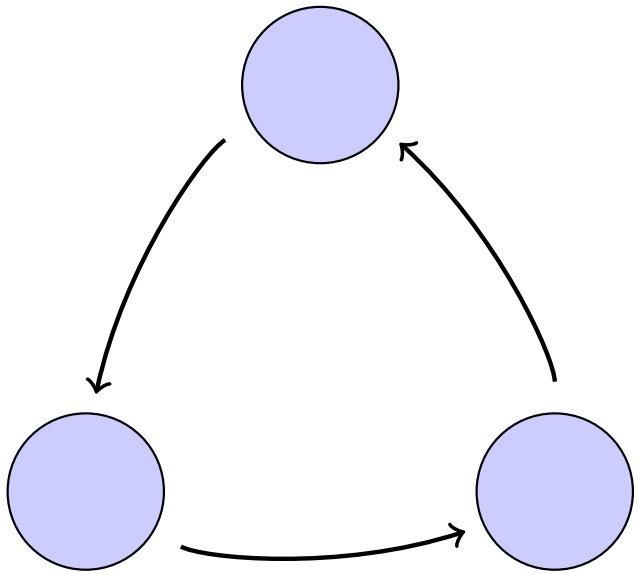


Interorganizational

Schools, companies, etc.



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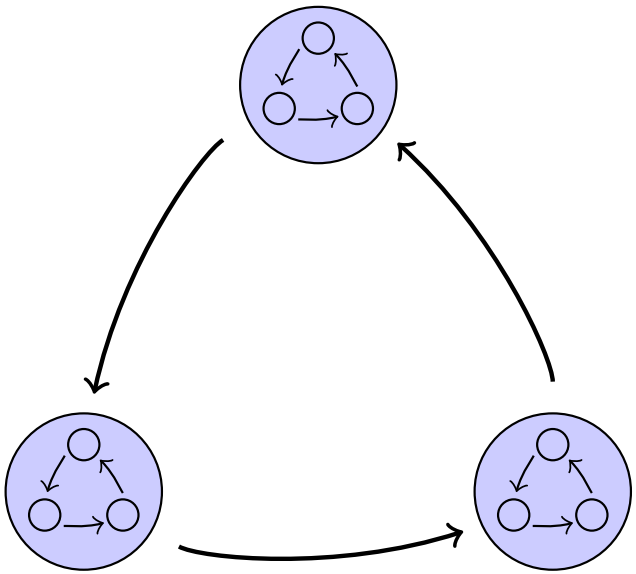

Intraorganizational

"Complete testing" could require the tester to:

- discover every bug,
- exhaust the time allocated,
- implement every planned test,
- . . . (Kaner et al., 2011, p. 7)

Taxonomies to the Rescue?

"The Problem" (cont.)

- Existing software testing taxonomies:
  - Tebes et al. (2020)
  - Souza et al. (2017)
  - Firesmith (2015)
  - Unterkalmsteiner et al. (2014)

Focus on:

The Testing Process
Organizing Terminology
Relations between Approaches
Traceability between Stages

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Research Questions

Research Question 1

What test approaches do the literature describe?

Research Question 2

How consistent are these descriptions?

Research Question 3

Can we systematically resolve any of these inconsistencies?

Research Question 1

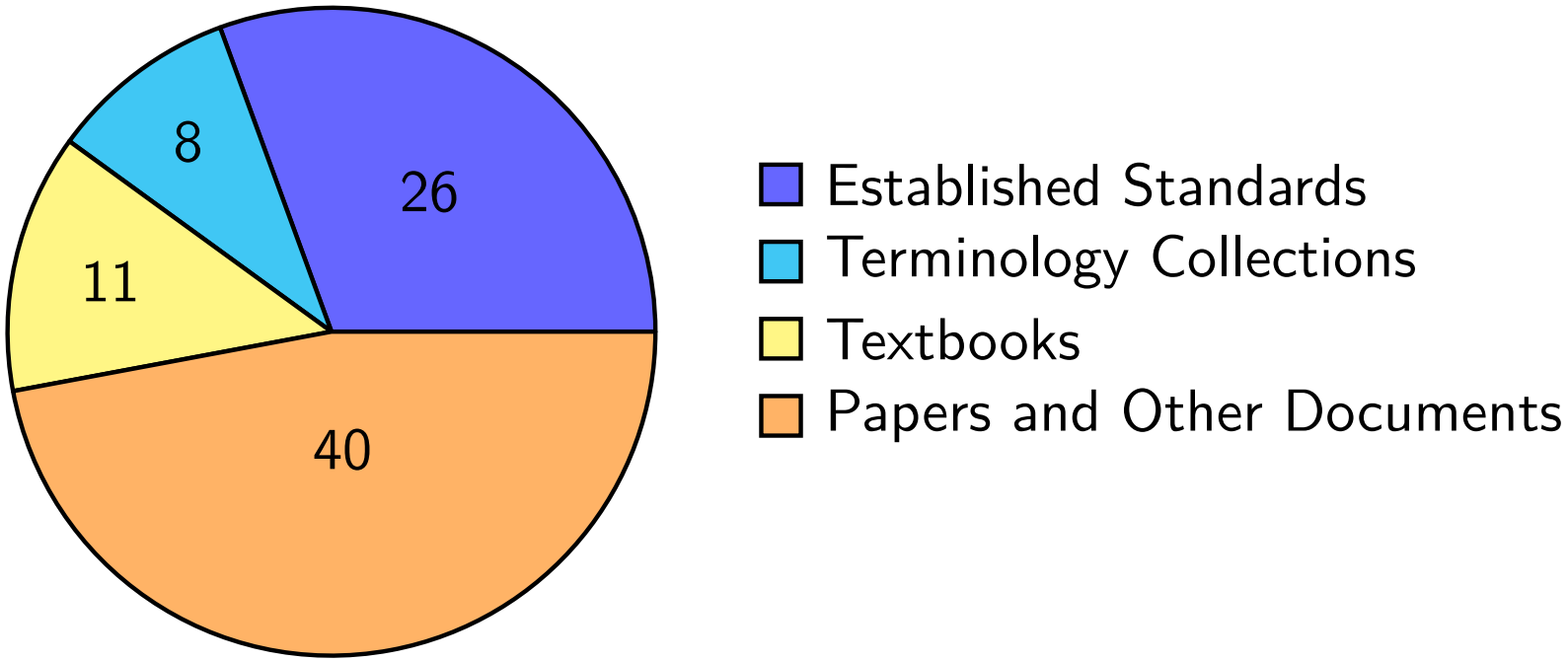
What test approaches do the literature describe?

1. Identify authoritative sources on software testing
2. Identify all test approaches and testing-related terms
3. Record data for these terms; test approach data are comprised of:
   1. Names
   2. Categories
   3. Definitions
   4. Synonyms
   5. Parents
   6. Flaws
4. Repeat steps 1 to 3 for any missing or unclear terms

Methodology

Sources

In total, we investigate 85 sources

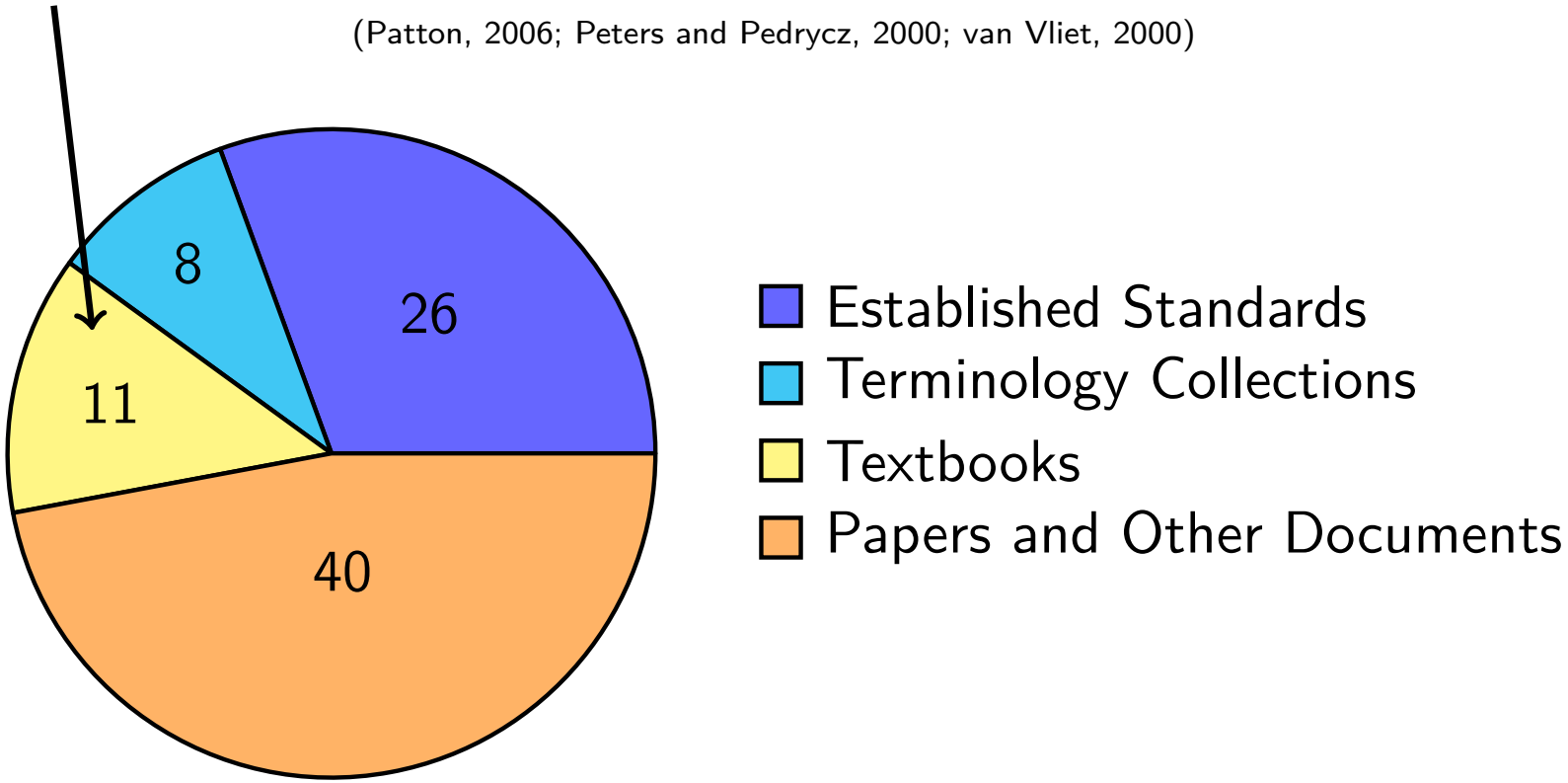


Methodology

Sources

Textbooks used at McMaster were our ad hoc starting points

(Patton, 2006; Peters and Pedrycz, 2000; van Vliet, 2000)



- We build a glossary with a row for each test approach

Name	Category	Definition	Parent(s)	Synonym(s)
A/B Testing	Practice (Fig. 2)	Testing "that allows testers to determine which of two systems or components performs better" (pp. 1, 36)	Statistical Testing (pp. 1, 36), ...	Split-Run Testing (pp. 1, 36)

Information from (ISO/IEC and IEEE, 2022)

- We gather this information from sources by looking for:
  - Glossaries, taxonomies, hierarchies, etc.
  - Testing-related terms
  - Terms described *by* other approaches
  - Terms that *imply* other approaches

Research Question 2

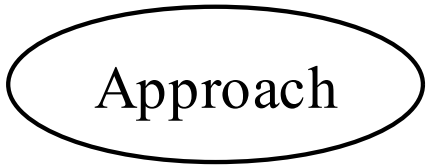
How consistent are these descriptions?

