

ForAllSecure

A

Welcome to the Mayhem Fuzzing Hackathon!

December 3rd, 2022



Mayhem Heroes Program



ForAllSecure Products Solutions Resources & Labs Company Get demo



ForAllSecure Launches \$2 Million Mayhem Heroes Program

EDITORIAL STAFF • APRIL 06, 2022

Pittsburgh, PA – April 6, 2022 – ForAllSecure, a leader in modern application security testing, today announced that it is investing \$2 million to make open source software (OSS) more secure. The company also announced that it will offer a free version of its flagship product *Mayhem*. The winner of the DARPA Cyber Grand Challenge and featured in a Smithsonian Institution AI exhibit, Mayhem will now be free to anyone integrating the product to any project on GitHub.

Open source software is mission critical, but its security is severely under-tested. The [Linux Foundation](#) reports that OSS developers want help with free security audits and the addition of security to their continuous integration pipeline. ForAllSecure is offering up to \$2 million to meet these needs with its [Mayhem Heroes](#) program. Anyone who integrates Mayhem into a qualified OSS GitHub project will receive \$1,000.

"We're on a mission to automatically find and fix the world's exploitable bugs before attackers can succeed. OSS developers need help, and don't have access to the tools they need to quickly and easily find vulnerabilities," said David Brumley, Chief Executive Officer and co-founder of ForAllSecure. "Our Mayhem Heroes program democratizes software security testing, will make tens of thousands of OSS projects safer, and ultimately impact the security of systems used by everyone around the world."

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Mayhem Heroes Program So Far...

The screenshot shows the Mayhem for Code web interface. At the top, there's a dark header bar with the Mayhem logo, navigation links for 'Projects', 'Organizations', and 'Runs (0 Active)', a search bar, and a user profile for 'fasmania ADMIN'. Below the header, the main content area has a sidebar on the left with icons for 'Projects' (selected), 'Members', 'Teams', and 'Settings'. The main panel displays various performance metrics:

Category	Value	Unit
Projects	1,337	Projects
Targets	1,951	
Users	3	Users
Defects Found	9,770	
Test Cases	2,073,671	
Tests Run	119,538,166,439	

Below these metrics is a section titled 'Projects' which lists eight specific projects with their last run status and associated runs:

Project	Last Run	Run ID
mayhemheroes / hactool	2 minutes ago	hactool / Run 9
mayhemheroes / openmls	2 minutes ago	welcome-decode / Run 35
mayhemheroes / rustybgp	1 minute ago	bgp-decode / Run 8
mayhemheroes / mrpt	a minute ago	ini2yaml / Run 13
mayhemheroes / stratagus	4 minutes ago	png2stratagus / Run 14
mayhemheroes / jettison	2 minutes ago	jsonfuzzer / Run 7
mayhemheroes / blurhash-ruby	13 minutes ago	encode-fuzz / Run 1

ForAllSecure



Agenda

- Mission
- Getting Help ~10 mins
 - Community and Discord
- Fuzzing Introduction ~45 mins
 - Mayhem Setup
 - Fuzzing Lighttpd
 - Fuzzing Overview and Fuzz Targets
- Mayhem CLI ~15 mins
- Packaging for Mayhem ~30 mins
 - Docker overview
 - Docker + Mayhem Exercise
- Build Systems ~30 mins
 - Common Patterns
 - CMake Exercise
- ~ Lunch ~ 30 mins
- OSS Fuzzers ~30 mins
 - libFuzzer Example
 - libFuzzer Exercise
- GitHub Actions ~30 mins
- Case Study ~20 mins
- Conclusions ~10 mins
 - Training Survey
- Mayhem Heroes ~10 mins
- Survey and Conclusion ~10 mins

After this training, you will be able to

- Explain what fuzz testing is
- Fuzz an application with Mayhem
- Reproduce a found defect
- Package a fuzz target using Docker
- Build a fuzz target
- Add instrumentation to a target with libFuzzer
- Automate the whole process using Github Actions

Mission



Fact

Growing cybersecurity
talent shortage

570x

Developers than
cybersecurity experts



Worse

We're shipping code
faster than ever, as
insecure as ever

87%

Of application security
isn't automated today



Result

Offense has a permanent
advantage today.

