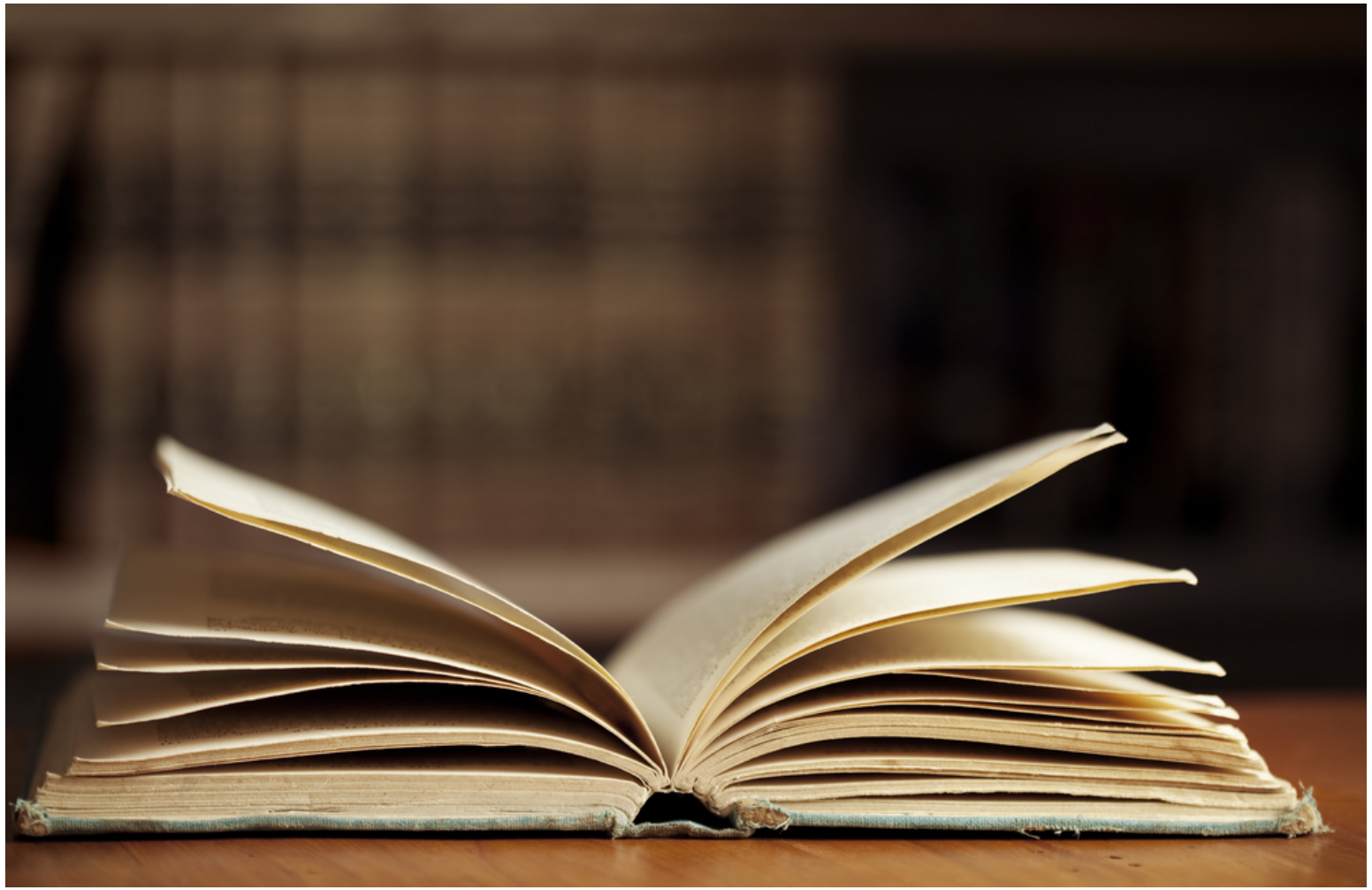
The Open Source Fortress

@iosifache

- Previous lives
  - 1.5 years in the Romanian Army
  - Tech lead in a cybersec startup
- Now software security engineer in the Ubuntu Security Team
- Bucharest-based
- Powered by Americanos
- Long-distance running as a hobby



Roundcube Webmail

- Open source, browser-based IMAP client
- Hosted on GitHub
- With 5.2k stars (as per October 30, 2023)
- Written in XHTML, CSS, JavaScript (with jQuery), and PHP

Q: What are we missing here?

1. `/installer/index.php` route stores the user-controlled configuration in `rcube->config`.
2. When an email with a non-standard format is received, `rcube::exec` executes the output of `getCommand`.

```php
private static function getCommand($opt_name)
{
    static $error = [];

    $cmd = rcube::get_instance()->config->get($opt_name);

    if (empty($cmd)) {
        return false;
    }

    if (preg_match('/^(convert|identify)(\.exe)?$/i', $cmd)) {
        return $cmd;
    }

    // Executable must exist, also disallow network shares on Windows
    if ($cmd[0] != "\\" && file_exists($cmd)) {
        return $cmd;
    }

    if (empty($error[$opt_name])) {
        rcube::raise_error("Invalid $opt_name: $cmd", true, false);
        $error[$opt_name] = true;
    }

    return false;
}
```

> From `program/lib/Roundcube/rcube_image.php`

A: Input sanitisation

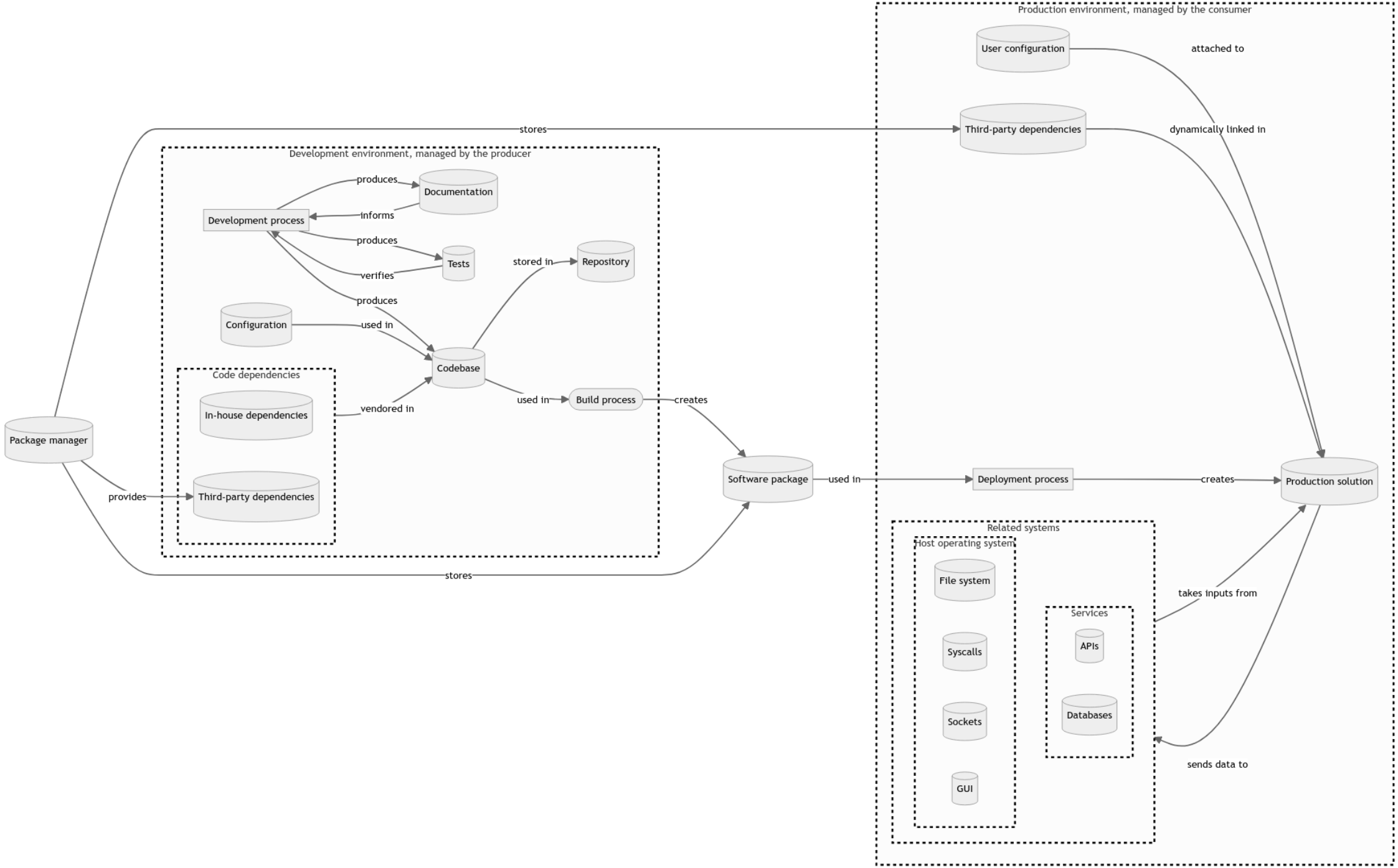
- CVE-2020-12641
- Many vulnerable configuration items, leading to arbitrary code execution
- 7.66% EPSS and 9.8 CVSS
- Used by APT28 to compromise Ukrainian organisations' servers
- Added by CISA in the Known Exploited Vulnerabilities Catalogue