5. Automatically analyze recorded test approach data
    1. Visualize approach relations
    2. Detect certain classes of flaws
    3. Analyze manually recorded flaws from step 3.6
6. Report results of flaw analysis

Research Question 3

Can we systematically resolve any of these inconsistencies?

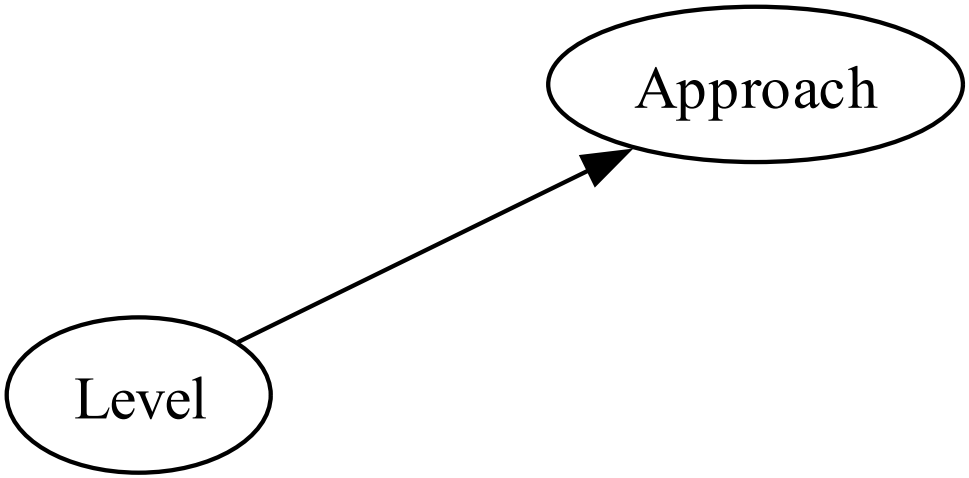
7. Provide examples of how to resolve these flaws



Approach: a "high-level test implementation choice" (ISO/IEC and IEEE, 2022, p. 10) used to "pick the particular test case values" (2017, p. 465)

Methodology

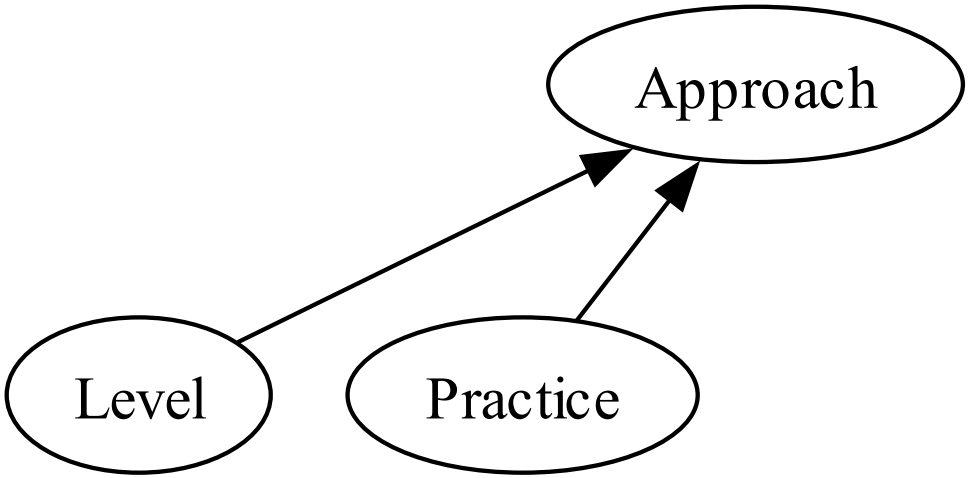
Categories



Level: a stage of testing with "particular objectives and . . . risks", each performed in sequence (ISO/IEC and IEEE, 2022, p. 12; 2021a, p. 6; 2021c, p. 6)

Methodology

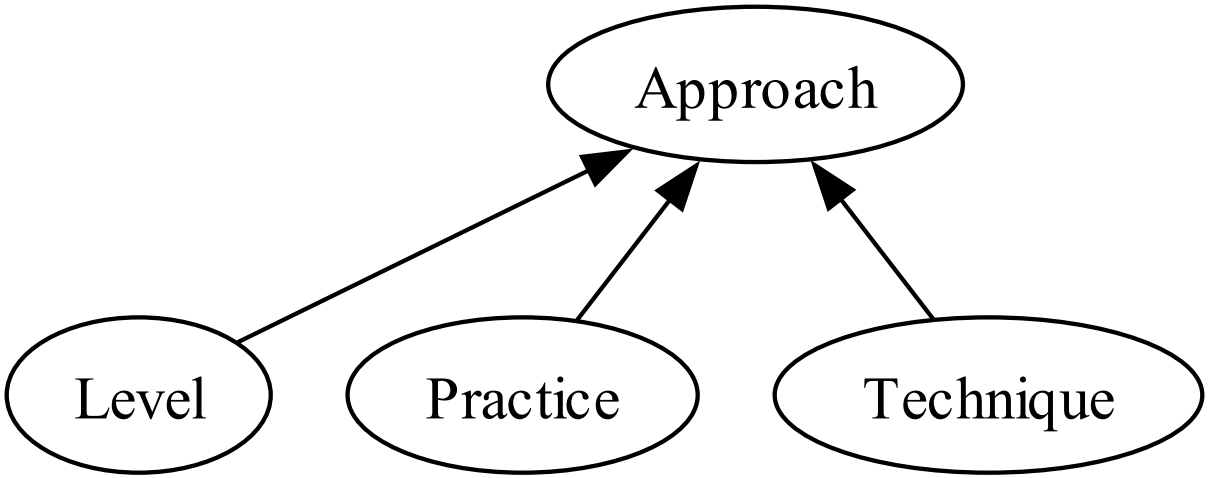
Categories



Practice: a "conceptual framework that can be applied to . . . [a] test process to facilitate testing" (ISO/IEC and IEEE, 2022, p. 14; 2017, p. 471)

Methodology

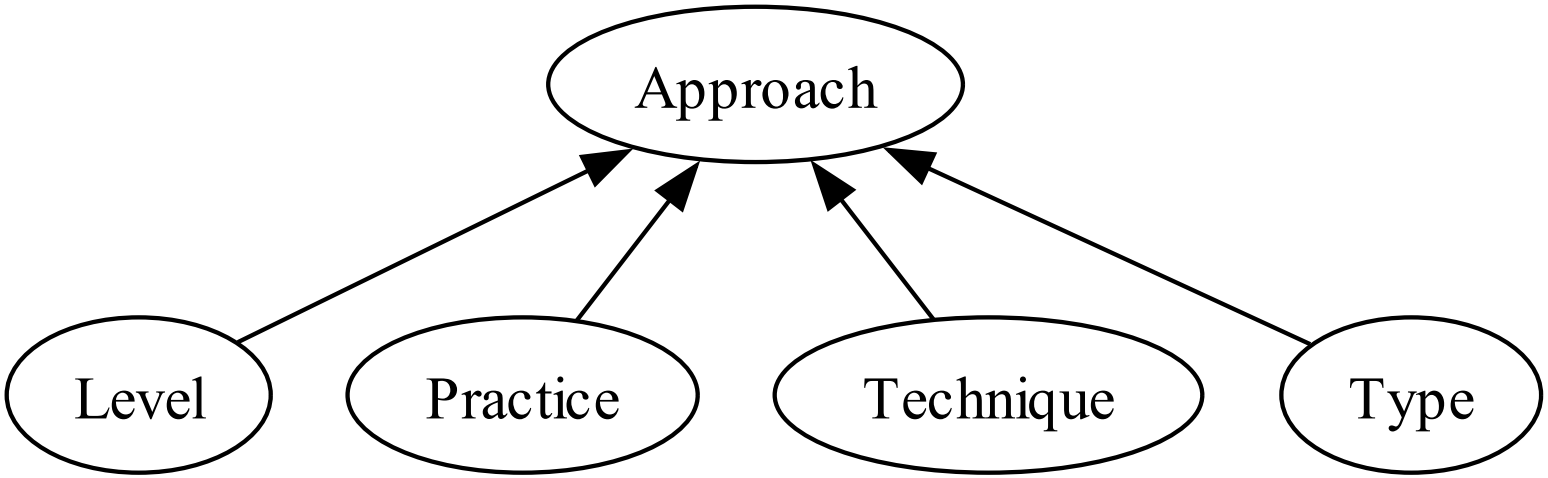
Categories



Technique: a "procedure used to create or select a test model, identify test coverage items, and derive corresponding test cases" (2022, p. 11; 2021a, p. 5; similar in 2017, p. 467)