Status quo

Is not working.

fluorescence

Richard Zhu



— Vision

A world where computers automatically test and protect the world's software from exploitable bugs at speeds and scale faster than any attacker.

Making It Autonomous

Suppose you managed a team of 3 humans looking for zero days



- 1. Work on the same app**
 - Software registry w/ docker
- 2. Run the app the same way**
 - Mayhemfile
- 3. Share work and reproduce results**
 - Results test corpus
- 4. Focus on a particular part of app**
 - Harnessing
- 5. Work intelligently**
 - Advanced algorithms

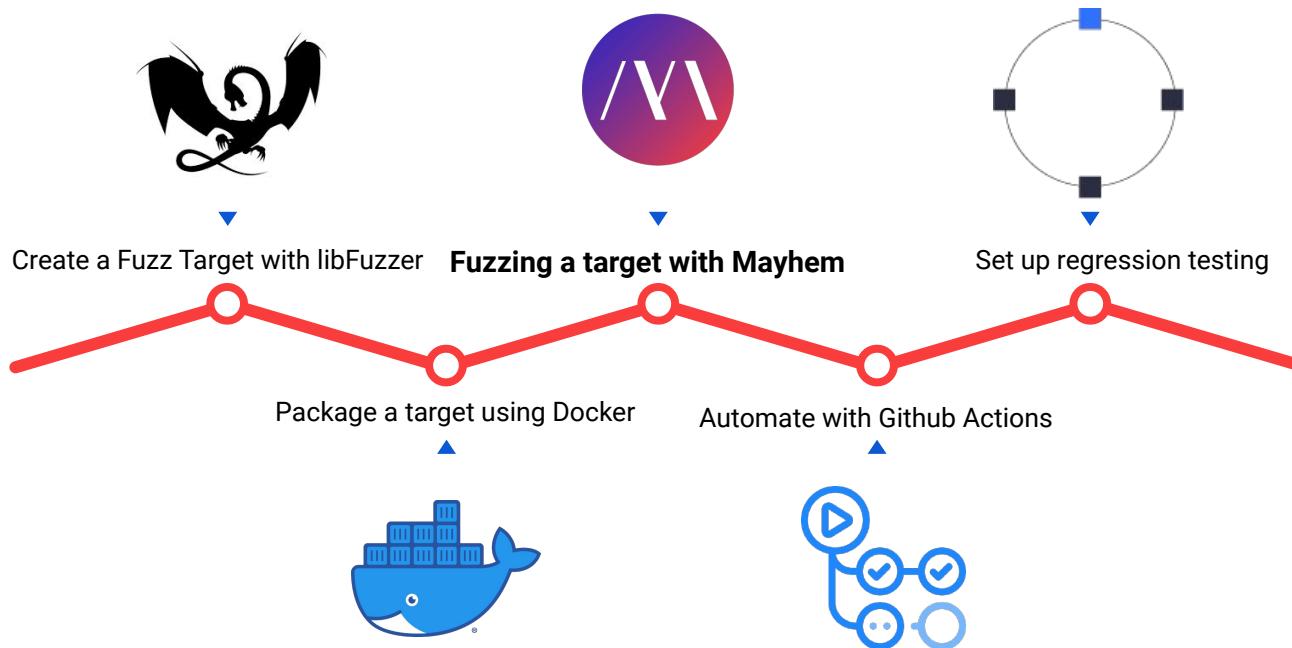
Fuzzing / fəzɪŋ / v.

The process of automatically sampling and testing the program input space to elicit new program behaviors.

Fuzz testing is a technique appsec experts leverage.

Open Source software is everywhere. So let's fuzz it before the bad guys do.

Fuzzing CI/CD Pipeline



Getting Help

UMD Hackathon Discord

Join us on Discord! You can message with questions, ideas, or anything you'd like:

Invite Link:

<https://discord.gg/KhSGZnrEpp>



Or, scan the QR Code with your phone:



Sign Up to the Community

- Navigate to **community.forallsecure.com**
- Click **Sign Up** at the top of the page
- Select “With Github”
- Login to Github if not already logged in
- **You are now ready to explore the Community**
- Navigate to **General > Tips and Tricks**
- **Learn Mayhem Hacking Best Practices!**

The screenshot shows the ForAllSecure community forum interface. At the top, there's a navigation bar with a logo, user links (Sign Up, Log In), a search icon, and a menu icon. Below the navigation is a section titled "Announcements" with four cards:

- ANNOUNCEMENT: Fuzzing Essentials: Training for Federal Employees and Contractors
- ANNOUNCEMENT: Fuzz in Your Language
- ANNOUNCEMENT: The Role of Functional Testing in Application Security
- ANNOUNCEMENT: Carnegie Mellon University Hackathon

Below the announcements is a navigation bar with links: General, Tips and Tricks, all tags, Latest (which is underlined), and Top.

