Carnegie Mellon University
Software Engineering Institute

DEV SEC OPS DAYS

Commonality and Trends in SAST Results

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Trends in SAST Results: Know Your Tools

Did you know……

- There is less than 1% overlap amongst the defects found by different AST tools
- 80% of context-determined severe defects are dismissed as unimportant by SASTs
- AST-found Java defects are 3 times more likely to have high confidence than C/C++ defects
- Only 5.5% of AST defects are easy to exploit
- Only 6.5% of AST defects are rated high severity by the AST

The Defect Database

10 SAST, 8 Open Source Projects

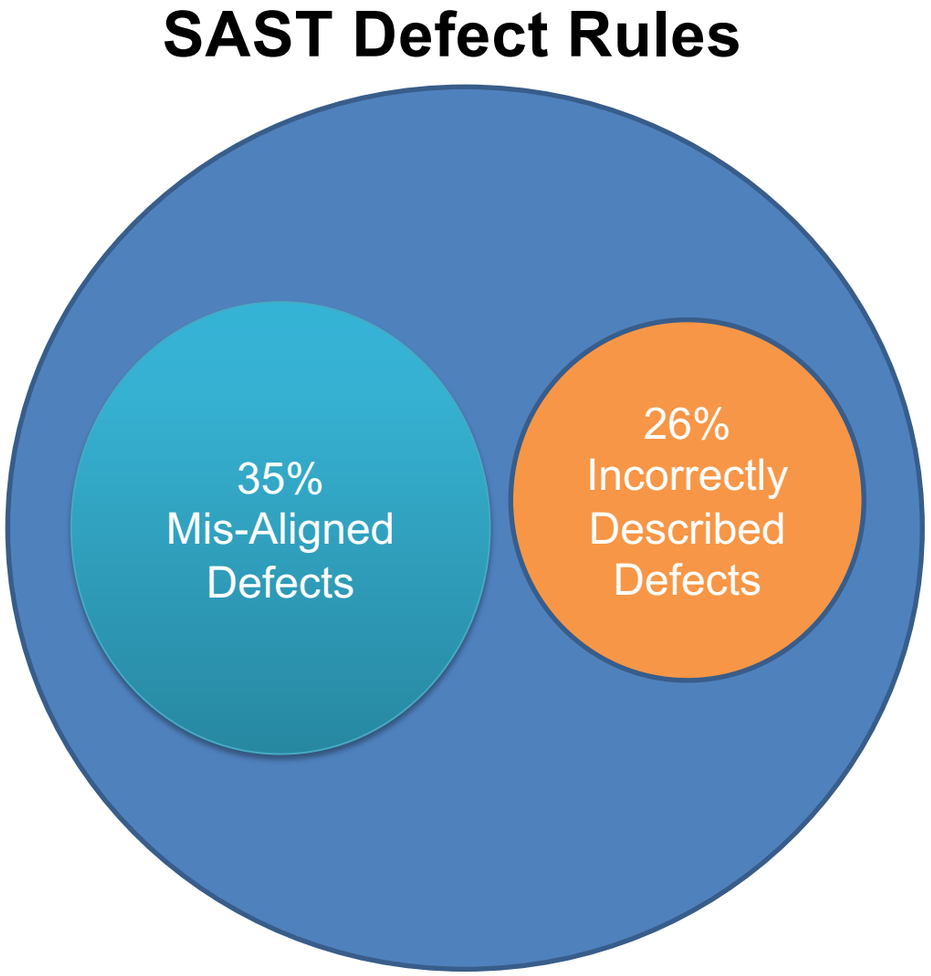
Project	Defect Density (Lines of Code/Defect)
A	6.8
B	7.2
C	14.9
D	1.3
E	8.1
F	32.0
G	37.6
H	24.0

- 7.7 MLOC: Java/Javascript and C/C++ code
- Mature: Well-used, well-maintained, dozens of release cycles, half were > 25 years old
- 684,816 Defects

Defect Normalization

10,102 Defects, 20 SAST, 10 Languages

- Re-alignment based on consistent & accurate mapping to MITRE CWE
- 11 commercial Tools
- Errors, laziness, keywords, effect-not-cause “expanded” coverage
- 9 open source tools: most do not map to CWE
- 415 CWE items covered



