Scale Your Security

by Embracing Secure Defaults and Eliminating Bug Classes

Grayson Hardaway | r2c.dev

Slides are posted at semgrep.dev

whois

me:
Grayson Hardaway, sr. security engineer @ r2c
Formerly: U.S. Department of Defense

r2c:
We're an SF based static analysis startup on a mission to profoundly improve software security and reliability.

Outline

1. Why Bug-Finding Isn't The Answer
2. How to Eradicate Vulnerability Classes
3. Tools & Techniques To Make It Real

1. Why Bug-Finding Isn't The Answer

Software Development has Changed

...thus Security Teams must too

In many companies:

- Security teams can hard block engineering rarely, if ever
- Security testing must be continuous, not point in time
- Focus on building, not just breaking
- Embedded or partnered closely with dev teams

We need to re-visit our prior assumptions

Massive Shifts in Tech and Security

Before	After
Waterfall development	Agile development
Dev, Ops	DevOps
On prem	Cloud

Massive Shifts in Tech and Security

Before	After
Waterfall development	Agile development
Dev, Ops	DevOps
On prem	Cloud
Finding vulnerabilities	Secure defaults and invariants

Invariant

A property that must either always or never be true

Key Insight ==

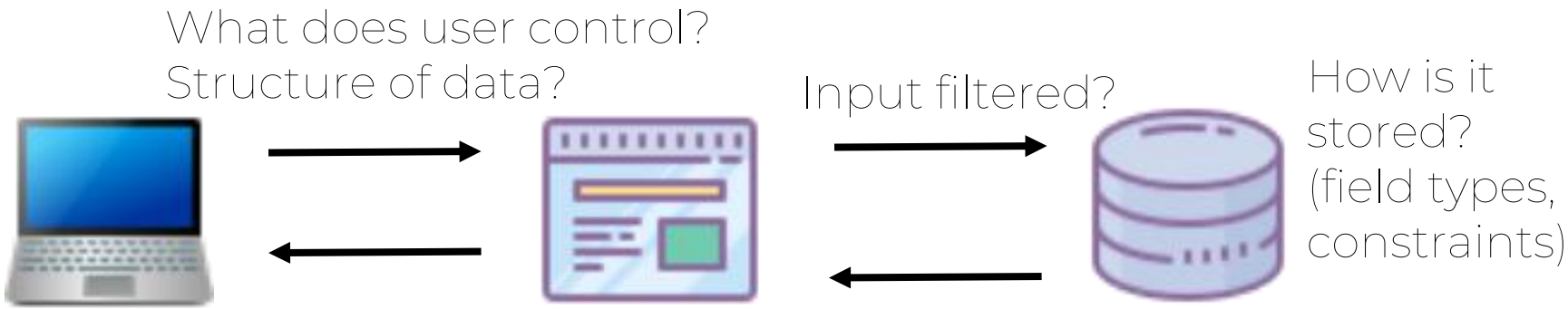
No context needed to make a decision

No operational time for the security team

Quiz: Does this app have XSS?

Icons by Icons8

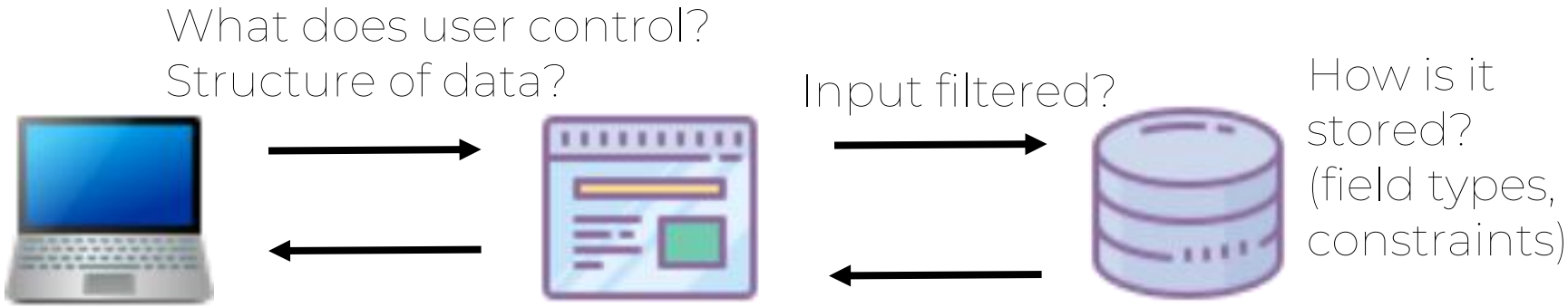
Quiz: Does this app have XSS?



Icons by Icons8

Quiz: Does this app have XSS?

Invariant: Frontend is React, banned dangerouslySetInnerHTML



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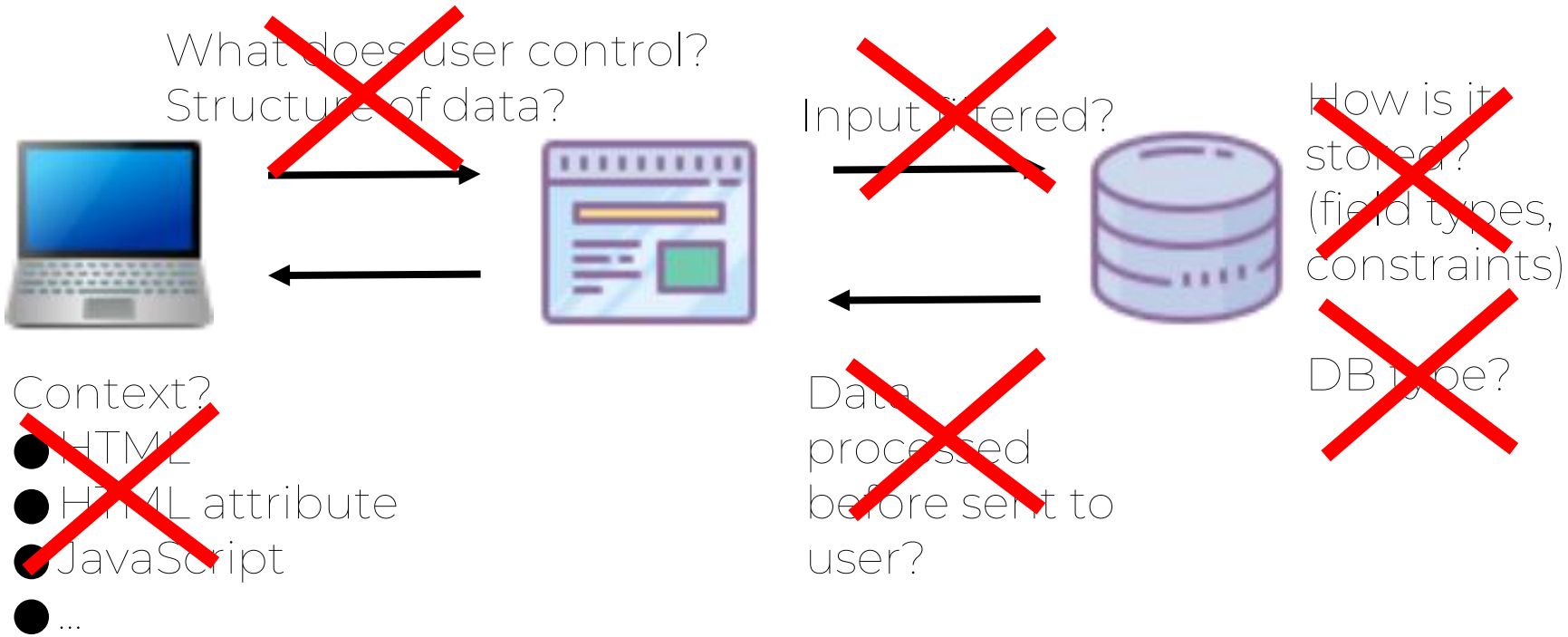


Icons by Icons8

Quiz: Does this app have RCE?

Quiz: Does this app have RCE?

What does user control?
Structure of data?

Input filtered?

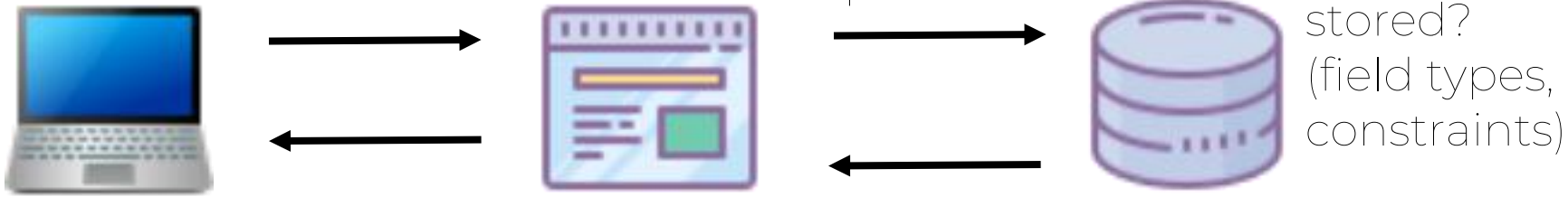
How is it stored? (field types, constraints)

Does the app?