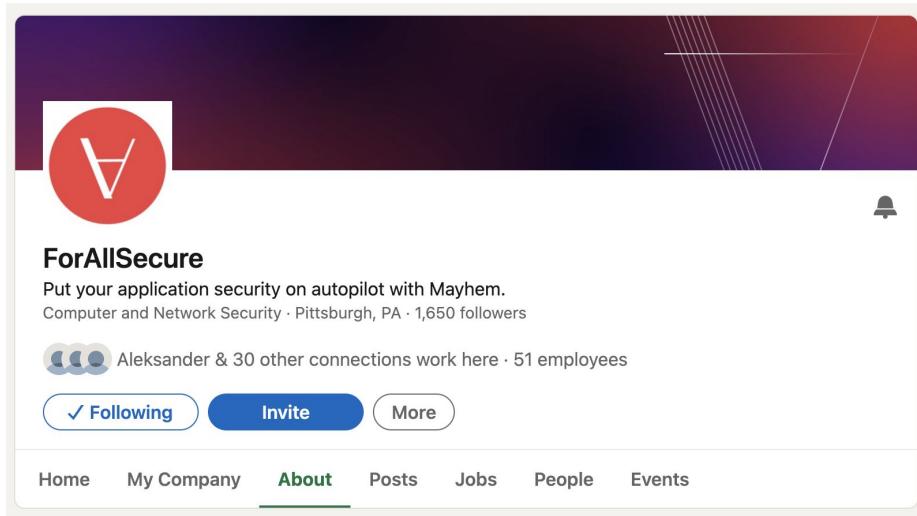
The main content area displays a list of topics under the "Tips and Tricks" category:

Topic	Replies	Views	Activity
* About the Tips and Tricks category	0	0	Feb 2
How to access, share and print a Mayhem Defects Report	0	4	8d
How to download and install Mayhem CLI	0	9	21d
How to figure out if defects are in your code or third-party code	0	7	26d
How to use target input in Mayhem	0	7	26d
How to fuzz firmware with Mayhem	0	6	28d
How to run multiple commands in Mayhem	0	8	28d
How to qualify good initial targets to fuzz with Mayhem	0	8	28d
How to reproduce defects with Mayhem	0	24	Feb 15

At the bottom, a message states: "There are no more Tips and Tricks topics."

Follow ForAllSecure on LinkedIn

- Login to your LinkedIn account
(create one if you don't have it already!)
- Search for ForAllSecure
- FOLLOW ForAllSecure to get the latest updates



Let's get started!

Lighttpd (“Lighty”)

Lighttpd

lighttpd is an open-source web server optimized for speed-critical environments while remaining standards-compliant, secure and flexible. It was originally written by Jan Kneschke as a proof-of-concept of the c10k problem – how to handle 10,000 connections in parallel on one server, but has gained worldwide popularity. Its name is a portmanteau of "light" and "httpd". [Wikipedia](#)

Original author(s): Jan Kneschke

Written in: C

Available in: English

Type: Web server

License: 3-clause BSD



LX 4008 Switch



Siemens SINAUT
MD741-1 EGPRS-Router



Lighttpd (“Lighty”)

SHODAN [lighttpd-1.4.15](#)  Explore Pricing Enterprise Access

Exploits Maps

TOTAL RESULTS 557

TOP COUNTRIES



Germany	260
Korea, Republic of	98
Italy	56
Spain	41
United States	41

TOP SERVICES

HTTPS	382
HTTP	66
AndroMouse	29
HTTP (81)	26
Symantec Data Center Security	24

TOP ORGANIZATIONS

Deutsche Telekom AG	190
Korea Telecom	57
Telekom Deutschland GmbH	54
Telecom Italia Mobile	52
Telefonica de Espana	26