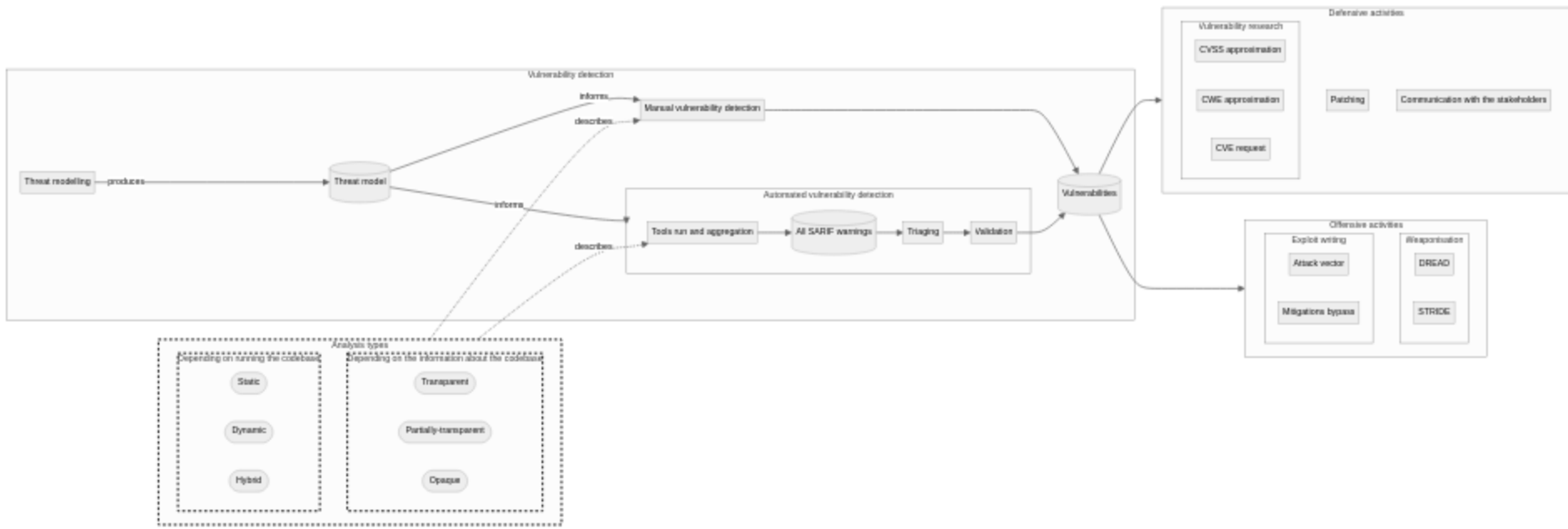
But … Was it preventable?

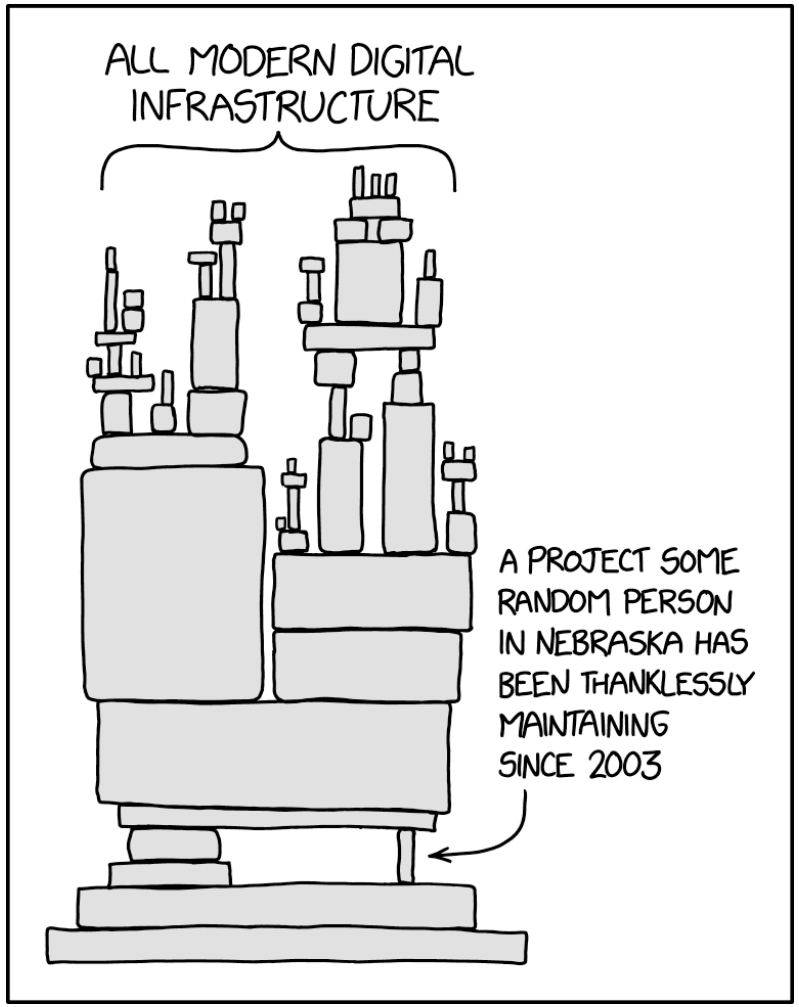
- Yes, but not with standard linters or scanners
- Taint analysis as a possible solution
  - `rcube->config` as a tainted data source
  - `rcube::exec` as a sensitive sink

The Open Source Fortress

- Lots of OSS tools that can be used to proactively detect vulnerabilities
- Structure
  - Factual information
    - General software and software security topics
    - Brief presentation of each analysis technique
  - Practical examples for analysing a vulnerable codebase
    - Infrastructure and access
    - Documentations
    - Proposed solutions