- Deserialize data
- Run shell commands
- Mix data and code
  - eval(), exec()
  - Metaprogramming

Quiz: Does this app have RCE?

Ban: exec(), eval(), shell exec, deserialization (objects, YAML, XML, JSON)



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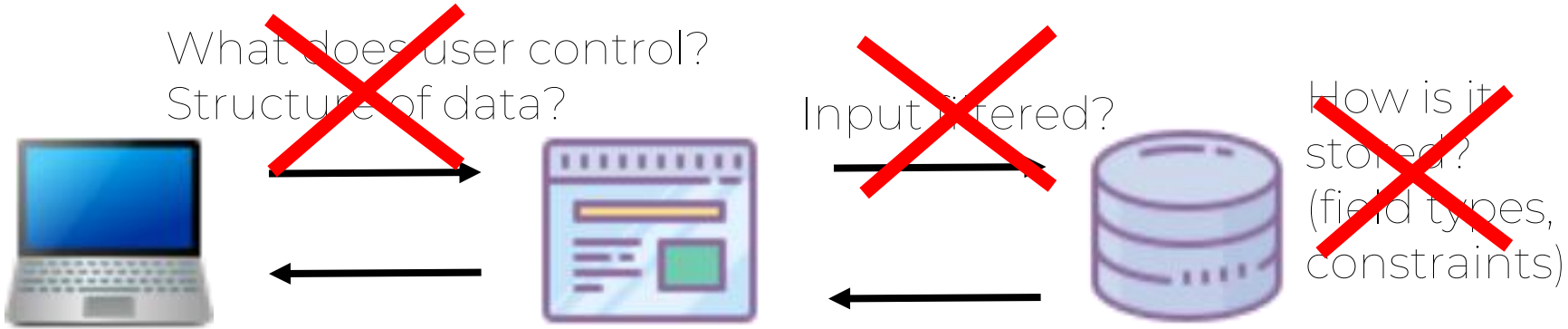

Does the app?

- Deserialize data
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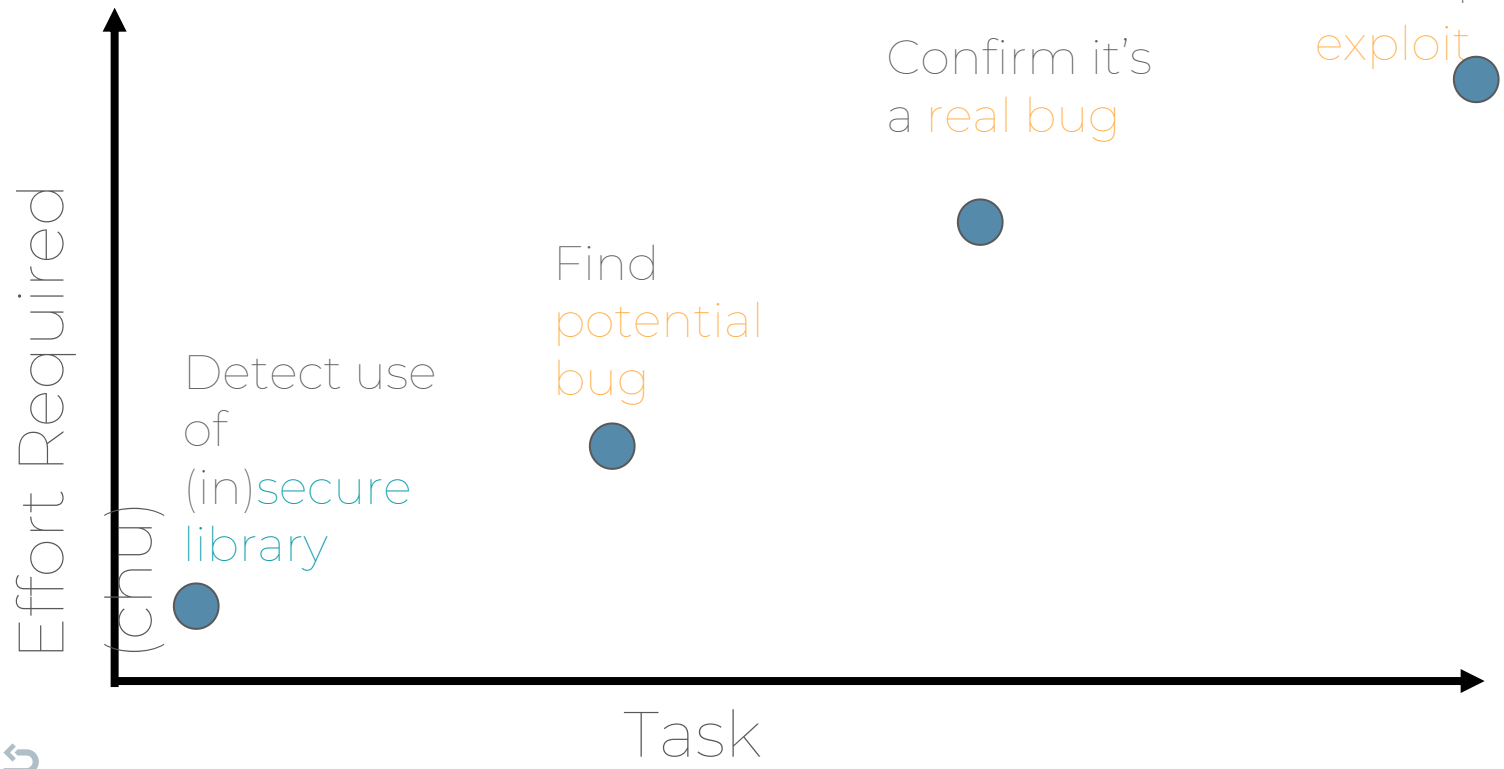
  - Metaprogramming