Methodology

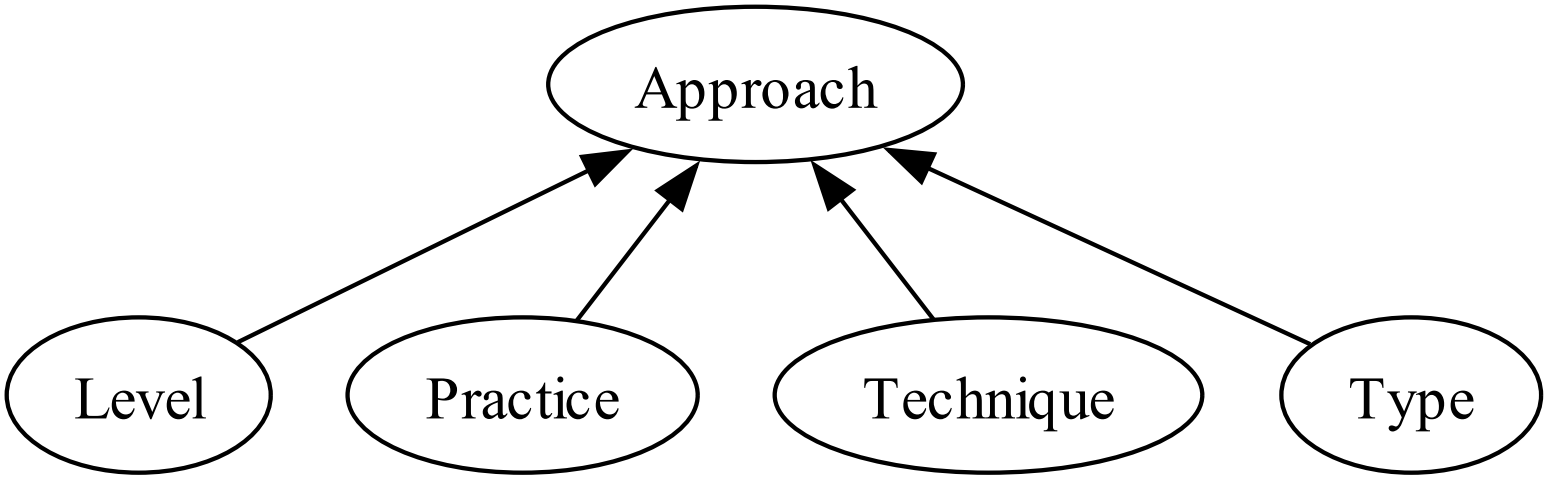
Categories



Type: "testing that is focused on specific quality characteristics" (ISO/IEC and IEEE, 2022, p. 15; 2021c, p. 7; 2017, p. 473)

Methodology

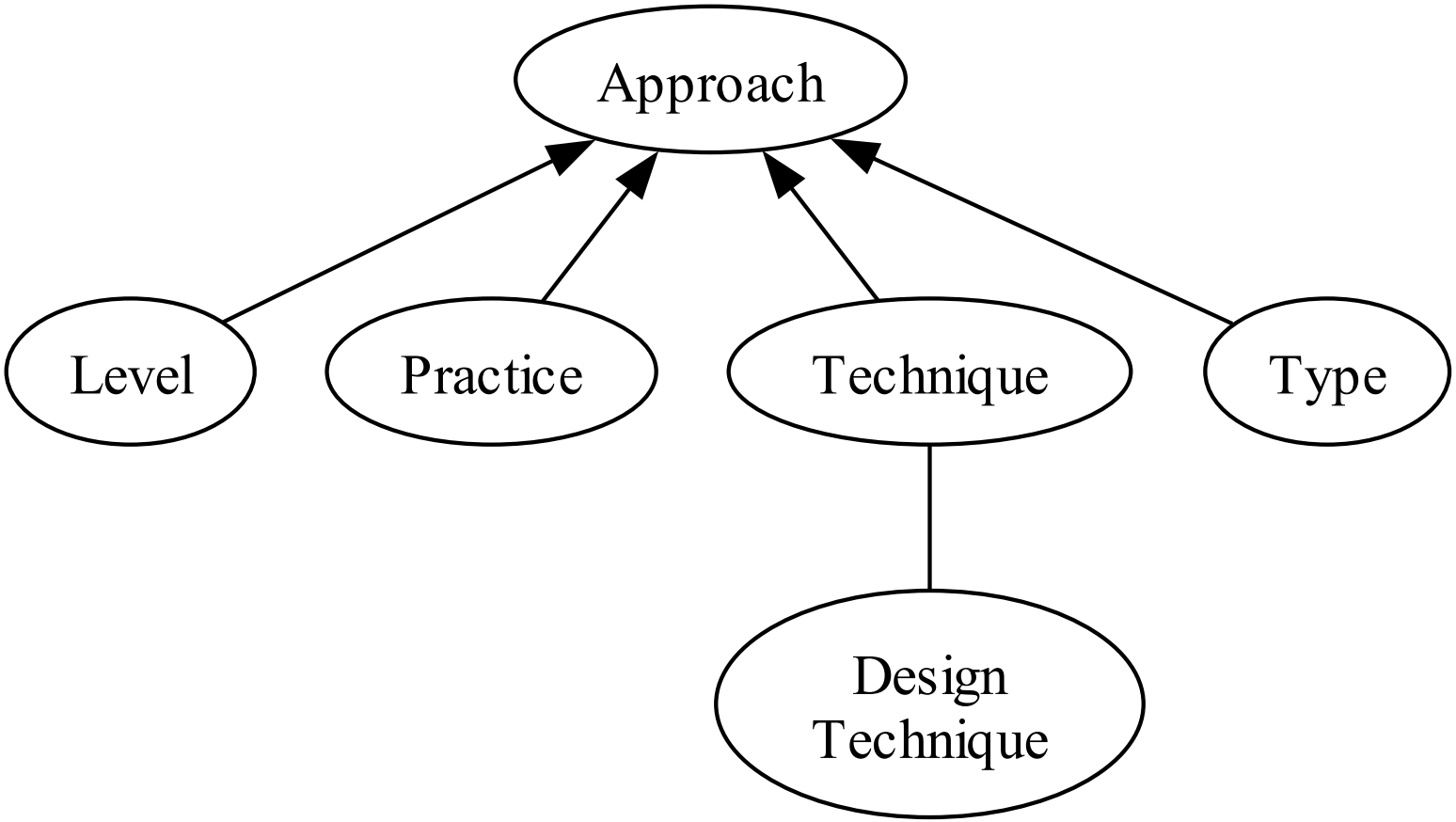
Visualization Notation



Arrows point from a *child* node to a *parent* node.

Methodology

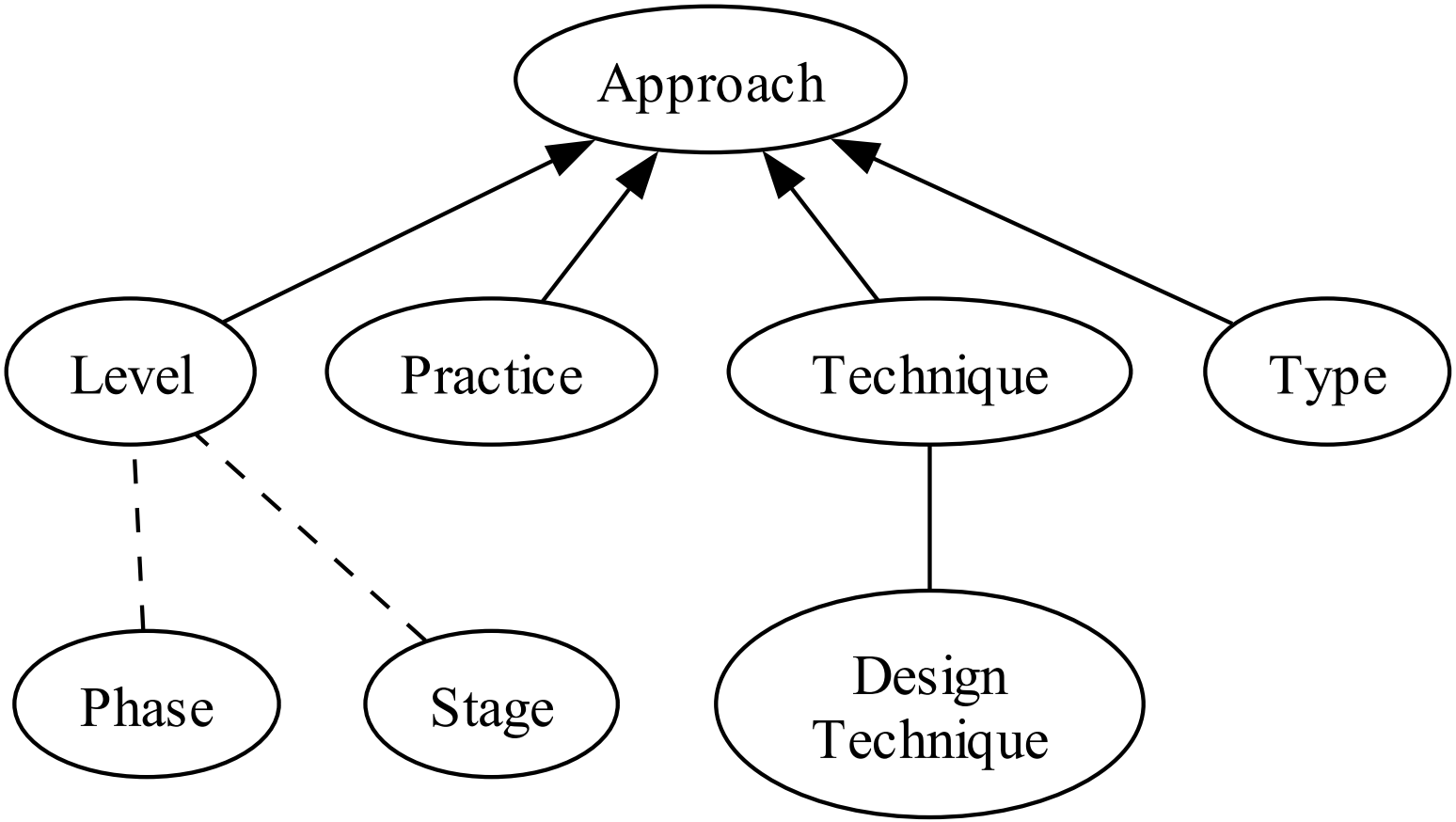
Visualization Notation



Lines without arrowheads connect *synonyms*.