Production environment, managed by the consumer
User configuration
attached to
Third-party dependencies
dynamically linked in
stores
Development environment, managed by the producer
produces
Documentation
Development process
informs
produces
Tests
stored in
Repository
verifies
produces
Configuration
used in
Codebase
Code dependencies
In-house dependencies
vendored in
used in
Build process
creates
Package manager
provides
Third-party dependencies
Software package
used in
Deployment process
creates
Production solution
stores
Related systems
Host operating system
File system
Syscalls
Sockets
GUI
Services
APIs
Databases
takes inputs from
sends data to


Vulnerability detection
Threat modelling
produces
Threat model
informs
describes
Manual vulnerability detection
informs
describes
Automated vulnerability detection
Tools run and aggregation
All SARIF warnings
Triaging
Validation
Vulnerabilities
Analysis types
Depending on running the codebase
Static
Dynamic
Hybrid
Depending on the information about the codebase
Transparent
Partially-transparent
Opaque
Defensive activities
Vulnerability research
CVSS approximation
CWE approximation
CVE request
Patching
Communication with the stakeholders
Offensive activities
Exploit writing
Attack vector
Mitigations bypass
Weaponisation
DREAD
STRIDE


ALL MODERN DIGITAL INFRASTRUCTURE
A PROJECT SOME RANDOM PERSON IN NEBRASKA HAS BEEN THANKLESSLY MAINTAINING SINCE 2003

YES,

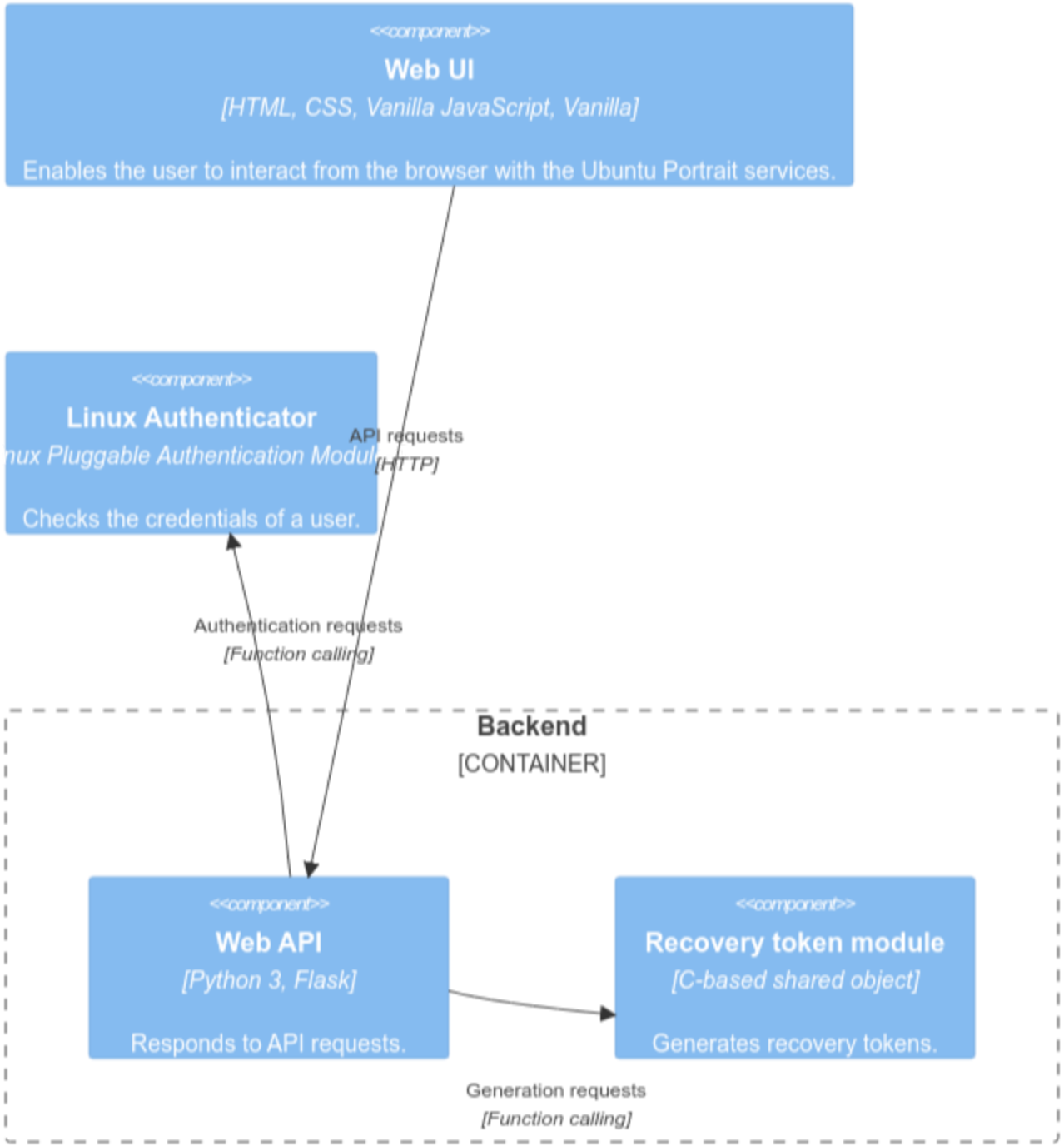
- Large scale use in:
  - Profitable companies
  - Critical infrastructures
- Permissive licences
- Publicly reviewable code

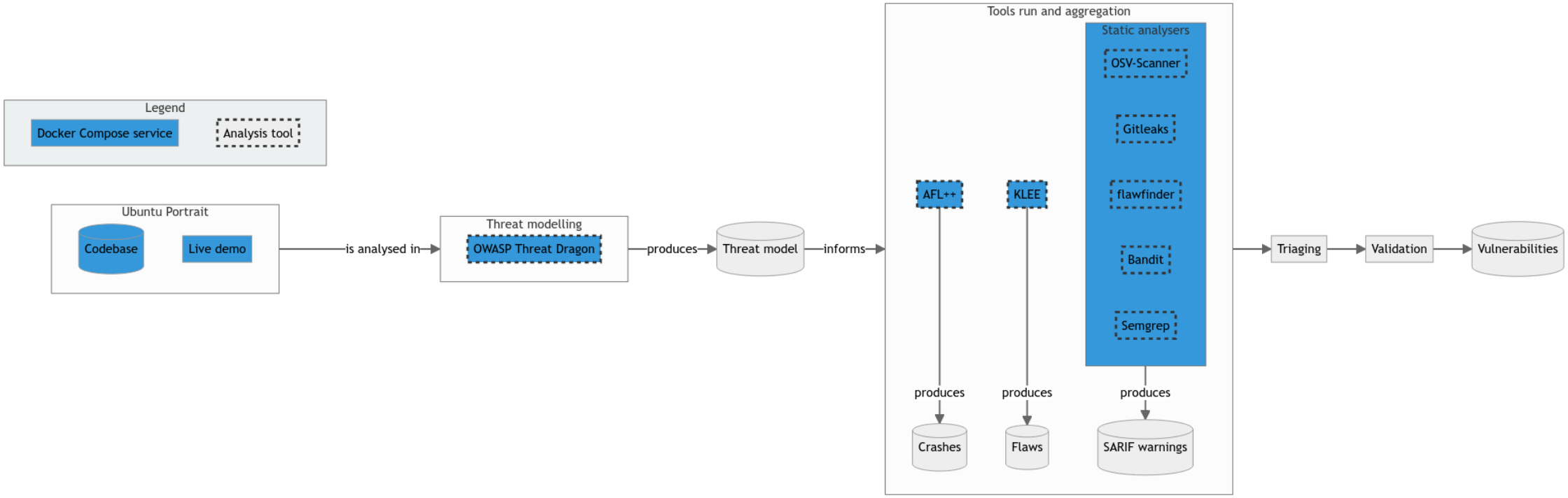
BUT

- Unpaid maintainers
- Unmaintained, vulnerable projects
- Lack of ethical security testing
- Low-hanging fruits for threat actors