Task vs Effort Required



Detecting (lack of) use of
secure defaults

is much easier than

finding bugs

#Broke

Finding every vulnerability

#Woke

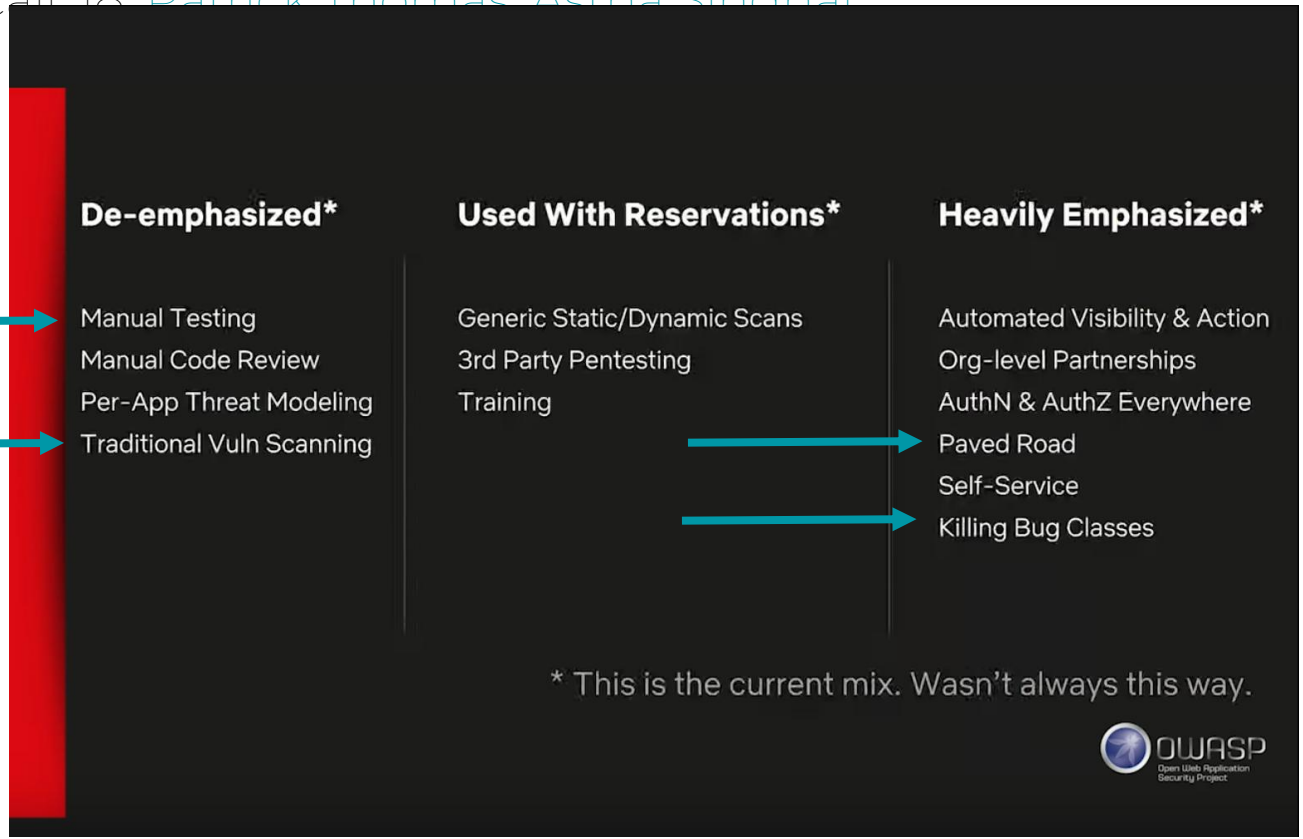
Preventing *classes* of vulnerabilities

Your Internal Dialogue?

- "All you've shown me is some hand-wavy diagrams"
- The security industry has focused on bug finding for decades
  - SAST, DAST, pen tests, bug bounty

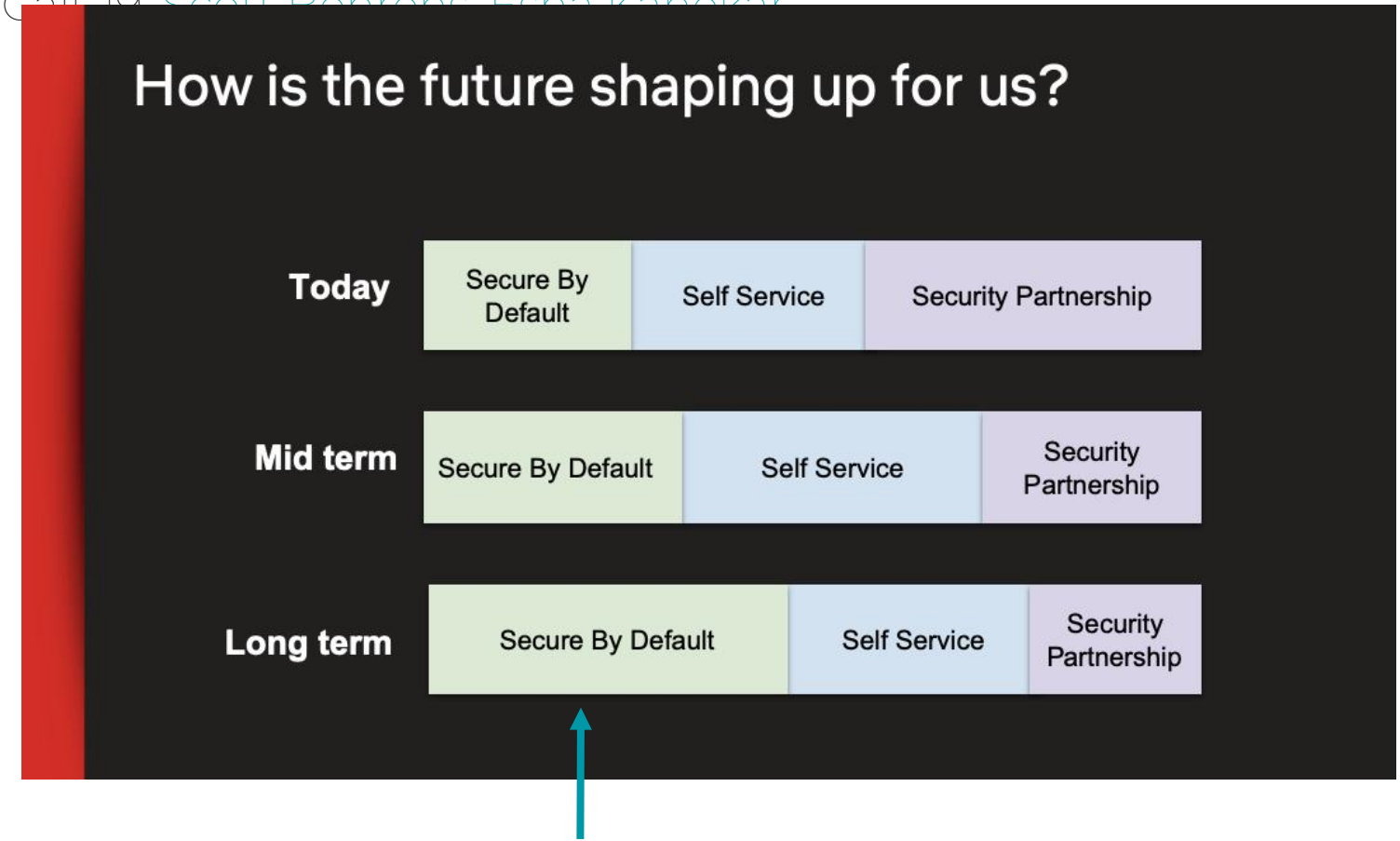
We Come Bearing Gifts: Enabling Prod Security w/ Culture & Cloud

AppSec Cali '18, Patrick Thomas, Astha Singhal



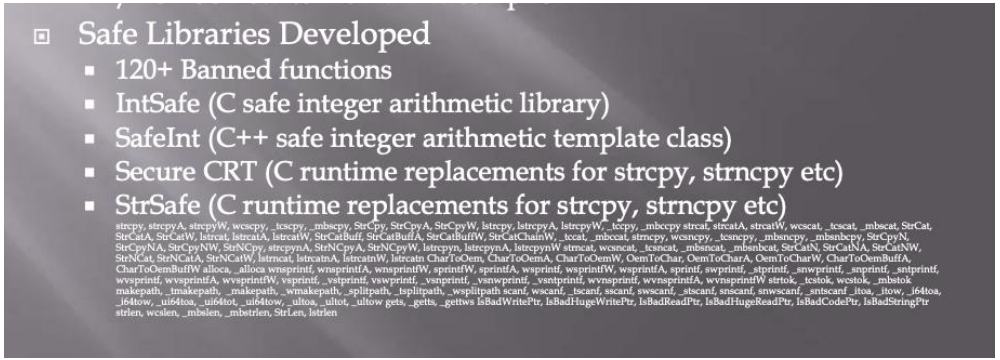
A Pragmatic Approach for Internal Security Partnerships

AppSec Cali '19 Scott Behrens, Esha Kanekar



How Valuable Can Banning Functions Be?

41% of vulnerability reduction from XP → Vista from banning *strcpy* and friends



Microsoft

Analysis of 63 buffer-related security bugs that affect Windows XP, Windows Server 2003 or Windows 2000 but not Windows Vista: 82% removed through SDL process

"Security Improvements in Windows Vista", Michael Howard

- 27 (43%) found through use of SAL (Annotations)
- 26 (41%) removed through banned API removal

Tools and Training Help, but are Not Enough

We need a safer systems programming language

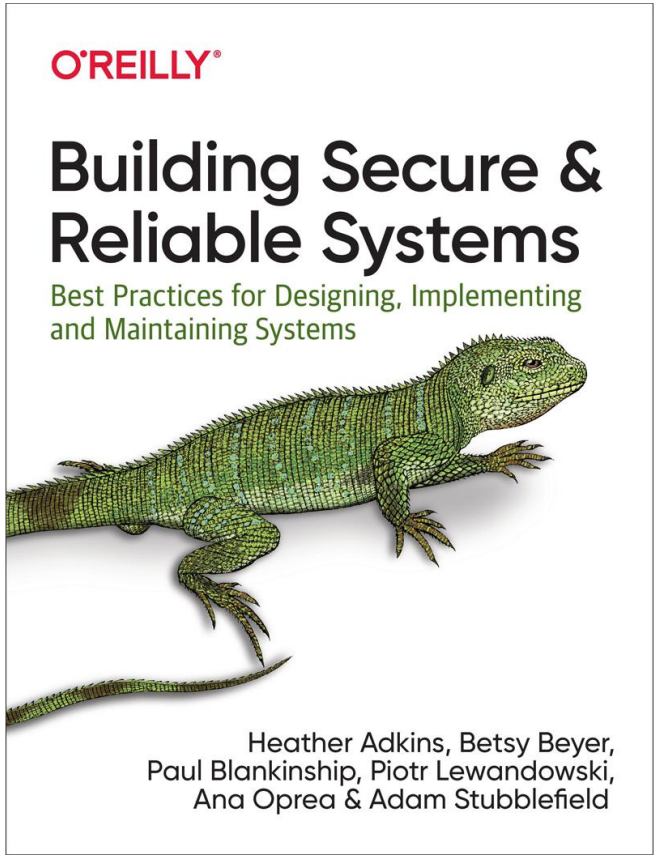
Security Research & Defense / By MSRC Team / July 18, 2019 / Memory Safety, Rust, Safe Systems Programming Languages, Secure Development

From the Microsoft Security Response Center blog:

- "Tools and guidance are demonstrably not preventing this class of vulnerabilities; memory safety issues have represented almost the same proportion of vulnerabilities assigned a CVE for over a decade."