Methodology

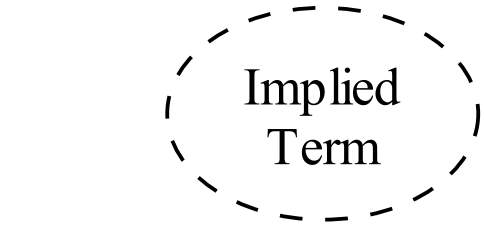
Visualization Notation



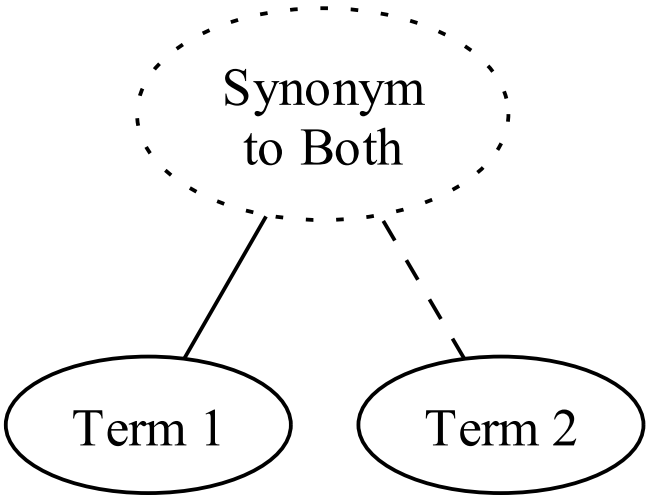
Dashed lines indicate a relationship is *implicit*.

Methodology

Visualization Notation



Dashed outlines indicate a term is *implicit*.



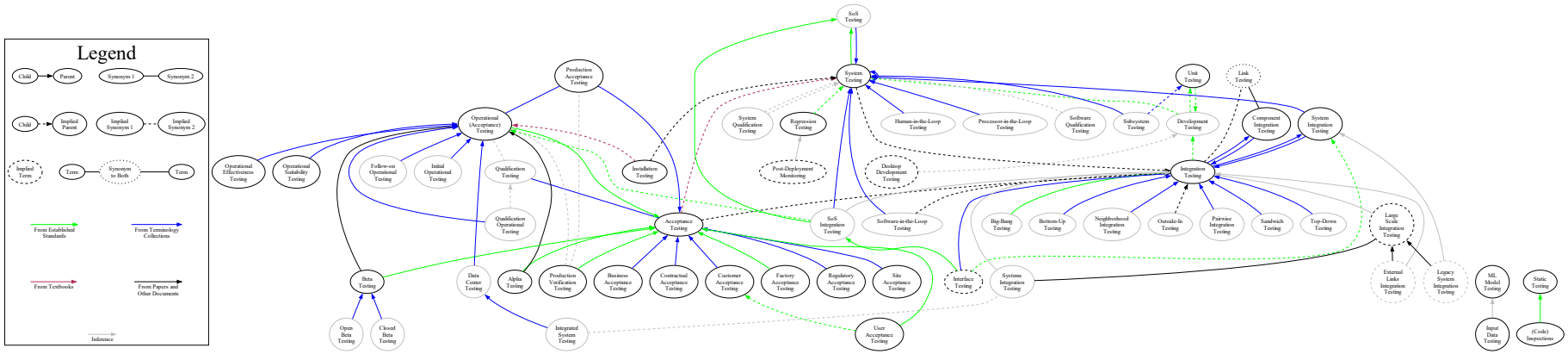
Dotted outlines indicate a term is a *synonym* to more than one term.

Visualization of Test Approaches

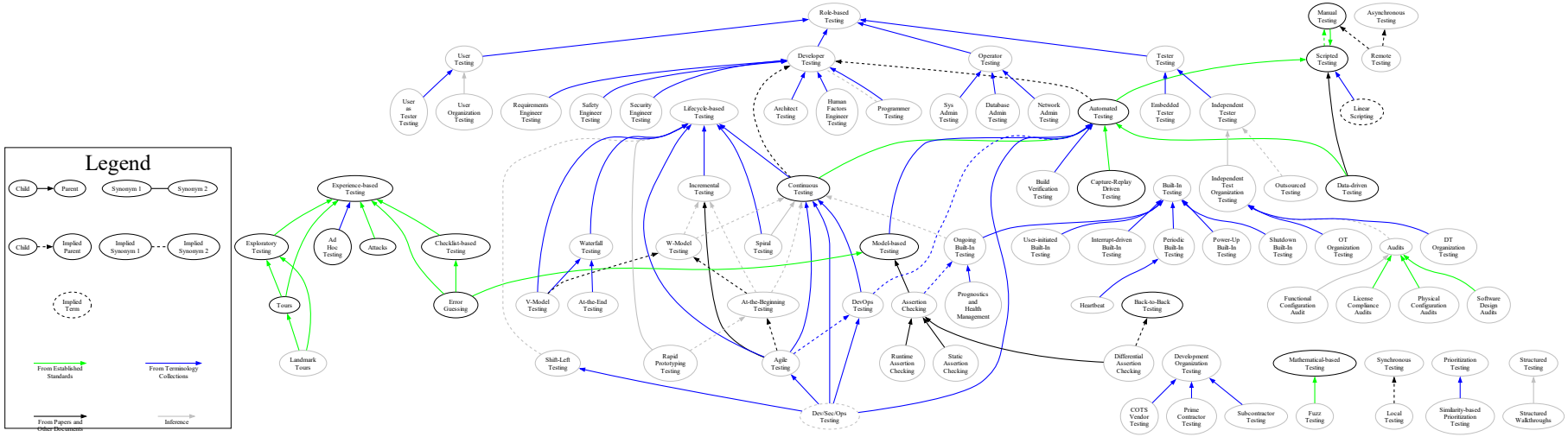
Visualization of Test Approaches

```
! Dimension too large.
```