New Service: Keep track of what you have connected to the Internet. Check out [Shodan Monitor](#)

401 - Unauthorized 

2.193.198.147
Telecom Italia Mobile
Added on 2021-03-13 19:42:12 GMT
 Italy, Bari

SSL Certificate
Issued By:
- Organization: Siemens AG
Issued To:
- Organization: Siemens AG

HTTP/1.1 401 Unauthorized
WWW-Authenticate: Digest realm="SINAUT MD741-1", nonce="6f7aff042563c0437ef134925ae27a22", qop="auth"
Content-Type: text/html
Content-Length: 351
Date: Wed, 24 Feb 2021 06:19:55 GMT
Server: lighttpd/1.4.15

Supported SSL Versions
SSLv2, SSLv3, TLSv1

401 - Unauthorized 

37.84.234.242
Telekom Deutschland GmbH
Added on 2021-03-13 19:09:02 GMT
 Germany, Bingen am Rhein

SSL Certificate
Issued By:
- Organization: Siemens AG
Issued To:
- Organization: Siemens AG

HTTP/1.1 401 Unauthorized
WWW-Authenticate: Digest realm="SINAUT MD741", nonce="d19ae2ae87b3db41b79a0108be83e91c", qop="auth"
Content-Type: text/html
Content-Length: 351
Date: Sat, 13 Mar 2021 17:12:56 GMT
Server: lighttpd/1.4.15

Supported SSL Versions
SSLv2, SSLv3, TLSv1

401 - Unauthorized 

46.16.218.88
mdex46-16-218-88.publico.mdex.biz
Wireless Logic mdex GmbH
Added on 2021-03-13 19:31:16 GMT
 Germany, Norderstedt

SSL Certificate
Issued By:
- Organization: Siemens AG
Issued To:
- Organization: Siemens AG

HTTP/1.1 401 Unauthorized
WWW-Authenticate: Digest realm="SCALANCE M-873-0", nonce="73eab94066df68e3d26f814d32c61890", qop="auth"
Content-Type: text/html
Content-Length: 351
Date: Sat, 13 Mar 2021 17:17:50 GMT
Server: lighttpd/1.4.15

Supported SSL Versions
SSLv2, SSLv3, TLSv1



<https://github.com/mayhemheroes/hackathon-resources>

Go here

The screenshot shows a GitHub repository page for 'Hackathon Resources'. At the top left is the file name 'README.md'. On the right side of the header is a pen icon for editing. The main content area has a dark background. It features two sections: 'Useful Links' and 'Exercises'. The 'Useful Links' section contains five items: 'Mayhem Online GUI', 'Mayhem Documentation', 'Mayhem Community', 'Discord Invite', and 'Survey'. The 'Exercises' section contains five items: '1. lighttpd exercise' (which is highlighted with a red box and a red arrow pointing to it from the text 'Click here' on the left), '2. Docker + Mayhem Exercise', '3. CMake Exercise', '4. libFuzzer Exercise', and '5. Mayhem GitHub Action Exercise'.

Useful Links

- Mayhem Online GUI
- Mayhem Documentation
- Mayhem Community
- Discord Invite
- Survey