Google:

- "It's **unreasonable** to expect any developer to be an expert in all these subjects, or to constantly maintain vigilance when writing or reviewing code.
- A better approach is to handle security and reliability in common frameworks, languages, and libraries. Ideally, libraries only expose an interface that makes writing code with common classes of security



Building Secure and Reliable Systems, by Google

Facebook:

"We invest heavily in building frameworks that help engineers prevent and remove entire classes of bugs when writing code."

Designing Security For Billions by Facebook

“But I’m not Google”

Framework / tech choices matter

- Mitigate classes of vulnerabilities

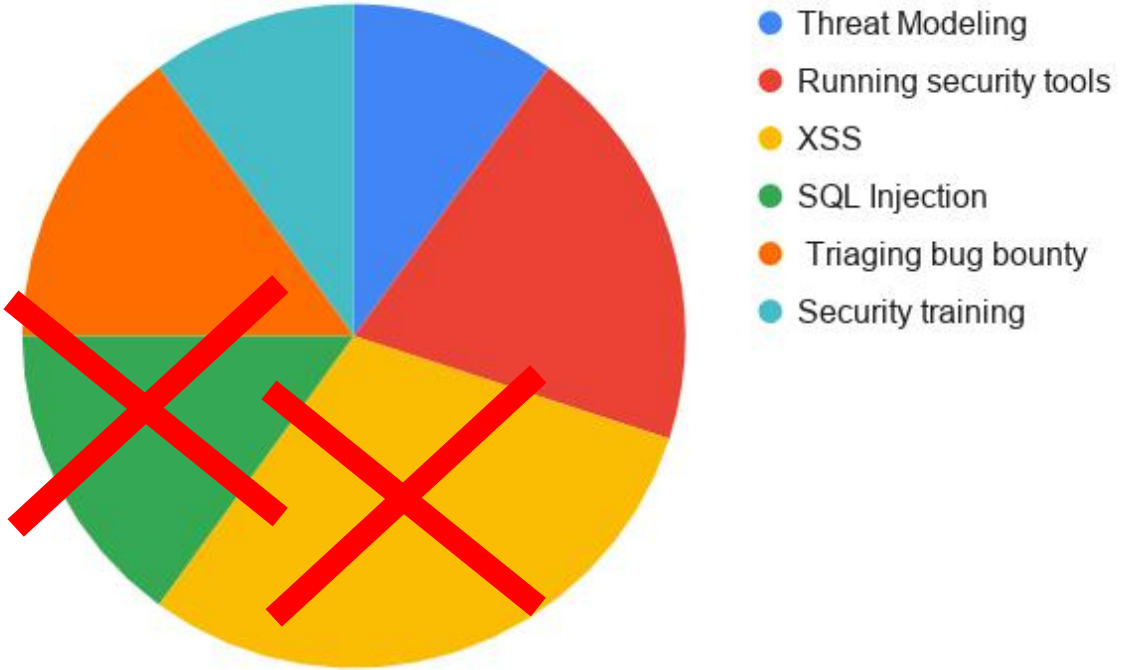
Examples:

- Using modern web frameworks
- DOMPurify - output encoding
- re2 - regexes
- tink - crypto

Web security before modern frameworks

2. How to Eradicate Vulnerability Classes

Compounding Effects of Killing Bug Classes



How to Eradicate Vulnerability Classes

1. Select a vulnerability class
2. Find/prevent it at scale
3. Select a safe pattern and make it the default
4. Train developers to use the safe pattern
5. Use tools to enforce the safe pattern

1. Select a vulnerability class

Common selection criteria

Bug classes that are:

1. The most prevalent
2. The highest impact / risk
3. Easiest to tackle (organizationally, technically)
4. Organizational priorities
5. Weighted: `f(prevalent, severe, feasible, org)`

1. Select a vulnerability class

Vulnerability Management more

Know your current state and if your future efforts actually work

1. Select a vulnerability class

Vulnerability Management (more)

Know your current state and if your future efforts actually work

Track:

- Risk, Severity, Impact
- Vuln class - access controls, XSS, SQLi, open redirect, …
  - Create a taxonomy (e.g. OWASP Top 10, Bugcrowd's VRT)
  - Aim for 20-40 categories (should have different root cause/fix)
- PR introducing / fixing the issue
- Relevant code base (and team/org)
- Root cause
- What source found this? (DAST, SAST, pen test, bug bounty, …)
- Mitigating factors

1. Select a vulnerability class

Building the List of Prior Vulnerabilities to Review

When your vuln tracking has been inconsistent

Common Sources

- JIRA/GitHub issues tagged “security”
- Create a list of security-relevant keywords
  - Search pull/merge requests, issue tracker, git commit history
  - `git log --grep “xss”`
- Security tool reports (SAST, DAST, …)
- Pen test reports, bug bounty submissions
- Ask development, ops, and security teams for examples

1. Select a vulnerability class

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- Pen test reports, bug bounty submissions
- Ask development, ops, and security teams
- Use Google! Use framework documentation!

Going Forward

Fully analyzing ad hoc historical data may not be worth the time

Now: create and document a *lightweight*, standardized process

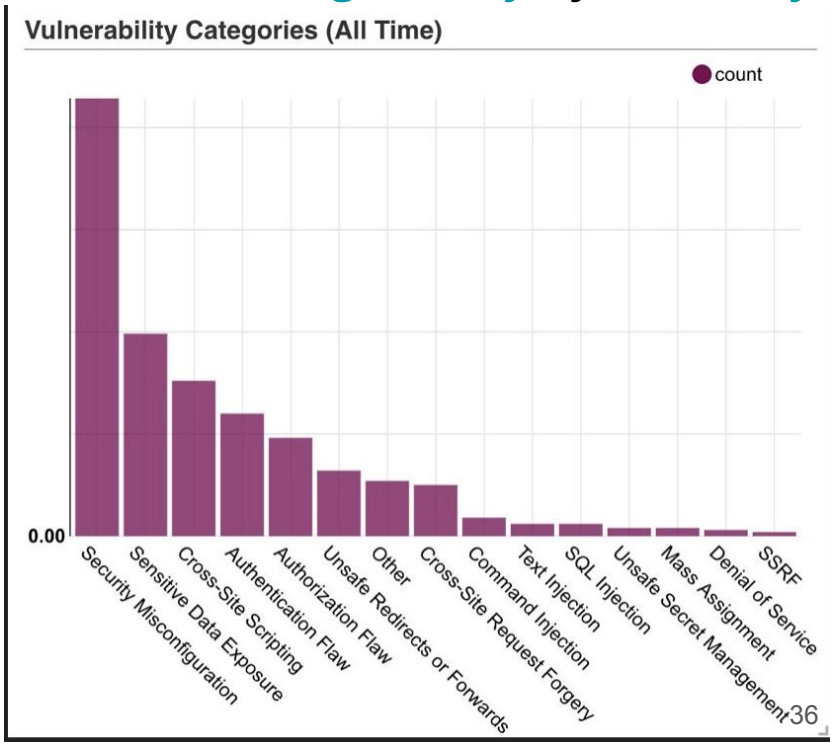
- Make your life easier next time

1. Select a vulnerability class

Slice and Dice

- Group by vulnerability class
- Group by source (DAST, SAST, BB…)
- Weight by severity/risk/impact

Data Driven Bug Bounty by @arkadiyt



1. Select a vulnerability class

Slice and Dice

- Group by vulnerability class
- Group by source (DAST, SAST, BB…)
- Weight by severity/risk/impact