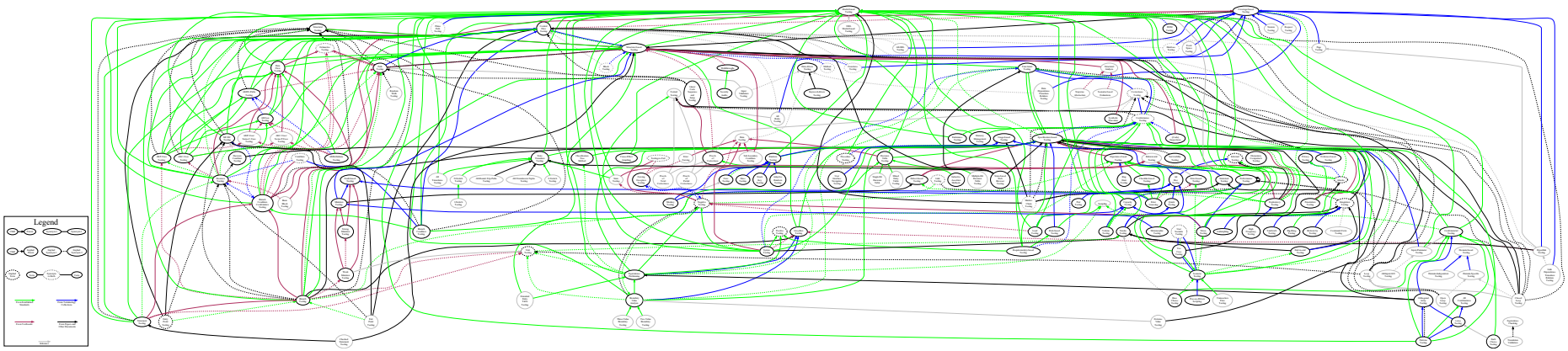
Visualization of Test Levels



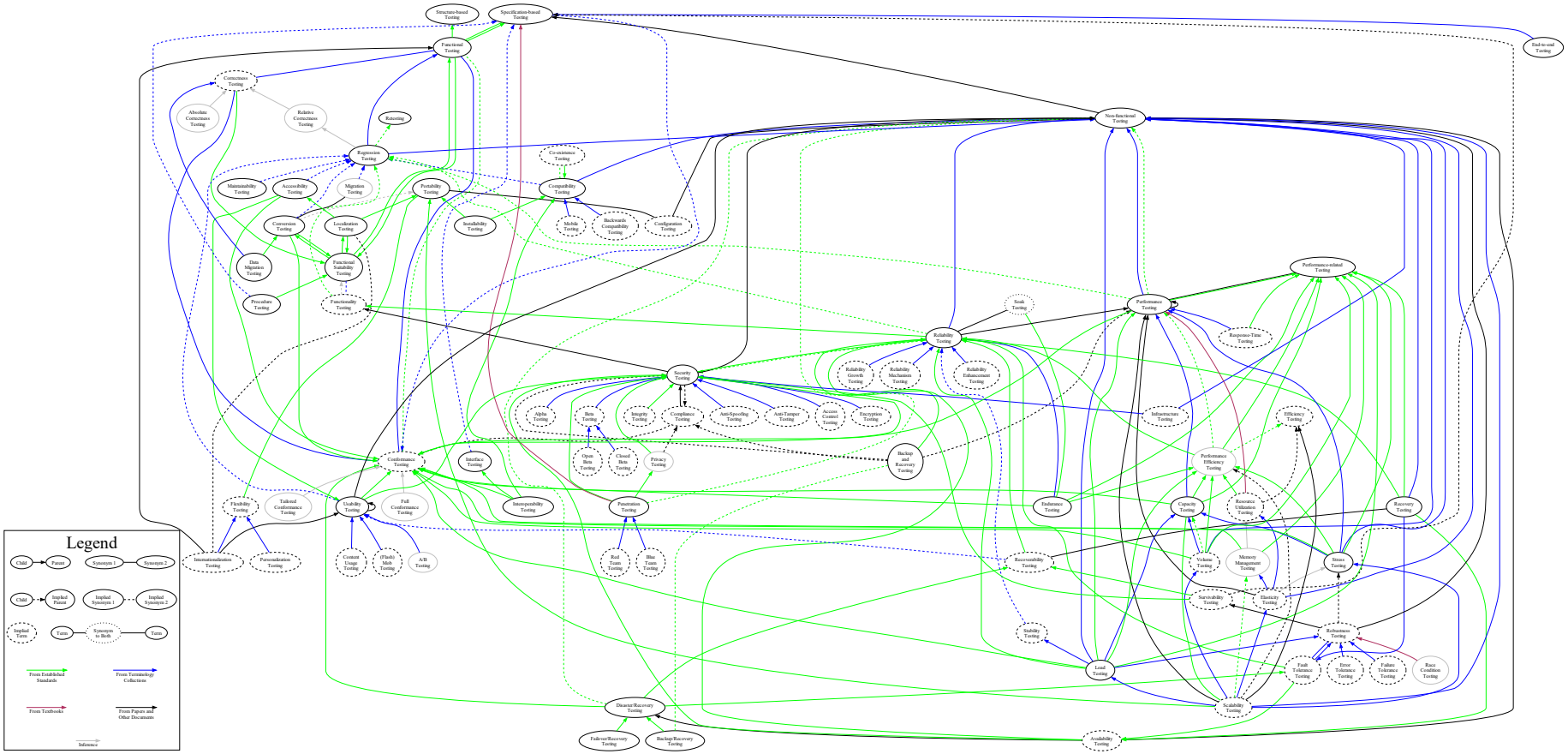
Visualization of Test Practices



Visualization of Test Techniques



Visualization of Test Types



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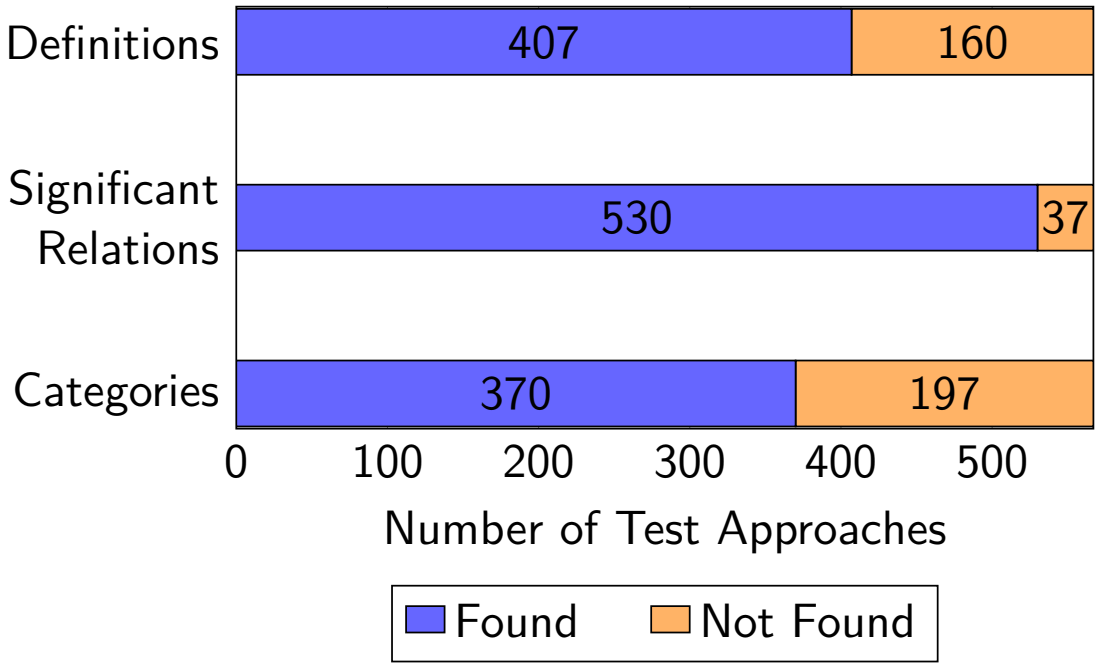
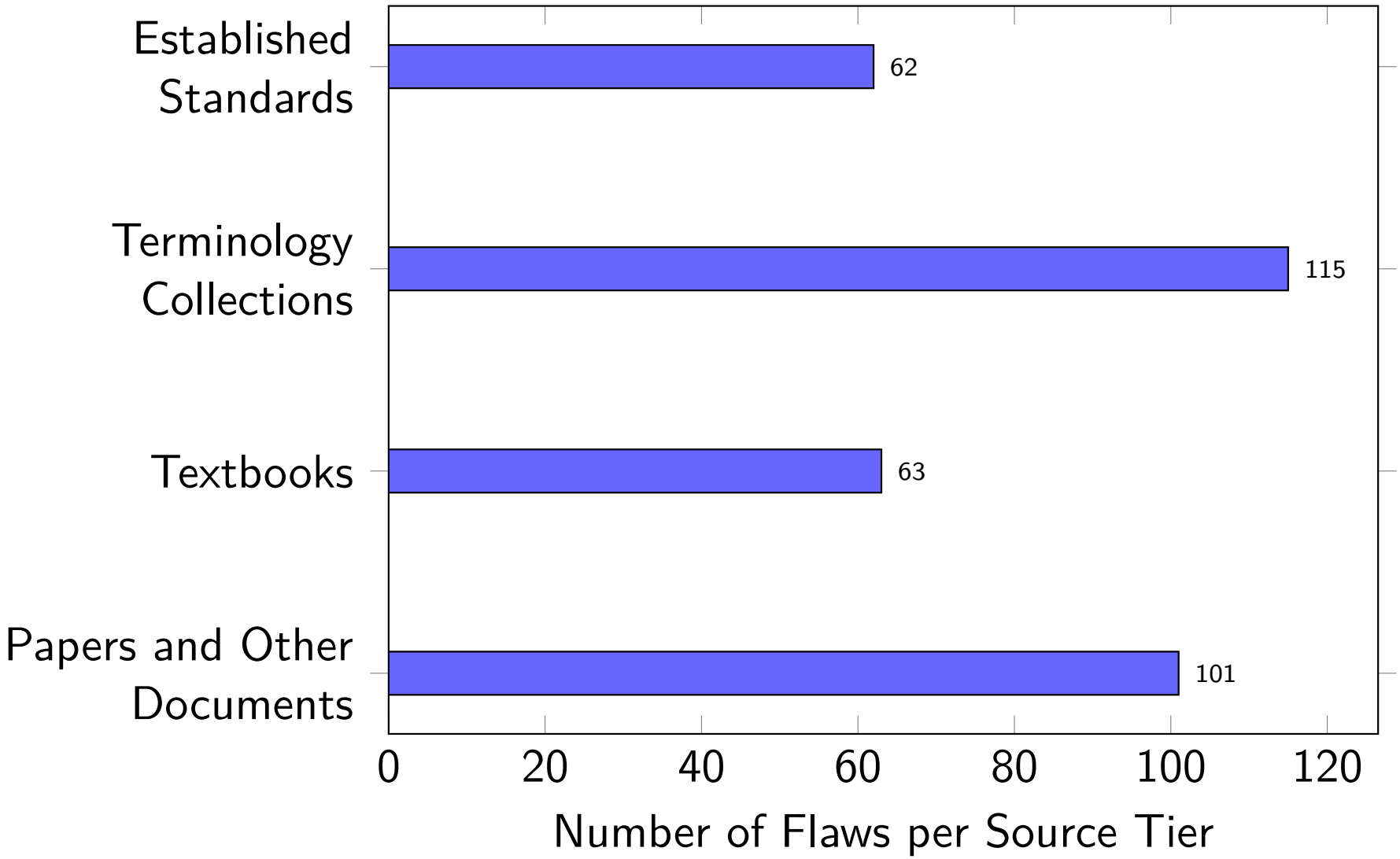
Overview

- 567 test approaches $\rightarrow$
- 75 software qualities
  (may imply test approaches)
- 341 flaws in the software testing literature