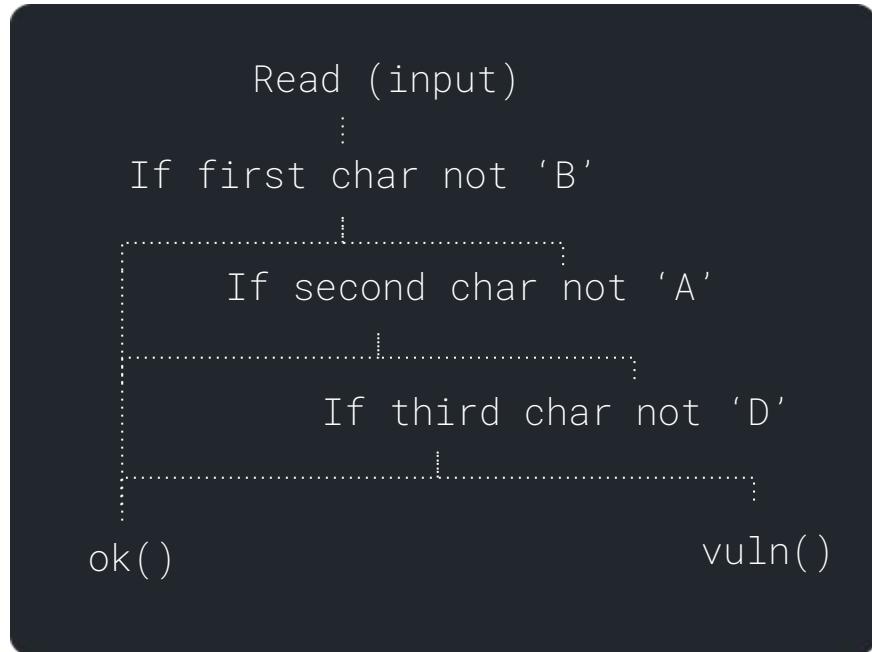
Exercises

1. lighttpd exercise
2. Docker + Mayhem Exercise
3. CMake Exercise
4. libFuzzer Exercise
5. Mayhem GitHub Action Exercise