Defect Commonality

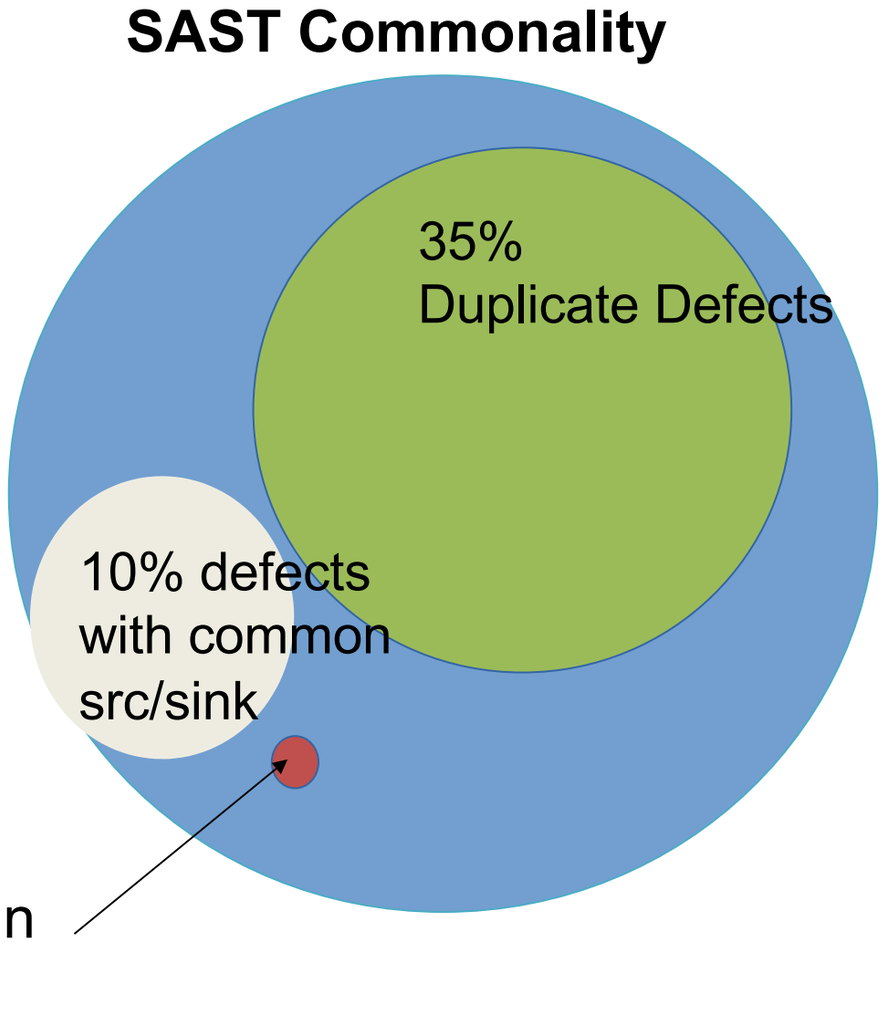
The Process

- Defect Normalization
- De-Duplication
- Common Sink-Source Location
- Parent-Child Relationships
- Cause-Effect Relationships

Defect Commonality

The Result: 6,705 common out of 684,816

- Common Source-Sink: 10%
- Parent-Child: 3x increase in commonality
- Cause-Effect: 12% increase in commonality



Results manually checked

False Positive Trends

The Method

	High	Medium	Low	No Confidence
Java 1	71.4	2.3	16.5	8.2
Java 2	60	1.9	20.8	16.4
Java 3	45.1	4.5	43.4	2.3
Java 4	76.1	0.9	18.5	2.8
C/C++ 1	6.4	13.4	59.5	19.3
C/C++ 2	9.7	6.4	77.4	4.9
C/C++ 3	23	12.3	53.3	9.2
C/C++ 4	16.4	6.5	62.7	13.4
Java Total	61.4	2.6	25.8	7.8
C Total	21.7	12.1	54.6	9.5
All Total	46.8	6.1	36.4	8.4

- Find relative probability that defect type is true positive
- Rule Specific e.g., narrowness of rule
- Analytic study: code properties that affect the math, path, and data value validity
- High confidence →>50% true positive
- No confidence →> 95% false positive

False Positive Trends

Java/Javascript is accurate;C/C++ is not

	High	Medium	Low	No Confidence
Java 1	71.4	2.3	16.5	8.2
Java 2	60	1.9	20.8	16.4
Java 3	45.1	4.5	43.4	2.3
Java 4	76.1	0.9	18.5	2.8
C/C++ 1	6.4	13.4	59.5	19.3
C/C++ 2	9.7	6.4	77.4	4.9
C/C++ 3	23	12.3	53.3	9.2
C/C++ 4	16.4	6.5	62.7	13.4
Java Total	61.4	2.6	25.8	7.8
C Total	21.7	12.1	54.6	9.5
All Total	46.8	6.1	36.4	8.4