Flaw Summary by Source Tier



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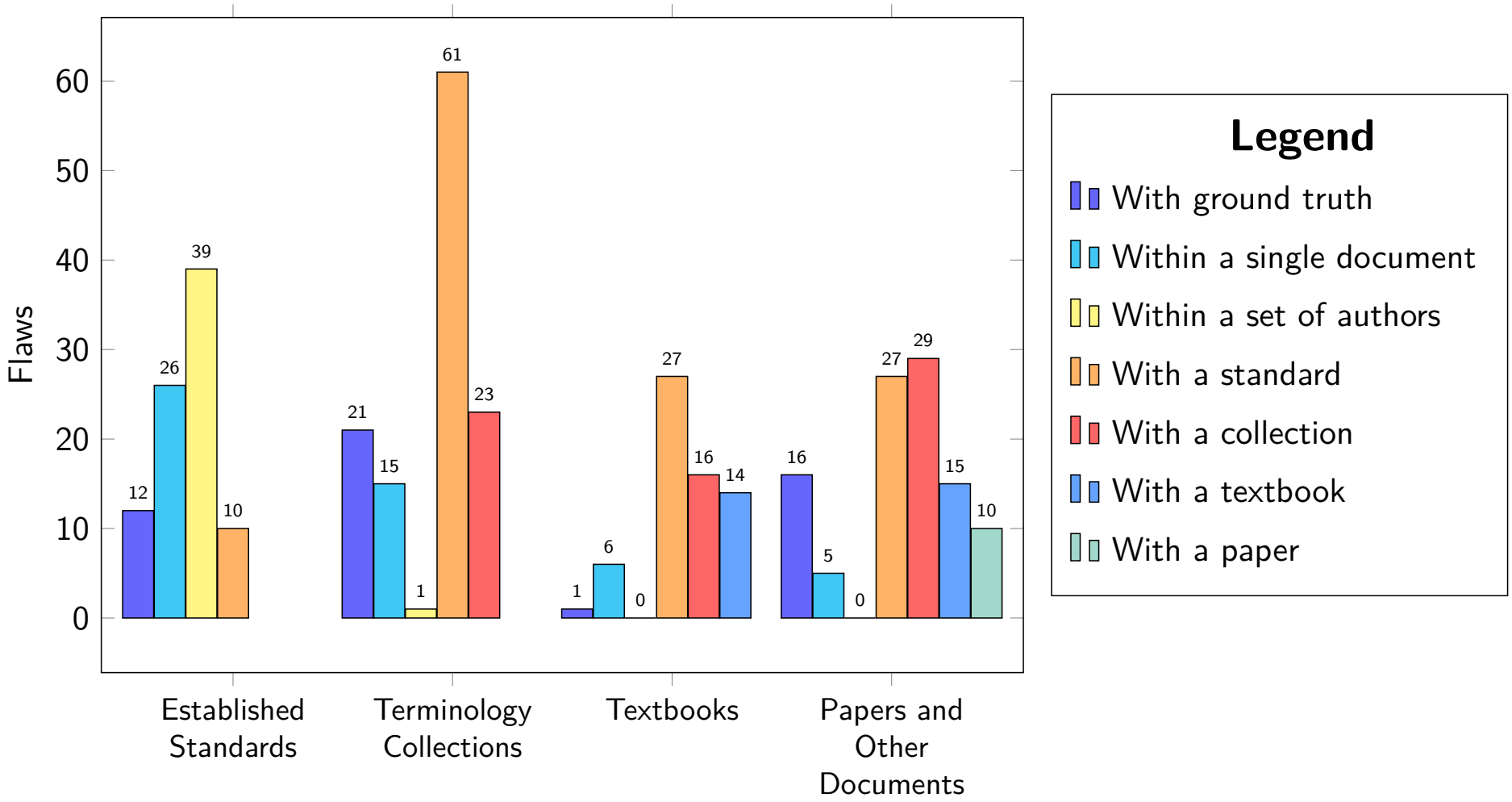
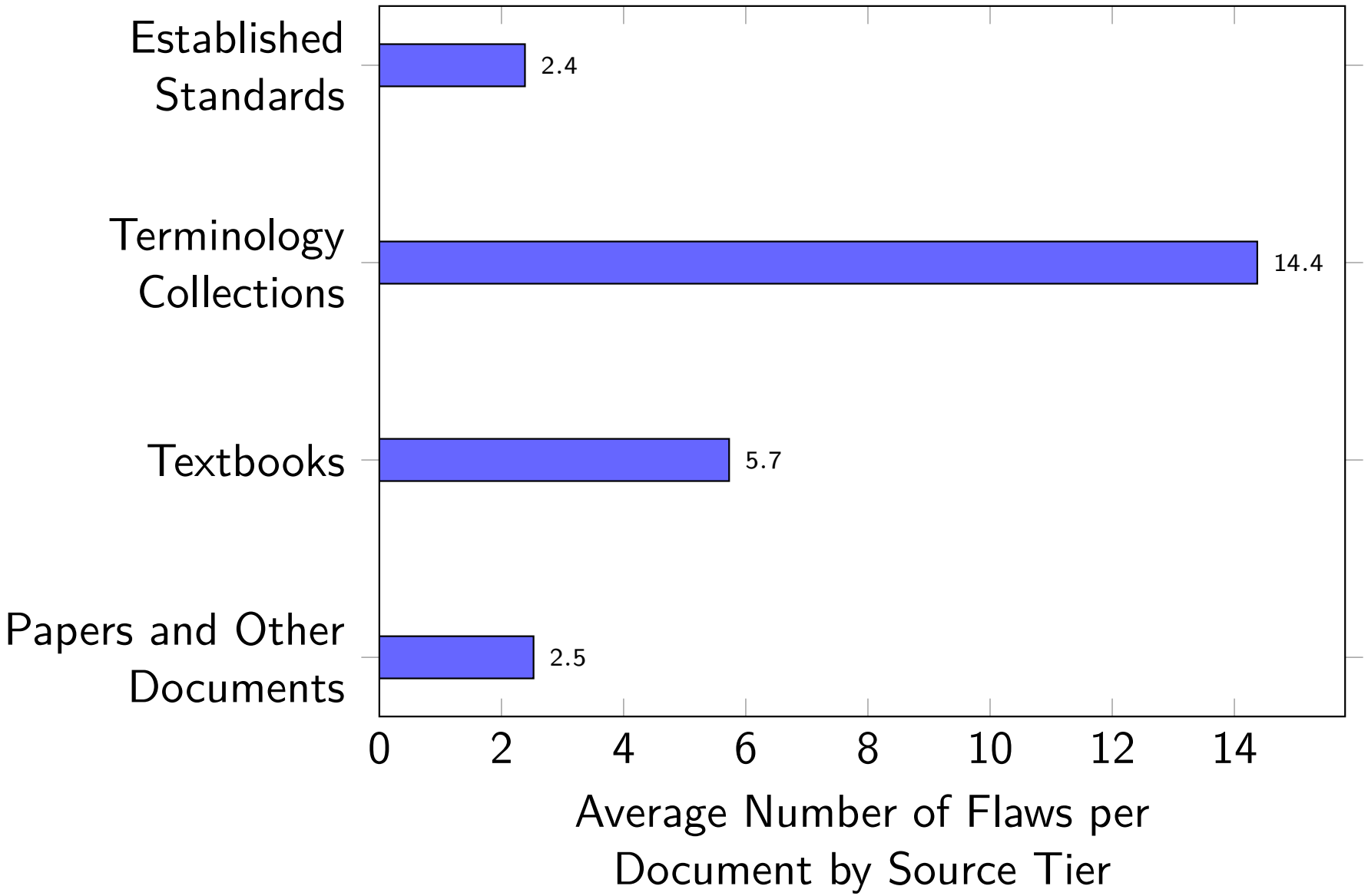