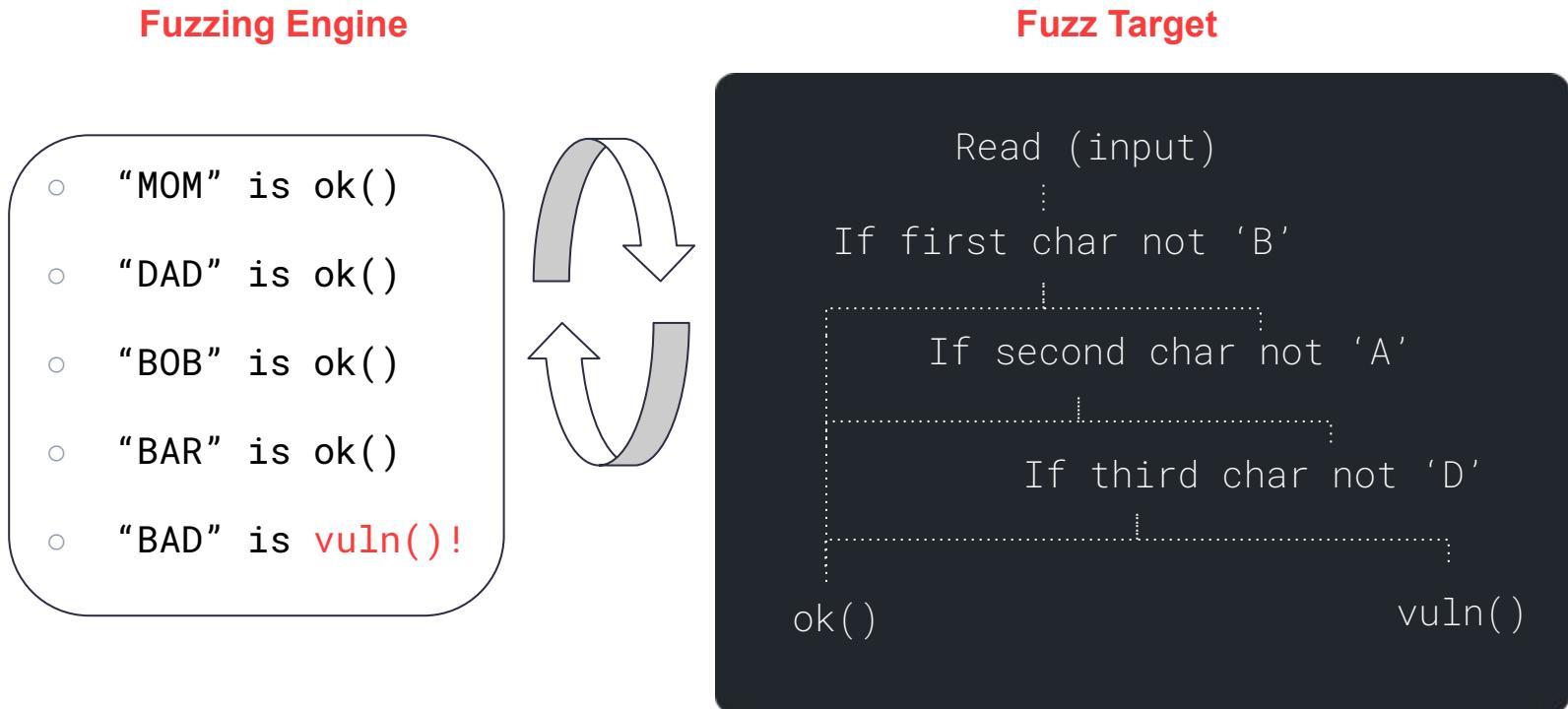
Introduction to Fuzz Testing

Covering the Bases

- “MOM” is `ok()`
- “DAD” is `ok()`
- “BOB” is `ok()`
- “BAR” is `ok()`
- “BAD” is `vuln()`!



Simple Fuzzing Dataflow

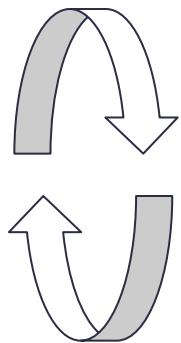


Simple Fuzzing Dataflow

Fuzzing Engine



Mayhem
for Code



Fuzz Target



How do we get here?

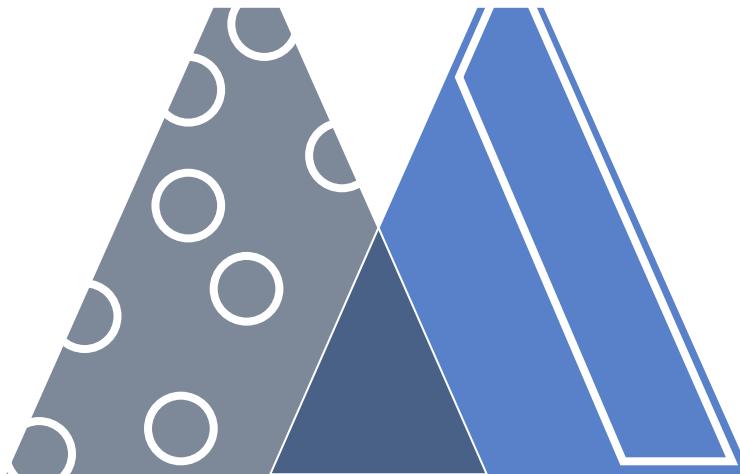
Mayhem Advanced Fuzz Testing



Guided Fuzzing

Uses sample inputs and target feedback to generate new test cases on-the-fly:

UNIQUE INPUTS: ↓
EXECUTION SPEED: ↑



Advanced Fuzzing

UNIQUE INPUTS: ↑
EXECUTION SPEED: ↑

Symbolic Execution

Models code as mathematical equations, and then solves them to come up with inputs:

UNIQUE INPUTS: ↑
EXECUTION SPEED: ↓

Example Fuzz Target

Input Vector

```
FILE *f = fopen(argv[1], "rb")
...
fread(buf, 1, buf_size, f)
...
```

Entrypoint

```
int main(int argc, char **argv)
```

Candidate Function

```
fuzzme(buf);
```

Example Fuzz Target

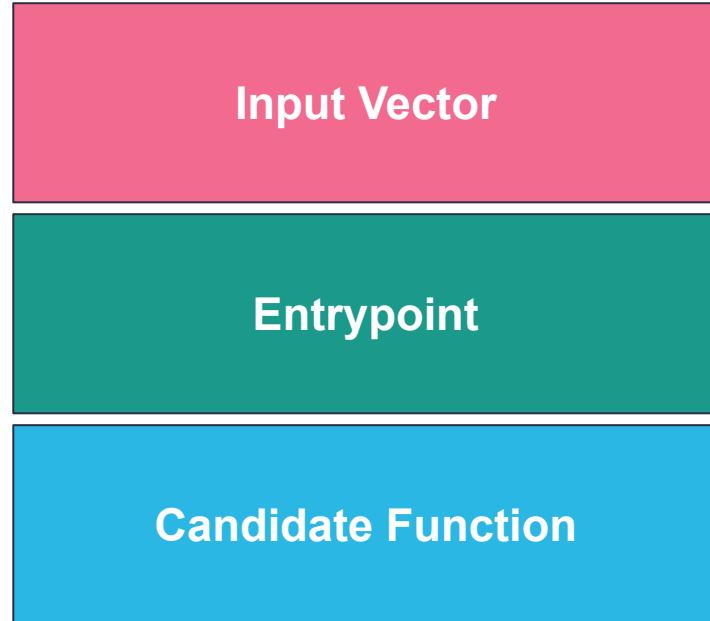
```
#include <stdio.h>
#include <stdlib.h>

int fuzzme(char *buf)
{
    if(strlen(buf) >= 3)
        if(buf[0] == 'b')
            if(buf[1] == 'u')
                if(buf[2] == 'g') {
                    printf("You've got it!");
                    abort();
                }
    return 0;
}

int main(int argc, char **argv)
{
    ...
    if (NULL == (f = fopen(argv[1], "rb"))) {
        fprintf(stderr, "could not open file for fuzzing\n");
        return 2;
    }

    if (!(sz = fread(buf, 1, sizeof(buf), f))) {
        fprintf(stderr, "no data read from file\n");
        return 3;
    }

    fuzzme(buf);
    ...
}
```