- Java/JavaScript results are much more accurate than C/C++
- Java results are either highly confident or not – no middle ground
- Considerable quantities of no confidence results are present
- One SAST had 20-25% no confidence rates
- Results verified with historical defect trends

Ease of Exploit Trends

The Method

	Easy	Medium	Hard	No Confidence
Java 1	0.8	35.6	54	8.2
Java 2	0.6	9.5	72.6	16.4
Java 3	14.3	14.2	64.6	2.3
Java 4	0.7	7.7	87.3	2.8
C/C++ 1	5.3	22.1	51.9	19.3
C/C++ 2	10.7	2.5	80	4.9
C/C++ 3	6.8	13.2	68.5	9.2
C/C++ 4	10	9.5	66.2	13.4
Java Total	4.7	17.7	67.5	7.8
C Total	6.9	13.1	68.3	9.5
All Total	5.5	16.1	67.8	8.4

- Expand the CAPEC attack associations with CWEs
- Direct vs indirect attacks
- Easy defects mapped to easy-to-moderate CAPEC
- Half of defects have no associated CAPEC
- Verified with MITRE CVE Database

Ease of Exploit Trends

SAST focuses on hard-to-exploit defects

	Easy	Medium	Hard	No Confidence
Java 1	0.8	35.6	54	8.2
Java 2	0.6	9.5	72.6	16.4
Java 3	14.3	14.2	64.6	2.3
Java 4	0.7	7.7	87.3	2.8
C/C++ 1	5.3	22.1	51.9	19.3
C/C++ 2	10.7	2.5	80	4.9
C/C++ 3	6.8	13.2	68.5	9.2
C/C++ 4	10	9.5	66.2	13.4
Java Total	4.7	17.7	67.5	7.8
C Total	6.9	13.1	68.3	9.5
All Total	5.5	16.1	67.8	8.4

- Few defects are easy to exploit
- Most defects are difficult to exploit with no associated common attack patterns (CAPEC)
- One SAST was considerably better than all others in finding easy-to-exploit defects

Severity of Consequence Trends

The Method

	High	Medium	Low	No Confidence
Java 1	0.2	40	50.3	8.2
Java 2	0.2	13.8	68.6	16.4
Java 3	14.3	10.4	68.4	2.3
Java 4	0.3	5.9	89.4	2.8
C/C++ 1	5.1	20.1	54	19.3
C/C++ 2	11.4	30.8	51.3	4.9
C/C++ 3	10.4	21.9	56.2	9.2
C/C++ 4	13.4	5.0	67.2	13.4
Java Total	4.3	18.7	66.9	7.8
C Total	10.2	22.2	55.9	9.5
All Total	6.5	20.0	62.9	8.4

- Consequence list extension
- Analytic study of likelihood of each consequence for each defect
- Breachable vs. non-breachable defects
- Verified with MITRE CVE Database

Severity of Consequence Trends

More severe C/C++ defects than Java defects

	High	Medium	Low	No Confidence
Java 1	0.2	40	50.3	8.2
Java 2	0.2	13.8	68.6	16.4
Java 3	14.3	10.4	68.4	2.3
Java 4	0.3	5.9	89.4	2.8
C/C++ 1	5.1	20.1	54	19.3
C/C++ 2	11.4	30.8	51.3	4.9
C/C++ 3	10.4	21.9	56.2	9.2
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Java Total	4.3	18.7	66.9	7.8
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- Most defects have low probability of severe consequences
- C/C++ defects have higher severity than Java/Javascript
- SASTs determined 35% were severe
- Big difference between probability and possibility of defect presence

Trend Implications

Use lots of tools!

- To get adequate coverage, a project needs to use multiple tools - both commercial and open source
- Increased tool usage adds to triage burden, especially for C/C++ projects
- Ease of exploitation should be used as a prioritization parameter
- Determine probability, not possibility

What is next?

AST Management Tools

- CyberSagacity has an application to determine these trends for numerous ASTs
    - We combine AST trend factors in a very-narrowing triage process
    - We will apply AST trend analysis to defect rules for tool comparisons/trait analysis
- **OPPORTUNITY: Trial use of our trends/triage application. See www.cybersagacity.io for more information.**