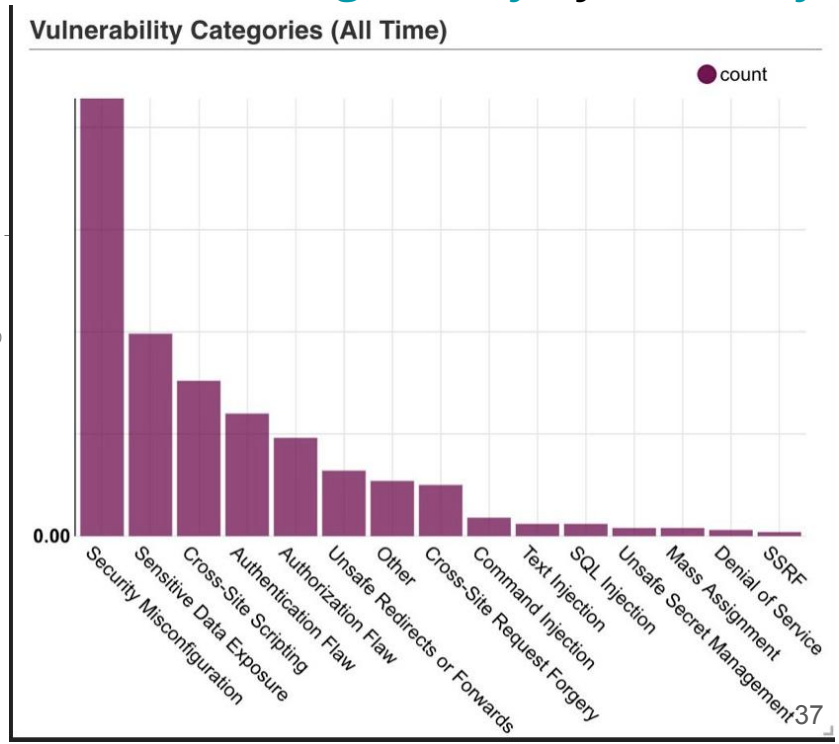
Choose a bug class and review the fixes

- What did the vulnerable code look like?
- What did the fix look like?

What trends do you see?

- Good: vulnerable code looks similar
- Bad: all buggy code looks different

[Data Driven Bug Bounty] by [@arkadiyt]



1. Select a vulnerability class

Ideal World

Choose a vulnerability class that is:

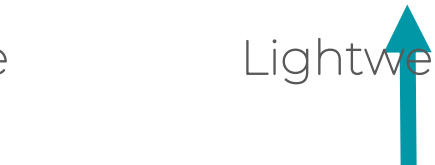
- Widespread across teams/repos
- High Risk
- Feasible to get devs to fix
- Aligns with company priorities
- Always broken in the same way

1. Select a vulnerability class

Pick one and eliminate it!

2. Find/prevent at Scale

Problem	Security Approach
Big picture, architectural flaws	Threat Modeling
Cloud misconfigurations	IaaC scanning, Cartography, BB
Complex business logic bugs	Pen tests, bug bounty
Protect vulns until they're patched	WAF, RASP
Known good/known bad code	Lightweight static analysis



3. Select a Safe Pattern and Make it the Default

- Based on internal coding guidelines, standards, your expertise, …

Application Security Verification Standard 4.0

Final

3. Select a Safe Pattern and Make it the Default

Update all internal coding guidelines (security & dev)

- READMEs, developer documentation, wiki pages, FAQs
  - Training slides, onboarding presentations, …
- Explain *why* these patterns exist and *how* to use them

Work with developer productivity team

- Secure version should have an even better dev UX than the old way
  - Potentially: build a secure library. Make the insecure pattern hard to use while still letting devs go fast
  - How can we increase dev productivity *and* security?
- Integrate security at the right points (e.g. new project starter templates) to get automatic, widespread adoption
- "Hitch your security wagon to dev productivity." - Astha Singhal

4. Train Developers to Use the Safe Pattern

Making Communications Successful

- What and why something is insecure should be clear
  - Use terms developers understand, no security jargon
- Convey impact in terms devs care about
  - Risk to the business, damaging user trust, reliability, up time
- How to fix it should be *concise* and *clear*
  - Link to additional docs and resources with more info
  - Have a dedicated #AppSec chat channel for further questions

Don't Run with Scissors: How to standardize how developers use dangerous aspects of your framework by Morgan Roman

How to write training/documentation

If you use <THE BAD WAY>, <BAD THING WILL HAPPEN>. Instead use the <THE GOOD WAY> since <IT STOPS THE BAD THING>.

DO NOT DO THIS:

<EXAMPLE OF THE BAD WAY>

DO THIS INSTEAD:

<EXAMPLE OF THE GOOD WAY>

Explain it simply and clearly.
You do not need to use security lingo like XXE/ReDoS/XSS/RCE etc.

First show an example on how the developer intends to do it if you have one
Then show how they can do it correctly.
Make sure it is simple to do.

4. Train Developers to Use the Safe Pattern

How to Engage: Some Options

- During developer onboarding
- Lead educational brown bag sessions over lunch
- Internal CTFs
- Security champions
- When in-person interaction is feasible again
  - Grab lunch with dev teams and/or schedule a happy hour
  - Have candy on desks by the security team

5. Use Tools to Enforce the Safe Pattern

Use lightweight static analysis (grep, linting) to ensure the safe patterns are used

3. Tools & Techniques To Make It Real

How to Eradicate Vulnerability Classes

1. Evaluate which vulnerability class to focus on
2. Determine the best approach to find/prevent it at scale

→ How to set up continuous code scanning

1. Select a safe pattern and make it the default
2. Train developers to use the safe pattern
3. Use tools to enforce the safe pattern

→ Checking for escape hatches in secure

Continuous Scanning: Related Work

AppSec USA:

- Put Your Robots to Work: Security Automation at Twitter | ‘12
- Providence: rapid vuln prevention (blog, code) | '15
- Cleaning Your Applications’ Dirty Laundry with Scumblr (code) | '16
- Scaling Security Assessment at the Speed of DevOps | '16
- SCORE Bot: Shift Left, at Scale! | ‘18

Continuous Scanning: Related Work

Salus: How Coinbase Sales Security Automation (blog, code)
DevSecCon London '18

Orchestrating Security Tools with AWS Step Functions (slides)
DeepSec '18

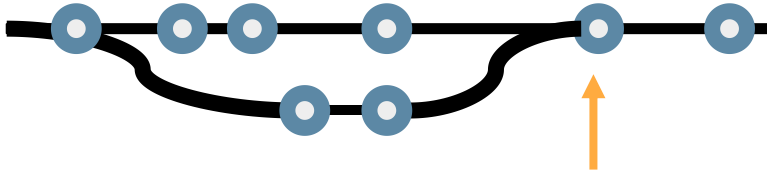
A Case Study of our Journey in Continuous Security (code)
DevSecCon London '19

Dracon- Knative Security Pipelines (code)
Global AppSec Amsterdam '19

Continuous Scanning: Best Practices

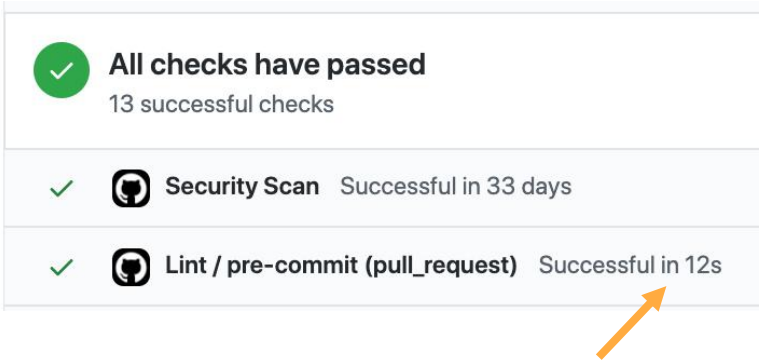
Scan Pull Requests

every commit is too noisy, e.g. WIP commits



Scan Fast (<5min)

feedback while context is fresh
can do longer / more in depth scans daily or weekly



Two Scanning Workflows

audit (sec team, visibility), blocking (devs, pls fix)