Ubuntu Portrait

- WebGoat-like codebase
- "*lightweight piece of software that runs on an Ubuntu server and allows users to control it through their browsers*"
- On-premise deployment
- Written in Python and C
- 12+ embedded vulnerabilities


<<component>>
Web UI
[HTML, CSS, Vanilla JavaScript, Vanilla]
Enables the user to interact from the browser with the Ubuntu Portrait services.
<<component>>
Linux Authenticator
nux Pluggable Authentication Modul
Checks the credentials of a user.
API requests
[HTTP]
Authentication requests
[Function calling]
Backend
[CONTAINER]
<<component>>
Web API
[Python 3, Flask]
Responds to API requests.
<<component>>
Recovery token module
[C-based shared object]
Generates recovery tokens.
Generation requests
[Function calling]


Legend
Docker Compose service
Analysis tool
Ubuntu Portrait
Codebase
Live demo
is analysed in
Threat modelling
OWASP Threat Dragon
produces
Threat model
informs
Tools run and aggregation
Static analysers
OSV-Scanner
Gitleaks
flawfinder
Bandit
Semgrep
AFL++
KLEE
produces
produces
produces
Crashes
Flaws
SARIF warnings
Triaging
Validation
Vulnerabilities

Setup

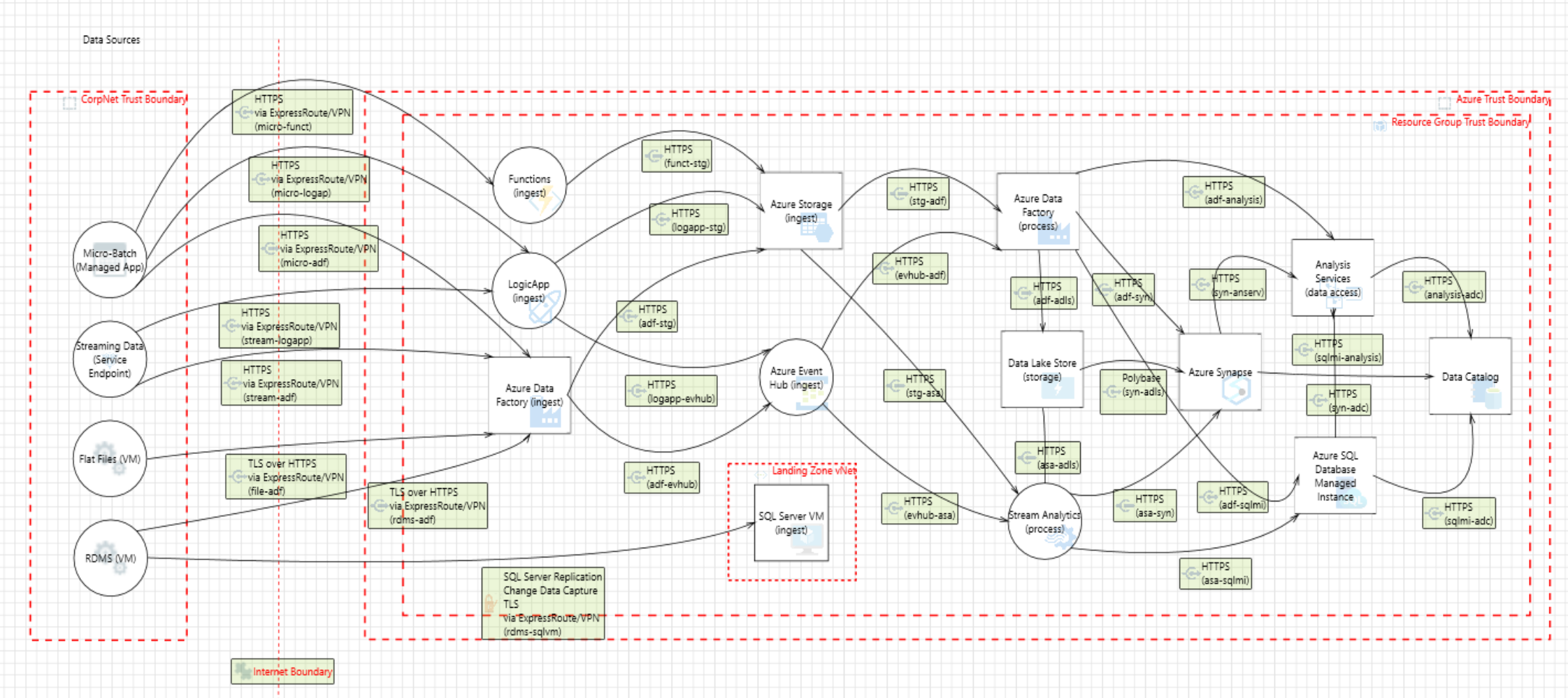
- Only `docker compose up` for:
  - Pulling the images from Docker Hub or GHCR
  - Creating and running the containers

Demo


Soymilk
ORIGINAL
7g SOY POWERED PROTEIN
CHECK FOR
CAT ARM B4
CLOSING

Threat modelling

- Identifying asset and threats
  - What we need to defend?
  - What can go wrong?
- Advantages
  - Secure by design
  - Prioritisation
  - Stakeholder confidence booster
  - Legal requirement (e.g., USA and Singapore)



> From `AzureArchitecture/threat-model-templates`

OWASP Threat Dragon

- Threat modelling tool backed by OWASP
- Usual process
    i. Threat model creation
    ii. Diagram creation: STRIDE, CIA
    iii. Asset representation: stores, process, actor, data flow, trust boundaries
    iv. Manual threat identification, with type, status, score, priority, description, and mitigation

Demo

"You do realize the key is under the mat."