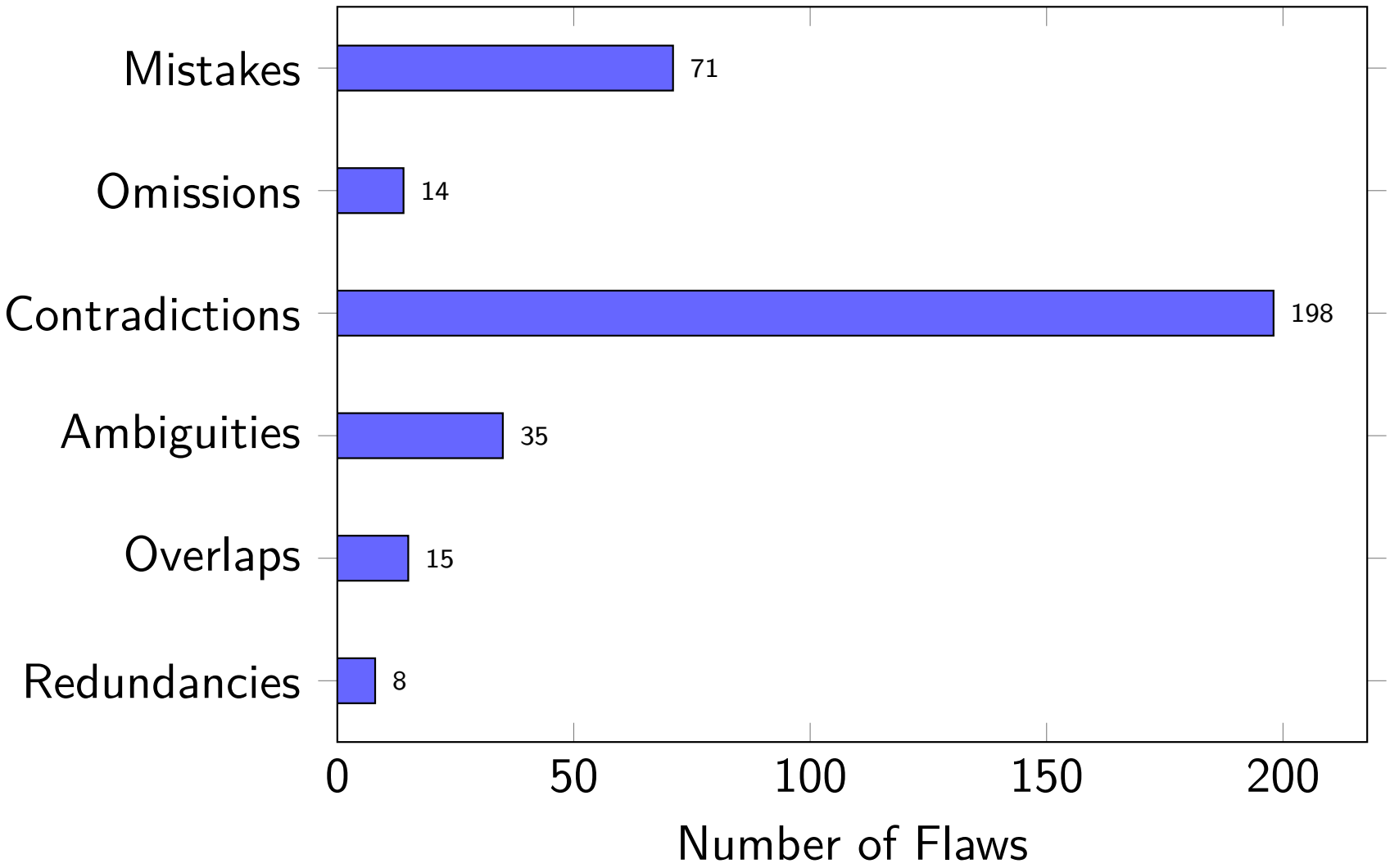
Normalized Flaw Summary



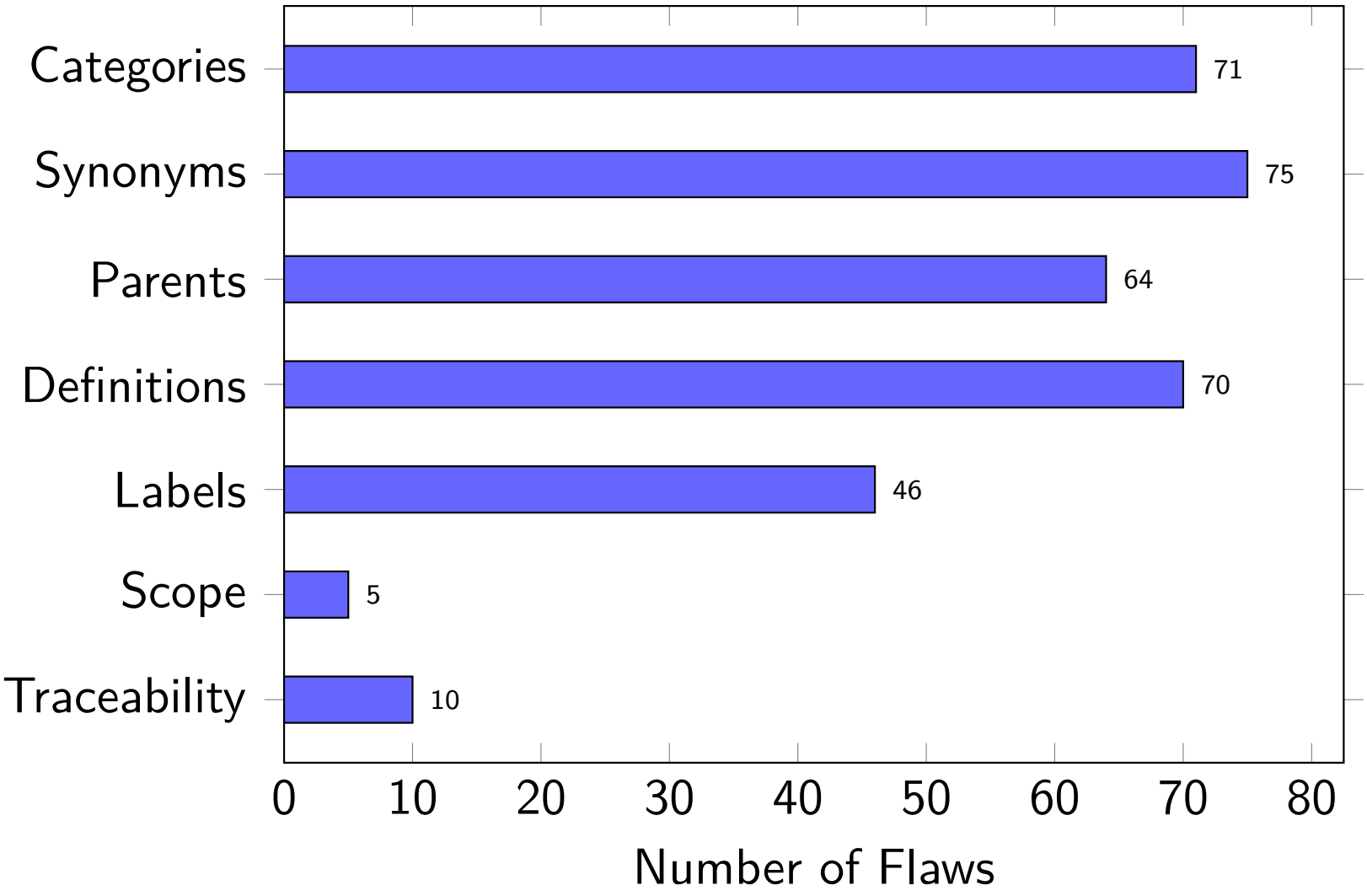
Flaws by Source Tier Observations

1. Established standards are not actually standardized, since:
   1. other documents frequently disagree with them and
   2. they are the most internally inconsistent source tier!
2. Less standardized documents, such as terminology collections and textbooks, are also not followed to the extent they should be.
3. Documents across the board have flaws within the same document, between documents with the same author(s), or even with assertions of ground truth!

Flaw Summary by Manifestation



Flaw Summary by Domain



General Flaw Observations

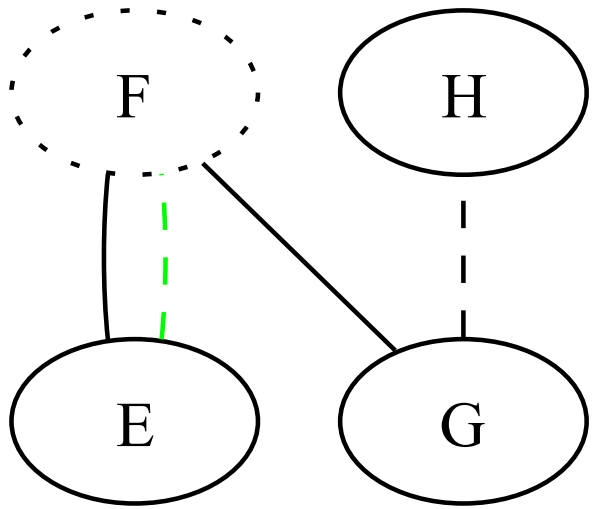
1. Contradictions are by *far* the most common manifestation. This is likely because these are the most obvious flaws to detect automatically and because two (sets of) authors using different resources and not communicating have a high chance of disagreeing.
2. Approach categorizations are the most subjective and one of the most common flaw domains, likely due to the lack of standardization about what categories to use.
3. In general, semantic flaws are more common than syntactic ones. The number of category flaws is comparable to the numbers of flaws with the relations and definitions of test approaches.

Automated Flaws

Intransitive Synonyms

Some terms are given as a synonym to two (or more) disjoint terms, making their relations ambiguous

Name	Synonym(s)
E	F (Author, 2022; implied by StdAuthor, 2021)
G	F (Author, 2017), H (implied by 2022)
H	X (StdAuthor, 2021)



Automated Flaws

Intransitive Synonyms

Some prominent examples:

	Source(s)
1. **Functional Testing:**	
• Specification-based Testing	(ISO/IEC and IEEE, 2017, p. 196; . . .)
• *Conformance Testing*	(Washizaki, 2025, p. 5-7)
• *Correctness Testing*	(Washizaki, 2025, p. 5-7)

Automated Flaws

Intransitive Synonyms

Some prominent examples:

	Source(s)
1. Functional Testing:	
• Specification-based Testing	(ISO/IEC and IEEE, 2017, p. 196; . . .)
• *Conformance Testing*	(Washizaki, 2025, p. 5-7)
• *Correctness Testing*	(Washizaki, 2025, p. 5-7)
2. Portability Testing:	
• Flexibility Testing	(ISO/IEC, 2023)
• Configuration Testing	(Kam, 2008, p. 43)
3. Soak Testing:	
• Endurance Testing	(ISO/IEC and IEEE, 2021c, p. 39)
• Reliability Testing	(Gerrard, 2000a, Tab. 2; 2000b, Tab. 1, p. 26)

Automated Flaws

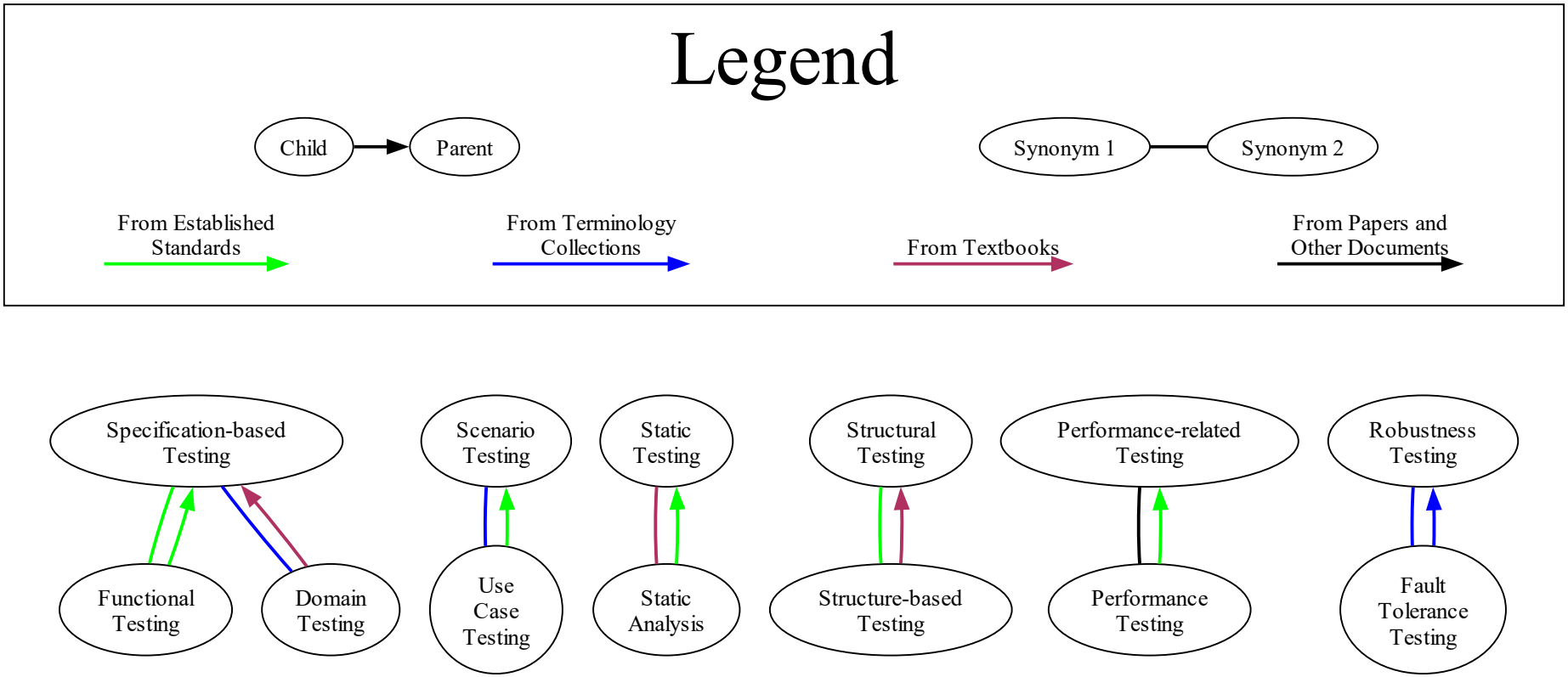
Irreflexive Parents

We also find some test approaches that are given as parents of themselves:

1. Performance Testing (Gerrard, 2000a, Tab. 2; 2000b, Tab. 1)
2. System Testing (Firesmith, 2015, p. 23)
3. Usability Testing (Gerrard, 2000a, Tab. 2; 2000b, Tab. 1)

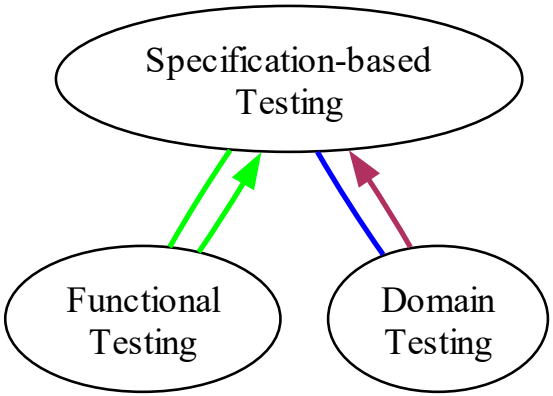
Automated Flaws

Synonym and Parent-Child Overlaps



Automated Flaws

Synonym and Parent-Child Overlaps



- Functional testing is a:
  - Synonym (ISO/IEC and IEEE, 2017, p. 196; van Vliet, 2000, p. 399; Kam, 2008, pp. 44–45, 48; . . .)
  - Child (ISO/IEC and IEEE, 2021c, p. 38; Kam, 2008, p. 42)
- Domain testing is a:
  - Synonym (Washizaki, 2025, p. 5-10)
  - Child (Peters and Pedrycz, 2000, Tab. 12.1)