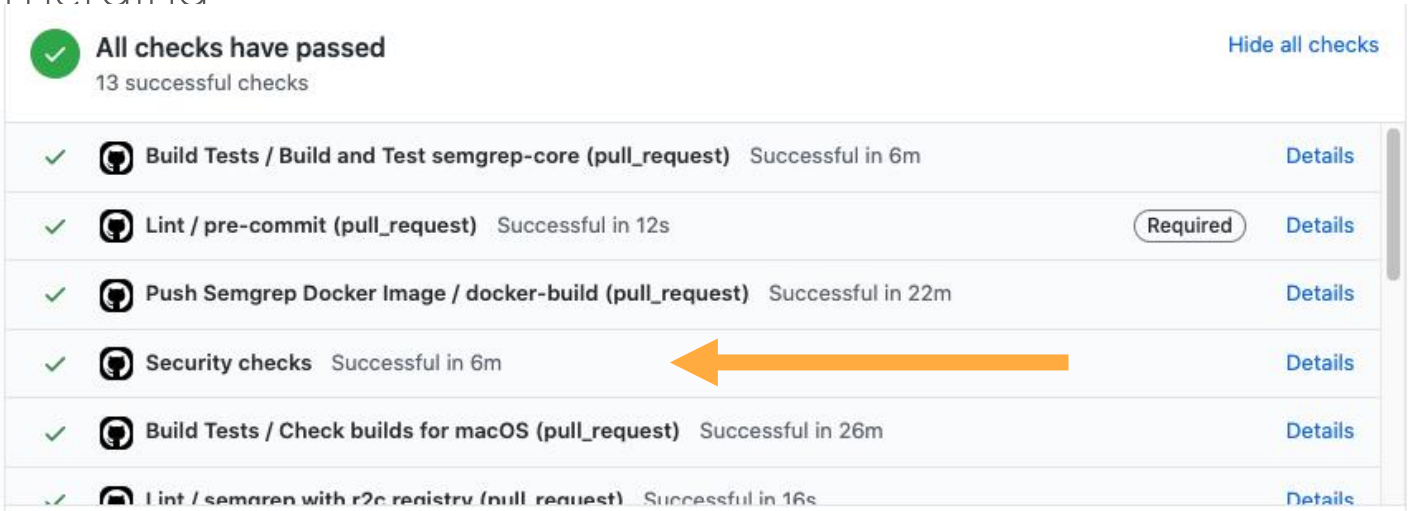
Make Adjustment Easy

Make it cheap to add/remove tools and new rules

Scan Fast

Don't come in last!

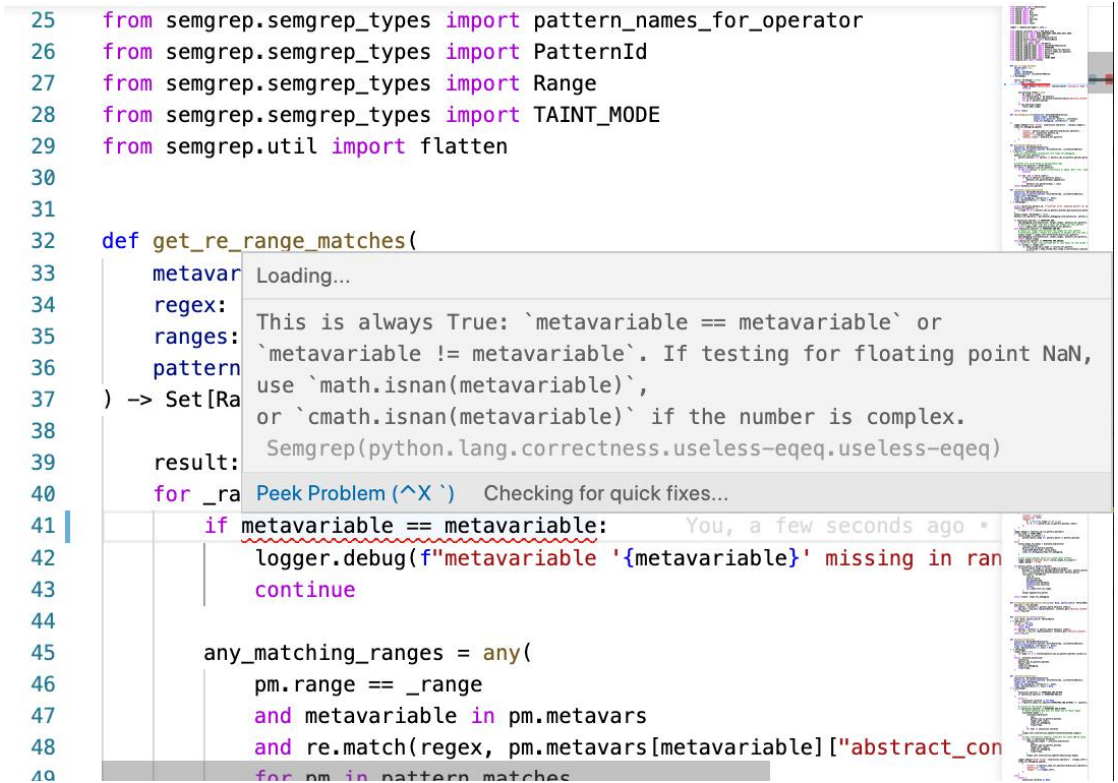
Security checks should not be the slowest check blocking developer from merging



Scan Early

Tell me as soon as possible, ideally in the editor.

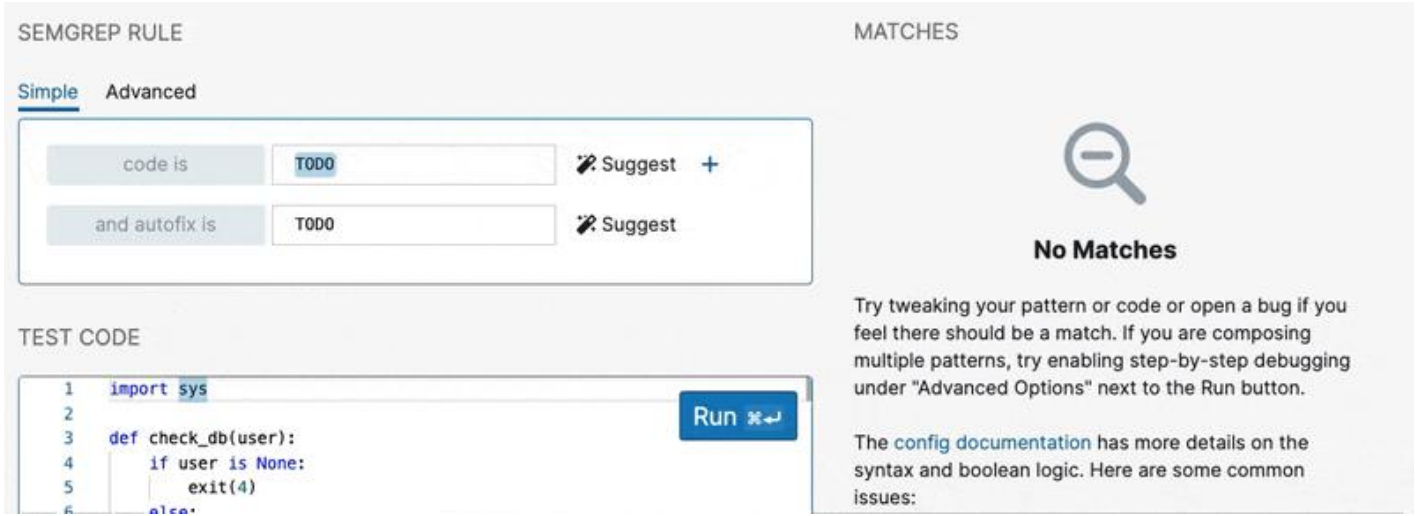
Also enforce in CI so that it can't be ignored.



Autofix

Make security fixes fast and easy.

Even an imperfect suggestion is better than nothing!

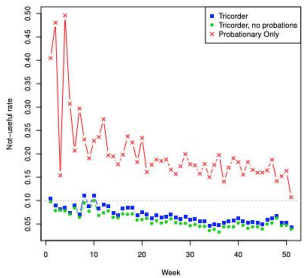


Try: https://semgrep.dev/ievans:tlsautofix

Continuous Scanning: Best Practices

Show tool findings within dev systems (e.g. on PR as a comment)

Clear, actionable, with link to more info




```
return getString() == "foo".toString();
```

▾ ErrorProne
StringEquality
1:03 AM, Aug 21

String comparison using reference equality instead of value equality
(see http://code.google.com/p/error-prone/wiki/StringEquality)

Please fix

Suggested fix attached: show

Not useful

```
}

public String getString() {
  return new String("foo");
}
}
```

(Screenshot from Google's, Tricorder: Building a Program Analysis Ecosystem)