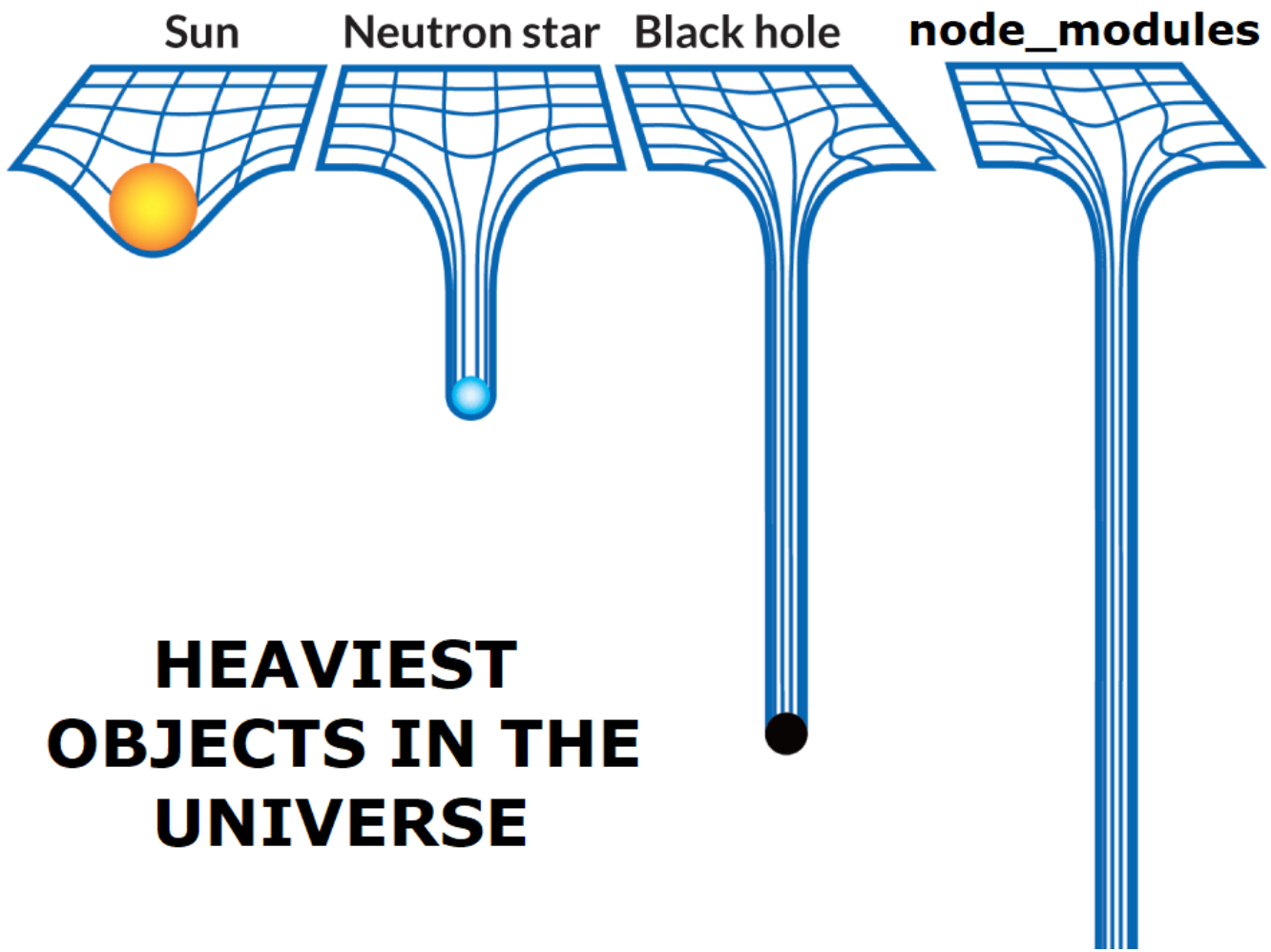
Secret scanning

- Searching for specific patterns or entropy for a secret (API key, credentials, tokens, etc.)
- Community (generic) rules

Gitleaks

- Detector for hardcoded secrets
- Analysis of the entire Git history
- Support for baselines and custom formats of secrets

Demo


Sun
Neutron star
Black hole
node_modules
HEAVIEST OBJECTS IN THE UNIVERSE

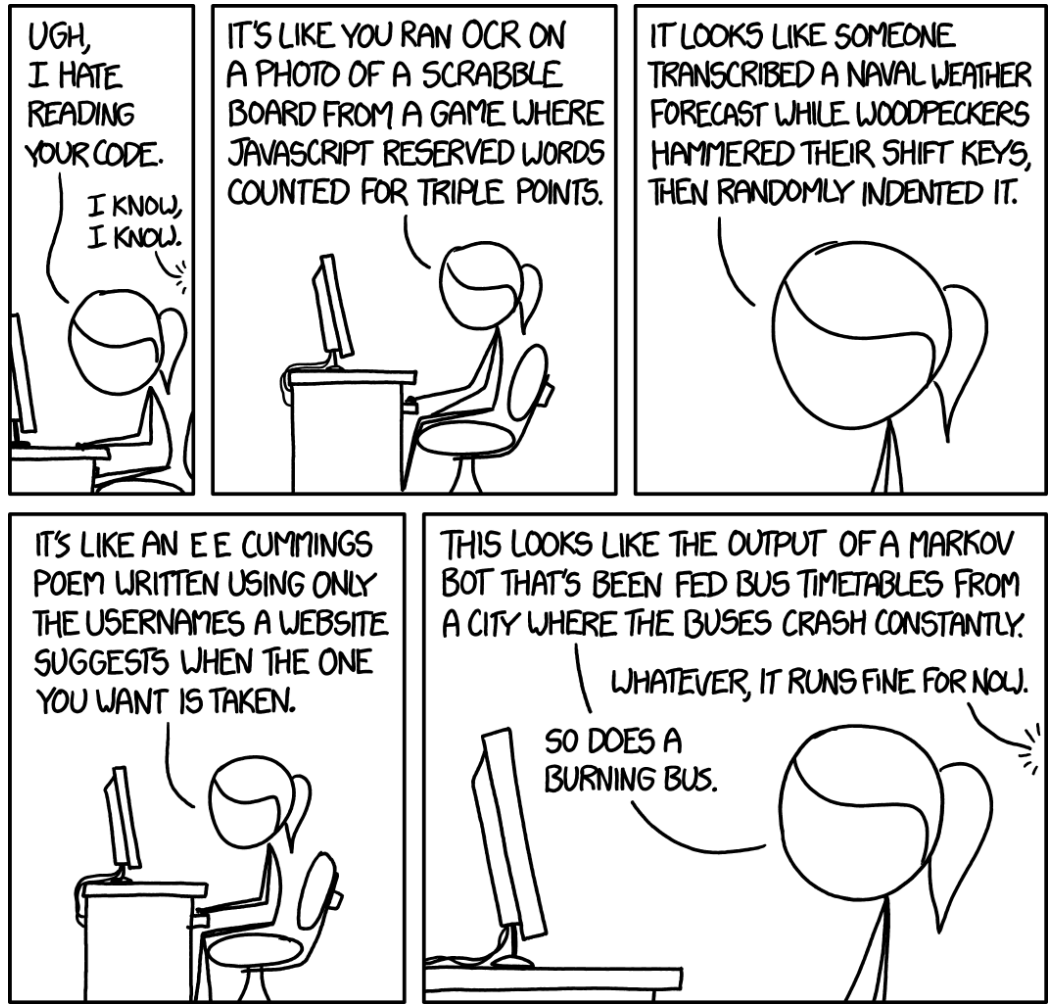
Dependency scanning

- Iterating through all dependencies for finding their vulnerabilities
- Usage of the dependencies declaration list

OSV-Scanner

- Client for Google's OSV database, which embeds:
  - GitHub Security Advisories
  - PyPA
  - RustSec
  - Global Security Database
- Support for ignored vulnerabilities

Demo


UGH, I HATE READING YOUR CODE.
I KNOW, I KNOW.
IT'S LIKE YOU RAN OCR ON A PHOTO OF A SCRABBLE BOARD FROM A GAME WHERE JAVASCRIPT RESERVED WORDS COUNTED FOR TRIPLE POINTS.
IT LOOKS LIKE SOMEONE TRANSCRIBED A NAVAL WEATHER FORECAST WHILE WOODPECKERS HAMMERED THEIR SHIFT KEYS, THEN RANDOMLY INDENTED IT.
IT'S LIKE AN E E CUMMINGS POEM WRITTEN USING ONLY THE USERNAMES A WEBSITE SUGGESTS WHEN THE ONE YOU WANT IS TAKEN.
THIS LOOKS LIKE THE OUTPUT OF A MARKOV BOT THAT'S BEEN FED BUS TIMETABLES FROM A CITY WHERE THE BUSES CRASH CONSTANTLY.
WHATEVER, IT RUNS FINE FOR NOW.
SO DOES A BURNING BUS.