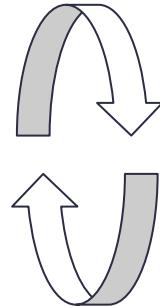


Example Fuzz Target

Fuzzing Engine



`./example_target @@`



Fuzz Target

Input Vector

Entrypoint

Candidate Function

```
#include <stdio.h>
#include <stdlib.h>

int fuzzme(char *buf)
{
    if(strlen(buf) >= 3)
        if(buf[0] == 'b')
            if(buf[1] == 'u')
                if(buf[2] == 'g') {
                    printf("You've got it!");
                    abort();
                }
    return 0;
}

int main(int argc, char **argv)
{
...
    if (NULL == (f = fopen(argv[1], "rb"))) {
        fprintf(stderr, "could not open file for fuzzing\n");
        return 2;
    }

    if (!(sz = fread(buf, 1, sizeof(buf), f))) {
        fprintf(stderr, "no data read from file\n");
        return 3;
    }

    fuzzme(buf);
...
}
```

Mayhem CLI

Mayhem from the Command Line

```
$ mayhem --help
usage: mayhem [-h] [-y] [--verbosity
{info,debug}] [--version] CMD ...
Command line client for interacting with Mayhem

positional arguments:
  check           Check targets to see if
they are Mayhem-eligible.
  docker-registry Gets the URI for
mayhem's docker registry.
  download        Download a target and
its test cases.
  init            Generate a Mayhemfile
  list            List projects and
targets you have run.
  login           Login to a Mayhem
server.
  logout          Logout from a Mayhem
server.
```

<p>package dependencies for Mayhem.</p> <p>run show stop sync state.</p> <p>validate wait</p> <p>optional arguments:</p> <p>-h, --help exit -y, --noninteractive for all prompts. Equivalent to setting the 'MAYHEM_NONINTERACTIVE' environment variable. --verbosity {info,debug} --version</p> <p>Mayhem CLI.</p>	<p>Package the given target and dependencies for Mayhem.</p> <p>Run a target through Mayhem.</p> <p>Show Mayhem run(s).</p> <p>Stop a Mayhem run.</p> <p>Sync a package to its latest state.</p> <p>Validate a Mayhemfile.</p> <p>Wait for a run to finish.</p> <p>show this help message and accept the default options for all prompts. Equivalent to setting the 'MAYHEM_NONINTERACTIVE' environment variable.</p> <p>Set mayhem verbosity level.</p> <p>Get the version of the Mayhem CLI.</p>
---	--

Mayhem from the Command Line

```
$ mayhem --help
usage: mayhem [-h] [-y] [--verbosity
{info,debug}] [--version] CMD ...
Command line client for interacting with Mayhem

positional arguments:
  check           Check targets to see if
they are Mayhem-eligible.
  docker-registry Gets the URI for
mayhem's docker registry.
  download        Download a target and
its test cases.
  init            Generate a Mayhemfile
  list            List projects and
targets you have run.
  login           Login to a Mayhem
server.
  logout          Logout from a Mayhem
server.
```