Capture metrics about check types, scan runtime, and false positive rates

Track & evict low signal checks: keep only +95% true positives

Otherwise causes ill will with devs + too much security team operational cost

Continuously Finding: Escape Hatches

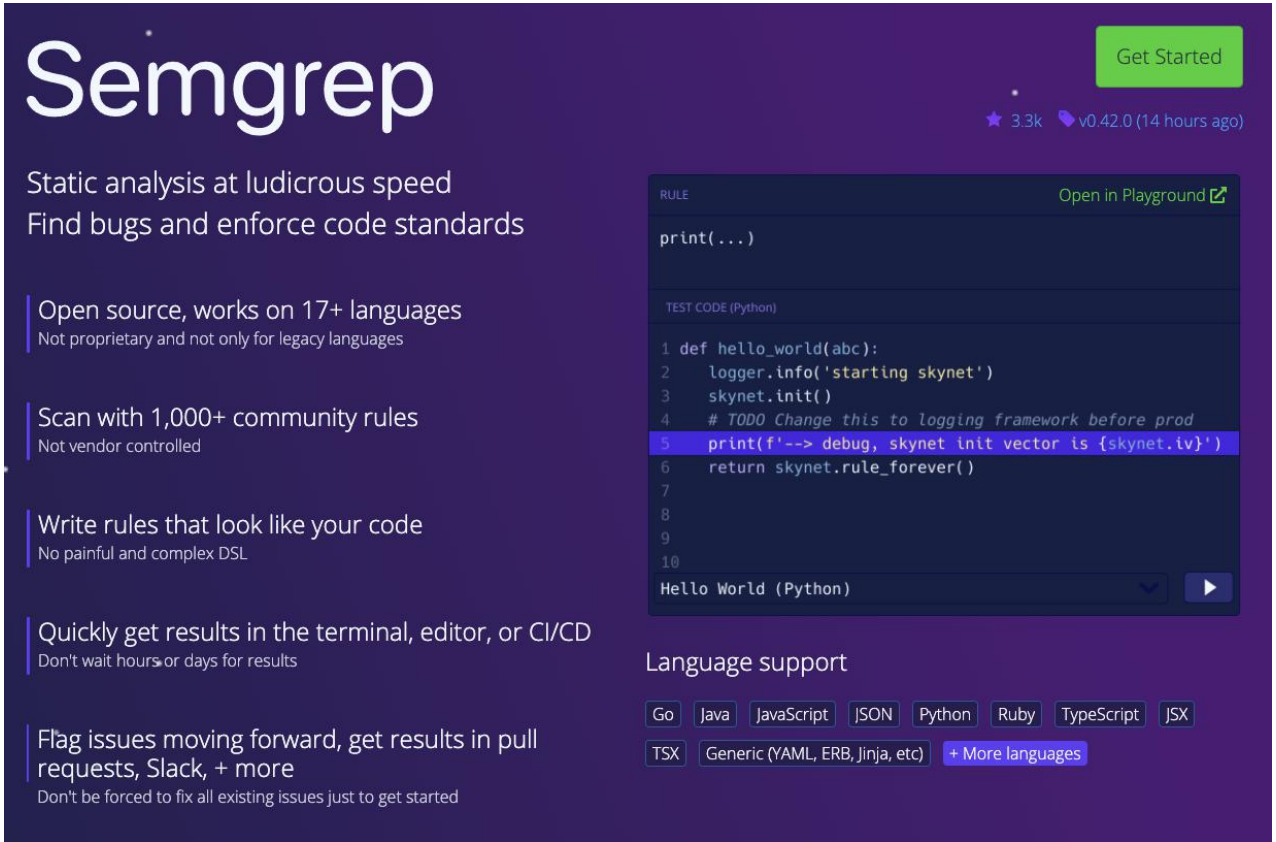
If we use secure frameworks that maintain invariants, all we need to do is detect the functions that let you "escape" from those invariants. For instance:

- `dangerouslySetInnerHTML`
- `exec`
- `rawSQL(...)`
- `myorg.make_superuser`

How to find them?

- Grep
  - Pro: easy to use, interactive, fast
  - Con: line-oriented, mismatch with program structure (ASTs)
- Code-Aware Linter
  - Pro: robust, precise (handles whitespace, comments, ...)
  - Con: Each parser represents ASTs differently; have to learn each syntax

What we do

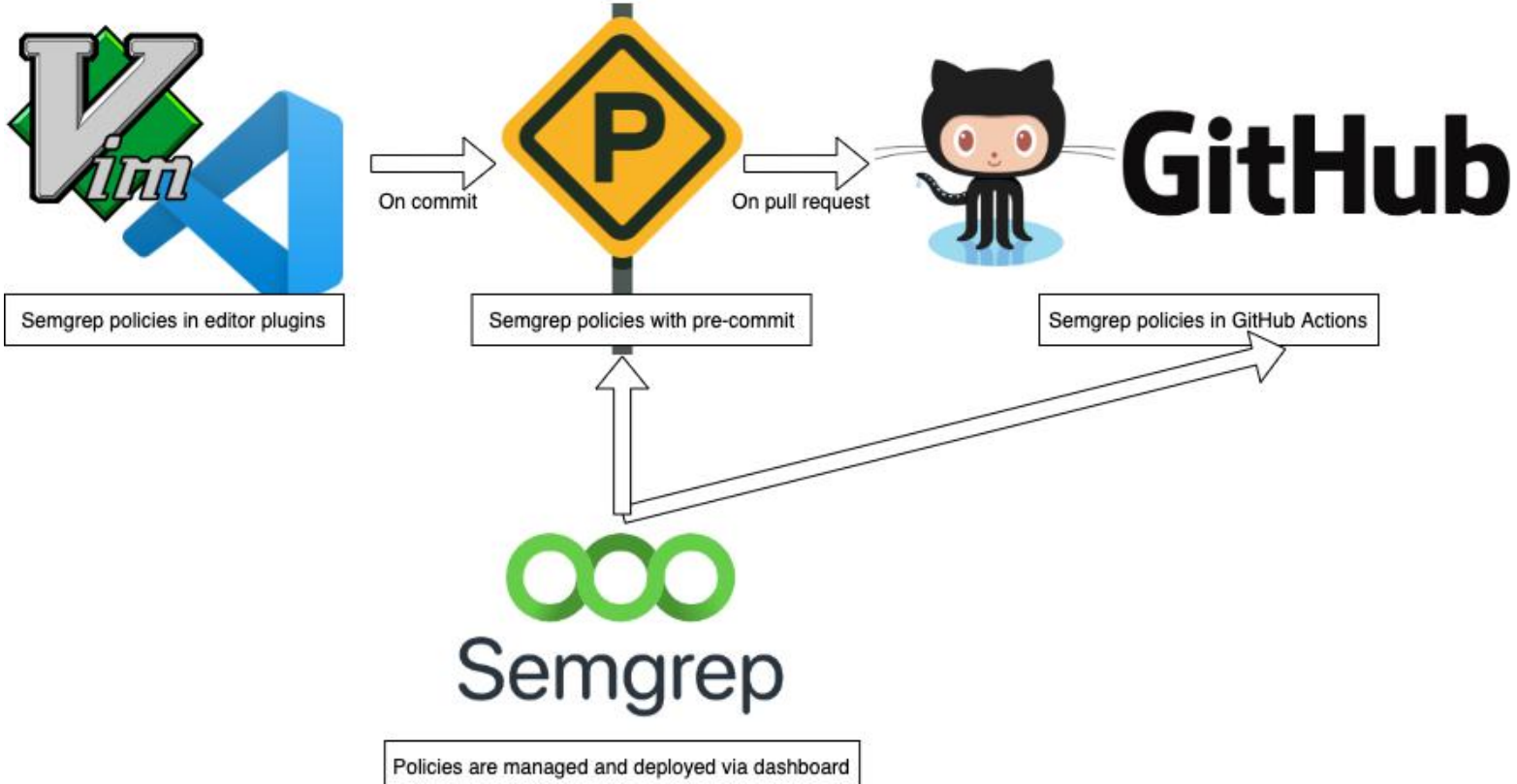

Semgrep
Get Started
3.3k
v0.42.0 (14 hours ago)
Static analysis at ludicrous speed
Find bugs and enforce code standards
Open source, works on 17+ languages
Not proprietary and not only for legacy languages
Scan with 1,000+ community rules
Not vendor controlled
Write rules that look like your code
No painful and complex DSL
Quickly get results in the terminal, editor, or CI/CD
Don't wait hours or days for results
Flag issues moving forward, get results in pull requests, Slack, + more
Don't be forced to fix all existing issues just to get started
RULE
Open in Playground
print(...)
TEST CODE (Python)
1 def hello_world(abc):
2 logger.info('starting skynet')
3 skynet.init()
4 # TODO Change this to logging framework before prod
5 print(f'--> debug, skynet init vector is {skynet.iv}')
6 return skynet.rule_forever()
7
8
9
10
Hello World (Python)
Language support
Go
Java
JavaScript
JSON
Python
Ruby
TypeScript
JSX
TSX
Generic (YAML, ERB, Jinja, etc)
+ More languages

1. Select a vulnerability class

- r2c is young
  - Two (2) primary codebases
  - Limited vulnerability history

- Prioritize based on common problems for the type of application:
  - Web application → XSS
  - Command line interface → Code and Command injection

2. Prevent it at scale



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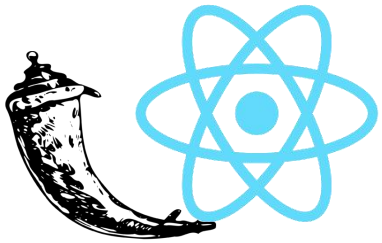


React

Flask

typescript.react.security.audit

Run Locally Add to Policy

react-dangerouslysetinnerhtml

Example 1 Example 2

Example

```
    return <div dangerouslySetInnerHTML={createMarkup()} />;
}

function TestComponent2() {
    // ruleid:react-dangerouslysetinnerhtml
    return <li className={"foobar"} dangerouslySetInnerHTML={createMarkup()} />;
}

function TestComponent3() {
    // ruleid:react-dangerouslysetinnerhtml
```

Setting HTML from code is risky because it's easy to inadvertently expose your users to a cross-site scripting (XSS) attack.