Linting

- Static analysis tool for finding issues before compiling/running the code
- Issues
  - Formatting
  - Grammar (for example, non-inclusive expressions)
  - Security

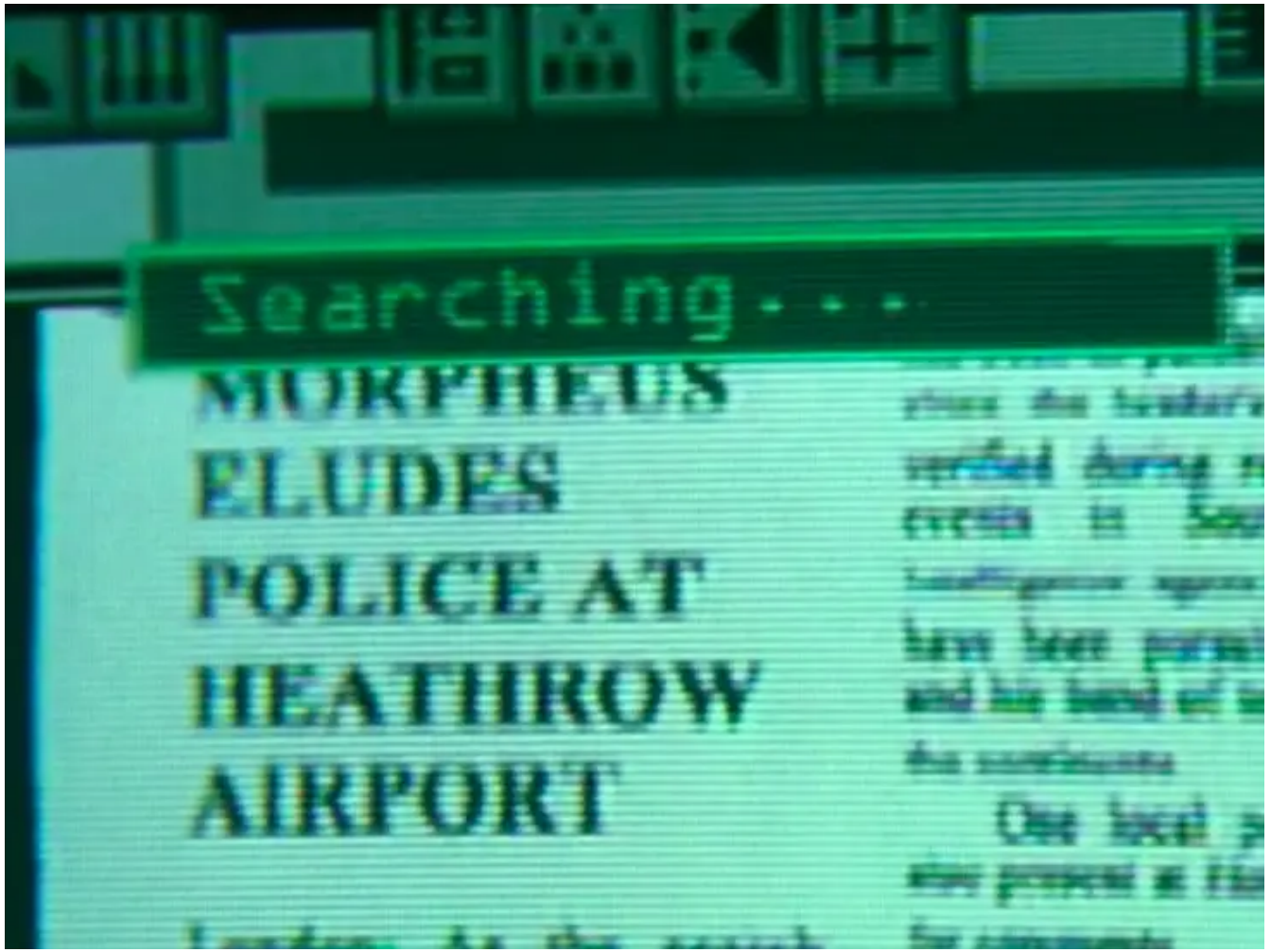
Bandit

- Linter for Python
- Abstract syntax tree representation of the code
- Custom modules for:
  - Patterns of suspicious code
  - Deny lists of imports and function calls
  - Report generation
- Support for baselines

flawfinder

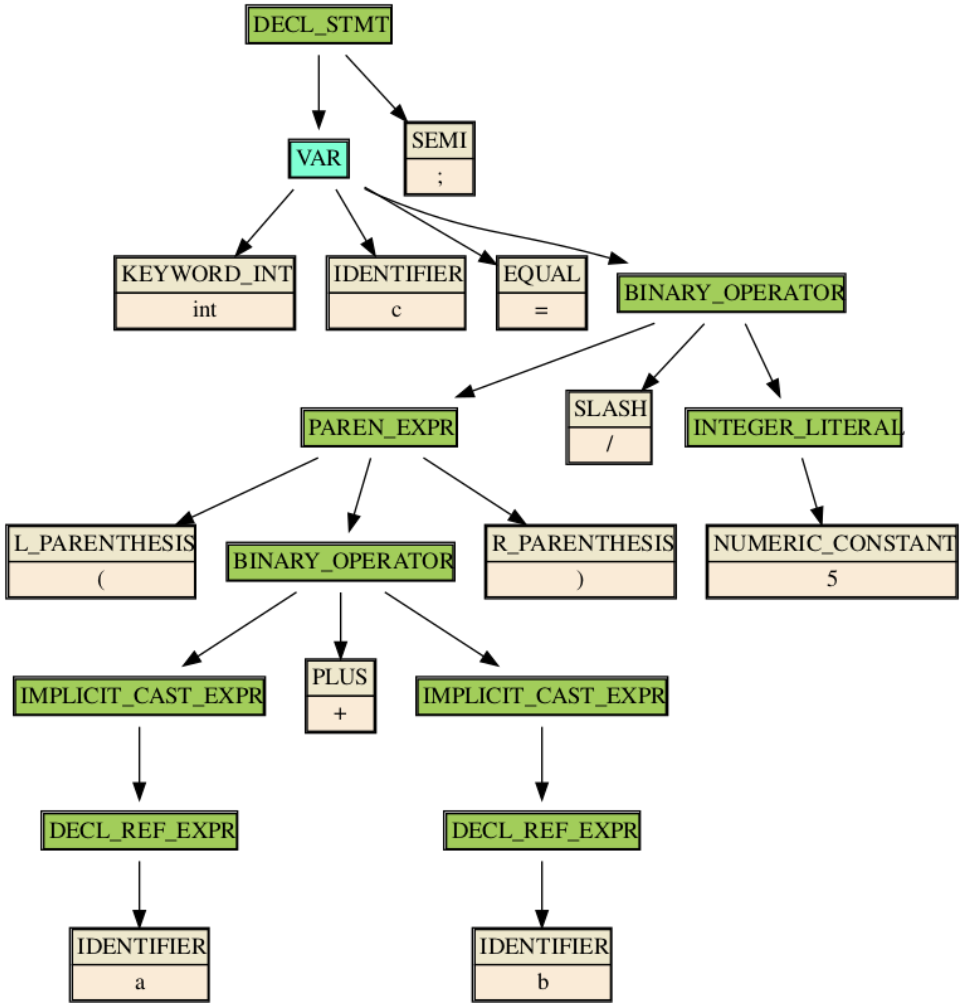
- Linter for C
- Lexical scanning with detection of sensitive tokens