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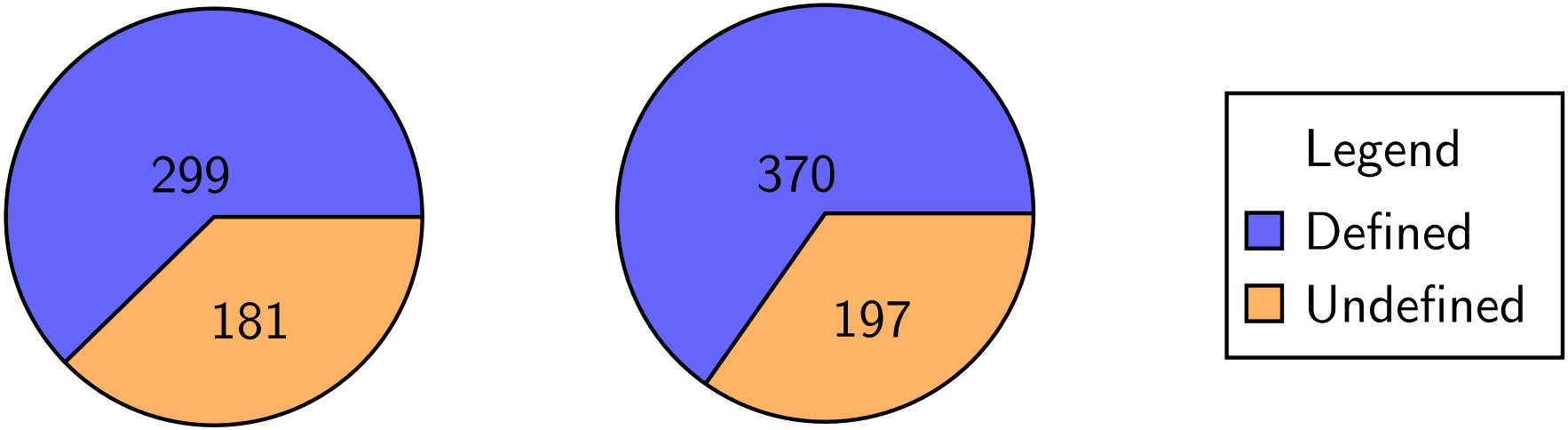
Future Work



1. Iterate over undefined test approaches
2. Investigate missing approaches
3. Fill in other approach data
4. Improve approach relation visualizations
5. Identify and detect more flaws

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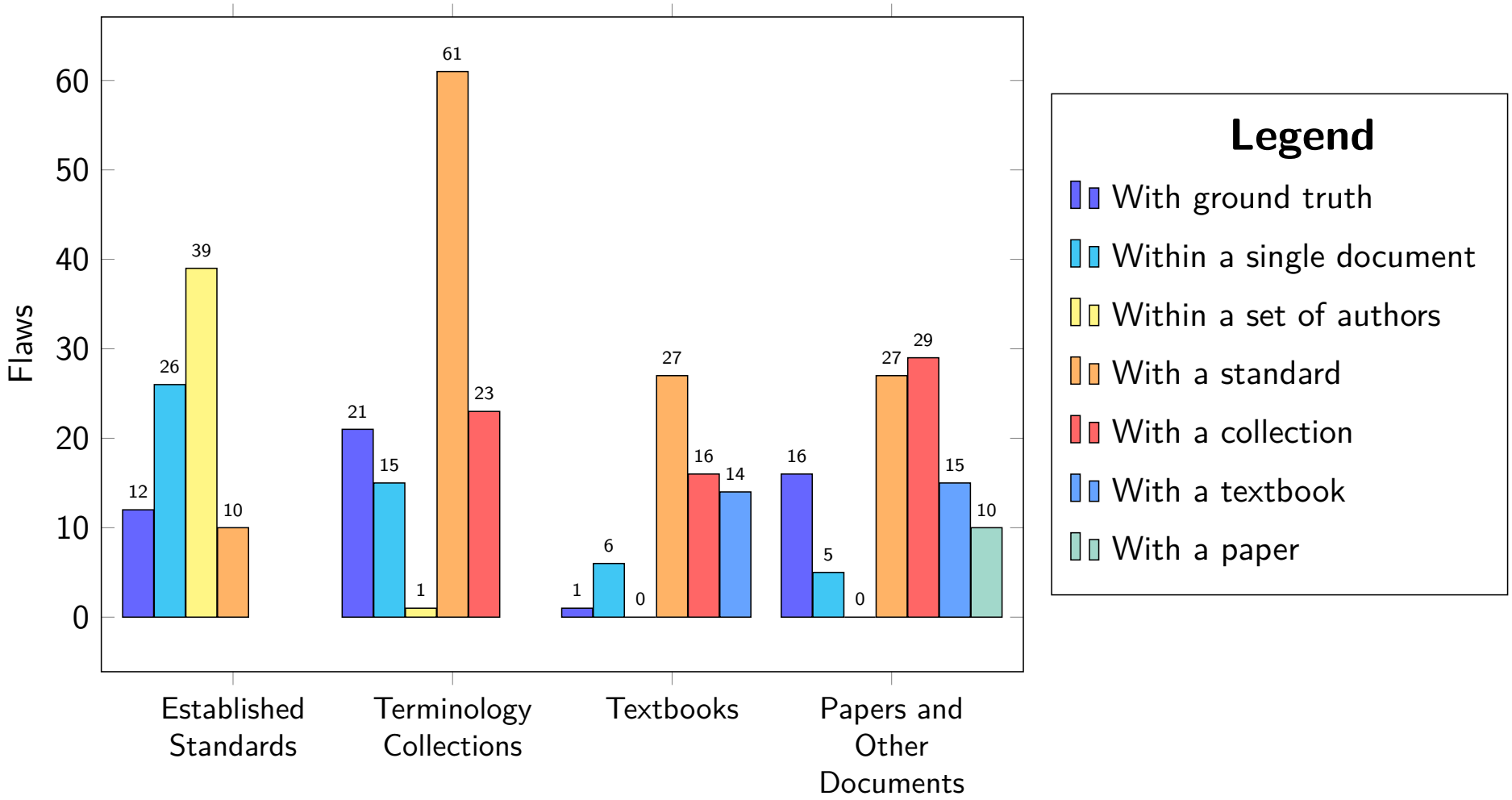
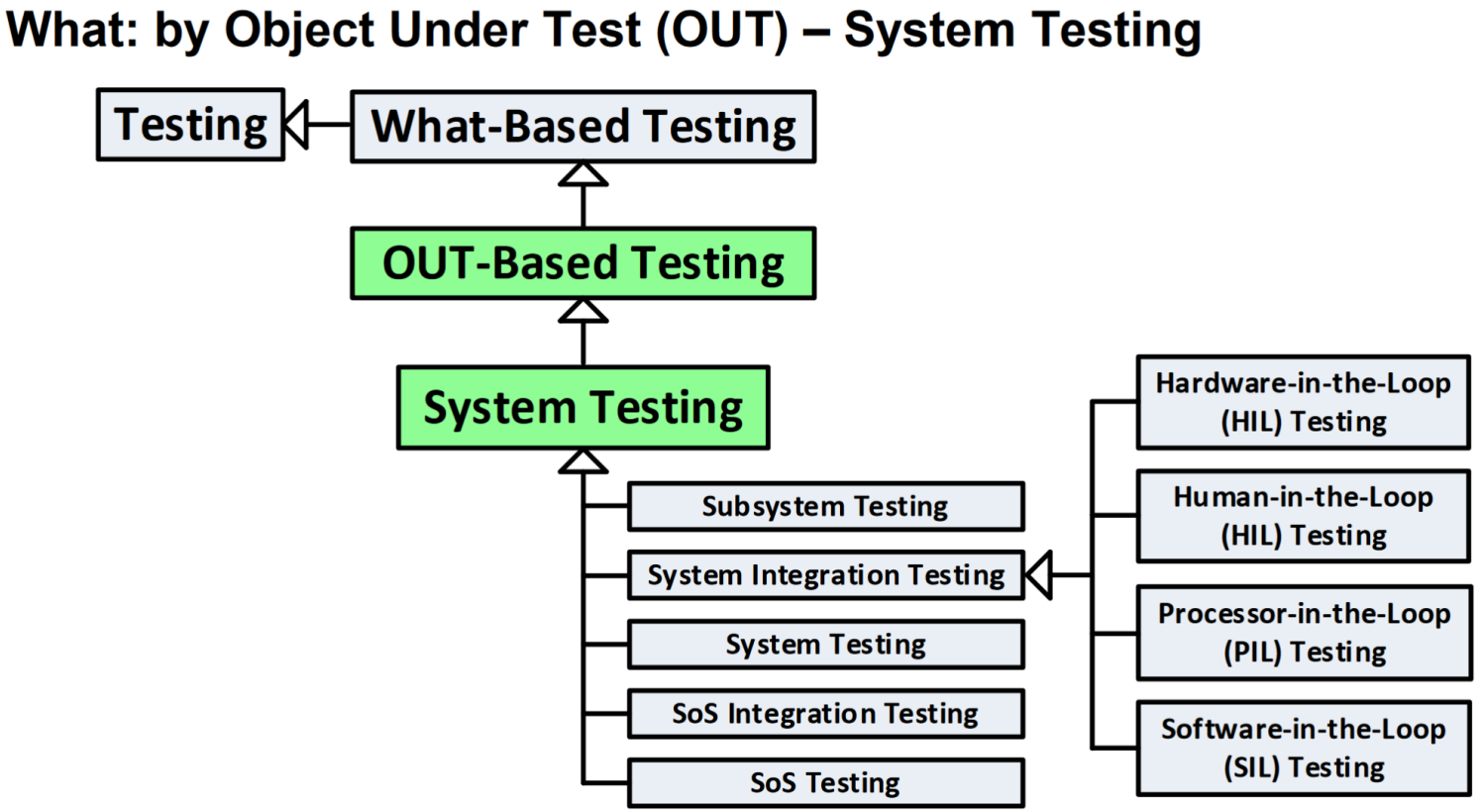
Conclusion

- The software testing literature is flawed, so don't assume everyone is on the same page



Conclusion

- The software testing literature is flawed, so don't assume everyone is on the same page
- Even if they are, there can still be issues!



(Firesmith, 2015, p. 23)

Acknowledgment

- Dr. Spencer Smith and Dr. Jacques Carette have been great supervisors and valuable sources of guidance and feedback
- The format of this presentation was *heavily* based on a previous presentation by Jason Balaci, who also provided a great thesis template
- My family has also supported me in more ways than I can count, and I cannot thank them enough

- ChatGPT was used to help generate supplementary Python code for constructing visualizations and generating LaTeX code, including regex
- ChatGPT and GitHub Copilot were both used for assistance with LaTeX formatting

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