Mitigations

Item	Name	Semgrep rule	Recommendation
1.A.	Ban `render_template_string()`	python.flask.security.audit.render-template-string.render-template-string	Use `render_template()`.
1.B.	Ban unescaped extensions	python.flask.security.unescaped-template-extension.unescaped-template-extension	Only use `.html` extensions for templates. If no escaping is needed, review each case and exempt with `# nosem`.
1.C.	Ban `Markup()`	python.flask.security.xss.audit.explicit-unescape-with-markup.explicit-unescape-with-markup	If needed, review each usage and exempt with `# nosem`.
2.A.	Ban returning values directly from routes	python.flask.security.audit.directly-returned-format-string.directly-returned-format-string	Use `render_template()` or `jsonify()`.
2.B.	Ban using Jinja2 directly	python.flask.security.xss.audit.direct-use-of-jinja2.direct-use-of-jinja2	Use `render_template()`.
3.A.	Ban `| safe`	python.flask.security.xss.audit.template-unescaped-with-safe.template-unescaped-with-safe	Use `Markup()` in Python code if necessary.
3.B.	Ban `{$ autoescape false %}`	python.flask.security.xss.audit.template-autoescape-off.template-autoescape-off	Use `Markup()` in Python code if necessary.
4.A.	Flag unquoted HTML attributes with Jinja expressions	python.flask.security.xss.audit.template-unquoted-attribute-var.template-unquoted-attribute-var	Always use quotes around HTML attributes.
4.B.	Flag template variables in `href` attributes	python.flask.security.xss.audit.template-href-var.template-href-var	Use `url_for` to generate links.
4.C.	Ban template variables in `<script>` blocks.	N/A	Use the `tojson` filter inside a data attribute and `JSON.parse()` in JavaScript.

Making Secure Defaults Easier

https://semgrep.dev/explore

insecure-transport

by Colleen Dai

Ensure your code communicates over encrypted channels instead of plaintext.

Java JavaScript Go

jwt

by Vasilii Ermilov

Avoid common JWT security mistakes

Go Ruby Python Java JavaScript TypeScript

xss

by Grayson Hardaway

Secure defaults for XSS prevention across 5 different languages

Go Ruby Python Java JavaScript

SECURITY CHEAT SHEETS

Django XSS

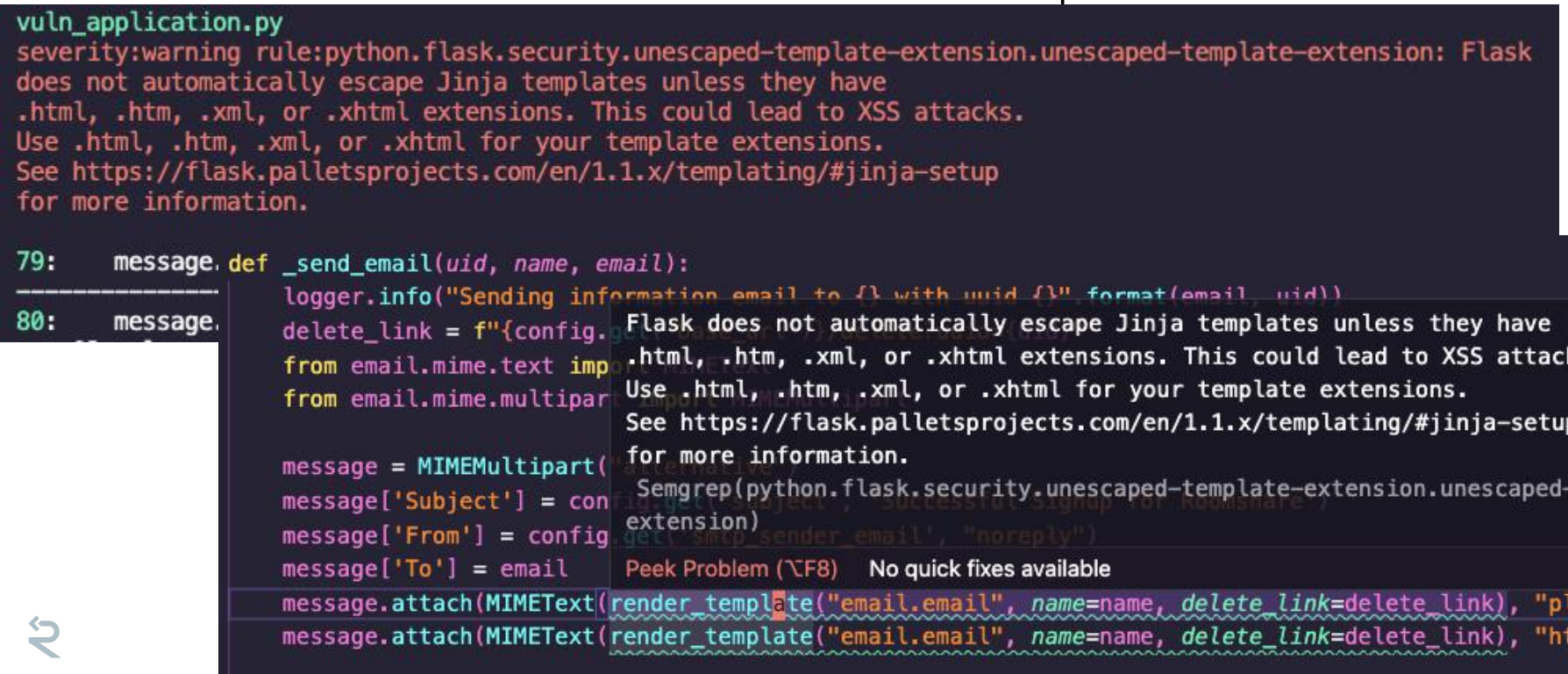
Flask XSS

Java/JSP XSS

Rails XSS

https://semgrep.dev/docs/cheat-sheets/django-xss/

4. Train developers to use the safe pattern +
5. Use tools to enforce the safe pattern



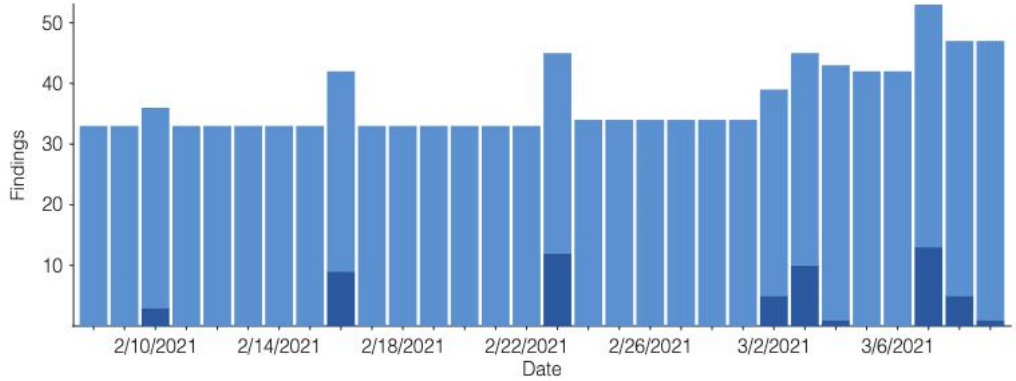
Semgrep Findings Overview over the last 30 days

Include non-blocking findings

Fix Rate: 76% (45 / 59)

13	45	1
Open Findings	Fixed Findings	Muted Findings

Open Findings Over Time



BONUS: Quietly monitor new policies

Conclusion

- Secure defaults are the best way to scalably raise your security bar
  - Not finding bugs (bug whack-a-mole)
- Killing bug classes makes your AppSec team more leveraged
- Define safe pattern → educate / roll out → enforce continuously
  - Fast & lightweight (e.g. semgrep), focus on dev UX

Slides:

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