Demo


Searching...
MORPHEUS
ELUDES
POLICE AT
HEATHROW
AIRPORT

Code querying

- Searchin a specific pattern in the codebase
- Optional abstract representation of the codebase
  - Abstract syntax trees
  - Control flow graphs
- Query types
  - Lexical
  - Regex
  - Data structures specific to the abstract representation
- Community queries (but generic)



> From Trail of Bit's "Fast and accurate syntax searching for C and C++"

Semgrep

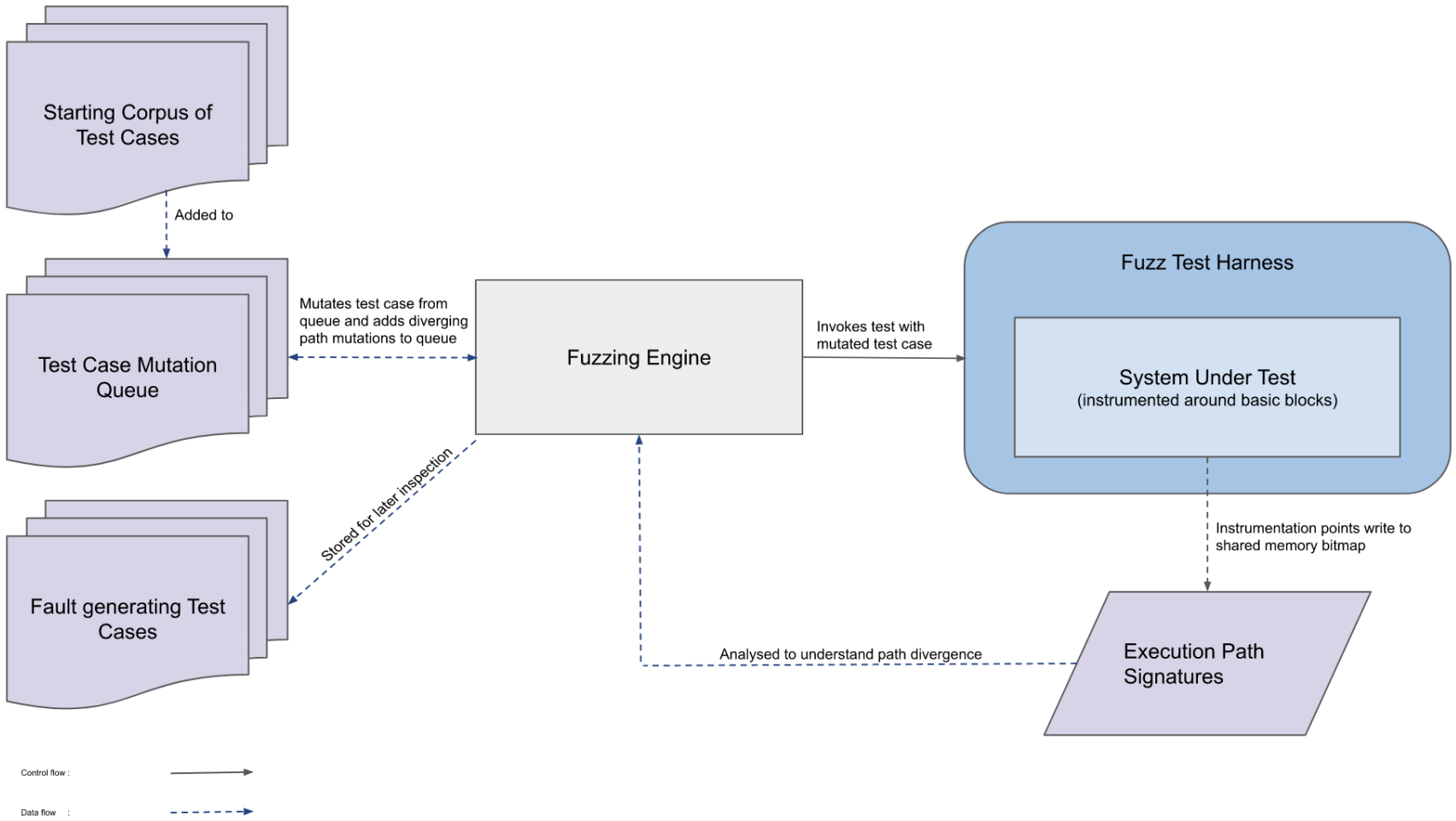
- (Partially) open-source code scanner
- Support for 30+ programming languages
- No prior build requirements
- No DSL for rules
- Default or third-party rules

Demo


FREE

Fuzzing

- Running a program and offering random, unexpected inputs
- A crash = a security issue
- BFS traversal of the CFG
- Optimisation
  - Instrumenting the source code
  - Knowing the input format
  - Defining the states
  - Testing all input streams



> From AdaCore's "Finding Vulnerabilities using Advanced Fuzz testing and AFLplusplus v3.0"

AFL++

- An American Fuzzy Lop (AFL) fork
- Additional features compared to AFL
  - QEMU emulation
  - Persistent mode
  - Optimisations
- Embedded in Google's OSS-Fuzz

Demo

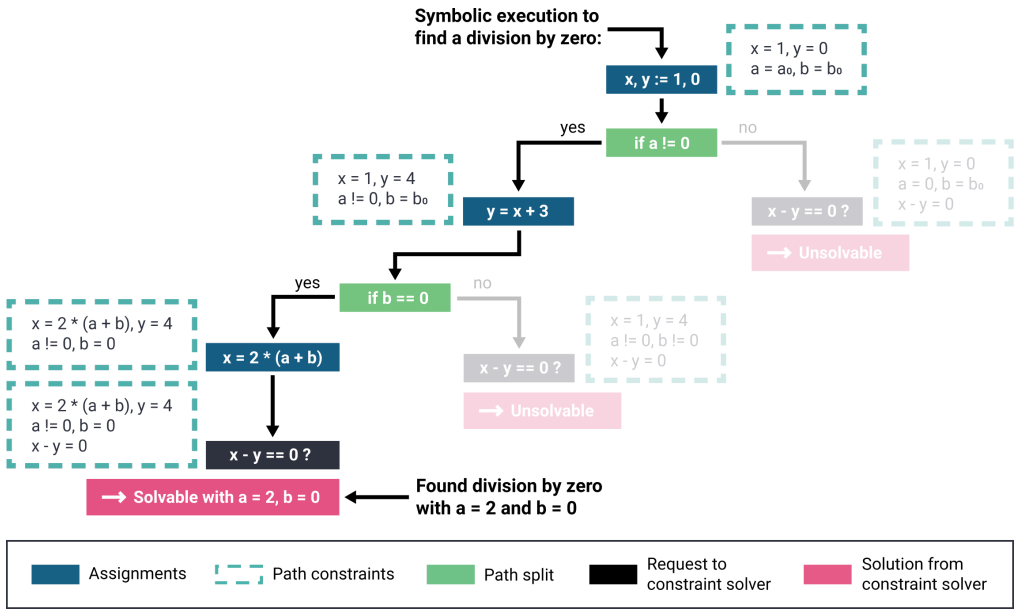
Symbolic execution

- Investigating all CFG paths by replacing the concrete values with symbolic ones
- Components
  - Sources
  - Sinks
  - Patterns
- Path explosion problem

```c
int f(int a, int b){
    int x = 1, y = 0;

    if (a != 0) {
        y = x + 3;
        if b == 0 {
            x = 2 * (a + b);
        }
    }

    return (a + b) / (x - y);
}
```



> From symflower's "What is symbolic execution for software programs"

KLEE

- Generic symbolic execution with security use cases
- Built on LLVM

Demo

Other techniques

- Stress/load testing
  - JMeter for many protocols and services
  - `k6` for Kubernetes
- Web dynamic analysis
  - OWASP's Zed Proxy Attack


Programmer
Task that takes
5 minutes
Can it be automated?

Security tooling automation

- SARIF Multitool for performing operations with SARIF files (merging, paging, querying, supressing, etc.)
- Make and Poe the Poet for running tasks
- IDE workflows (e.g., VSCode tasks) for running the tooling while coding
- `pre-commit` for managing Git pre-commit hooks
- `act` or GitLab Runner for running CI/CD workflows locally
- GitHub Actions or GitLab pipelines for running CI/CD workflows


CHECK AFTER ENGINE START
1 Oil pressure CHECKED 1 pf
2 RPM 740 +/- 30 CHECKED 2 pf
3 Warm up time START 3 pf
Warm up:
Idle.....2 minutes
50% load.....until Oil >50° and Coolant > 60°C
4 Fuel pumps (2) check OFF 4 pf
5 Fuel selectors (2) X-FEED 5 pf
6 Pitot heat ON, annunciation + Amps checked 6 pf
7 Pitot heat OFF 7 pf
8 PFD/MFD NORMAL MODE 8 pf
9 Avionics master ON 9 pf
FMS SETUP
I nitialize profile (AUX 4, MAP)
F light plan
R adios (COM, NAV, ADF, DME, CDI, BRG ½)
P erformance (speed bugs; Flight ID if applicable)
10 FMS setup COMPLETED 10 pf
AUTOPILOT TEST
DISCONN press, check electric trim not working
AP ON, check annunciations and FD
DISCONN press, check AP off
GA button press, check FD commands climb
11 Autopilot test COMPLETED 11 pf
12 Flood light CHECKED, ON as required 12 pf
rudder trim
AP DISC
PTT

Security checklist I: Proactive vulnerability discovery

☑️ Create a threat model.
☑️ Choose a suite of security tools to scan your codebase.
☑️ Automate the suite of security tools in local/development environments and CI/CD pipelines, with quality gates.
☑️ Request the integration of your project with OSS-Fuzz.
🔁 Periodically check for vulnerabilities in your dependencies.
🔁 Constantly validate the warnings from your security tooling.
🔁 Keep the threat model updated.

> One-time activities are marked with ☑️, and the recurrent ones with 🔁.

Security checklist II: Secure users

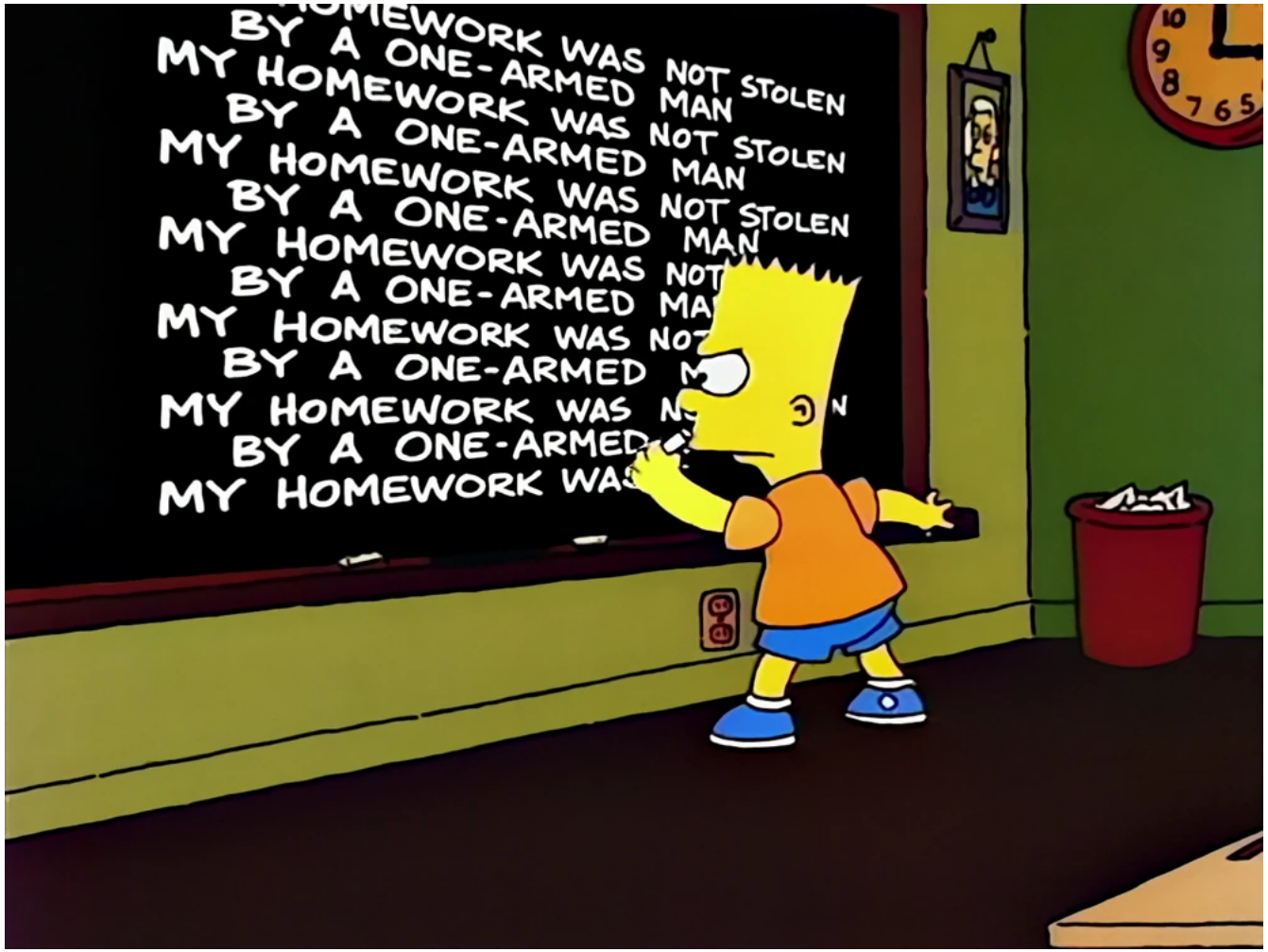
- ☑️ Design your software to be secure by default.
- ☑️ Have security recommendations for users.
- ☑️ Create SBOMs.

> One-time activities are marked with ☑️, and the recurrent ones with 🔁.

Security checklist III: Established security reporting process

☑️ Have a standardised, documented process for responding to vulnerabilities.
☑️ Create a security policy with preferred way to contact and report format.
☑️ Find backup security responders.
🔁 Be transparent and verbose with the reported vulnerabilities: mention patching commits, attach security tags to issues, and request CVE IDs.

> One-time activities are marked with ☑️, and the recurrent ones with 🔁.


MY HOMEWORK WAS NOT STOLEN
BY A ONE-ARMED MAN
MY HOMEWORK WAS NOT STOLEN
BY A ONE-ARMED MAN
MY HOMEWORK WAS NOT STOLEN
BY A ONE-ARMED MAN
MY HOMEWORK WAS NOT
BY A ONE-ARMED MA
MY HOMEWORK WAS NOT
BY A ONE-ARMED M
MY HOMEWORK WAS N
BY A ONE-ARMED
MY HOMEWORK WA

Recap I

- Roundcube Webmail vulnerability
- Open Source Fortress
- Software development model
- Software security model
- Open source software

Recap II

- Techniques
  - Threat modelling
  - Secret scanning
  - Dependency scanning
  - Linting
  - Code querying
  - Symbolic execution
  - Fuzzing
- Automation
- Checklist


That's all Folks!