<p>package dependencies for Mayhem.</p> <p>run show stop sync validate wait</p> <p>optional arguments:</p> <p>-h, --help exit -y, --noninteractive `MAYHEM_NONINTERACTIVE` environment variable. --verbosity {info,debug} --version</p> <p>Mayhem CLI.</p>	<p>Package the given target and dependencies for Mayhem.</p> <p>Run a target through Mayhem.</p> <p>Show Mayhem run(s).</p> <p>Stop a Mayhem run.</p> <p>Sync a package to its latest state.</p> <p>Validate a Mayhemfile.</p> <p>Wait for a run to finish.</p> <p>show this help message and</p> <p>Accept the default options for all prompts. Equivalent to setting the `MAYHEM_NONINTERACTIVE` environment variable.</p> <p>Set mayhem verbosity level.</p> <p>Get the version of the</p>
--	---

Mayhemfiles

```
# Namespaced project name that the target belongs to
project: myRepo

# Target name (should be unique within the project)
target: myTarget

# Base image to run the binary in.
image: ghcr.io/xansec/myTarget:latest

# List of commands used to test the target
cmds:

# Command used to start the target, "@@" is the input file
# (when "@" is omitted Mayhem defaults to stdin inputs)
# NOTE: There is normally only one command per target. Mayhem does not support multiple
# commands in this section
- cmd: /myTarget
```

Lab 1b: Run with the Mayhem CLI

Lab 1b: Run with the Mayhem CLI

Overview

This guide will show you how to start a run using the Mayhem CLI.

Time to complete: About 5 minutes

From lighttpd exercise, go to this section

Step 1. Install the Mayhem CLI

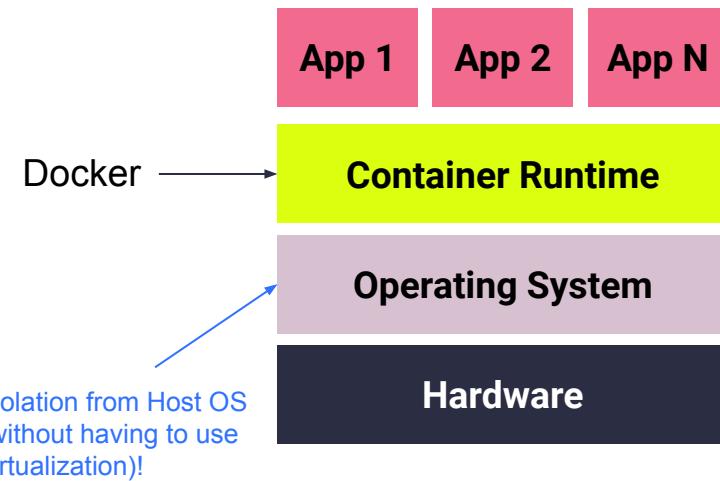
Before using the Mayhem CLI, you need to install it. Fortunately, Mayhem provides instructions for you.

- Click on "Download Mayhem CLI"

The screenshot shows the Mayhem web application interface. At the top, there is a navigation bar with links for 'Projects', 'Organizations', and 'Runs (0 Active)'. On the right side, there is a user profile dropdown menu for 'nathanjackson ADMIN'. Below the navigation bar, there are two main sections: 'Projects' and 'Runs'. The 'Projects' section lists three projects: 'nathanjackson / lighttpd', 'nathanjackson / cista', and 'mjkoo-fas / restic'. The 'Runs' section lists four runs: 'Run 3' (started 8 minutes ago), 'Run 1' (started 18 hours ago), 'Run 2' (started 3 days ago), and 'Run 2' (started 3 days ago). A red box highlights the 'Download Mayhem CLI' link in the sidebar under the 'My Profile' section. The sidebar also includes links for 'Tutorials', 'Documentation', 'API Documentation', 'Settings', 'ADMIN' (with 'Users', 'Reporting Dashboard', and 'Admin Settings' sub-links), and a toggle switch for 'Dark Mode'.

Containerization - Docker

What is Docker? Why do we need it?



- Mayhem accepts various types of packages, but the easiest to use is Docker images
- Docker is the industry standard for Containers.
 - Not just for Mayhem!
- Perfect for Mayhem's use case!
- We'll go over building, distributing, and running containers.

Docker Basics

Dockerfile - Configuration as Code that describes how to build a Docker Image

```
$ docker build -t <image-name> .
```

- This will **build** a Docker **image** based on the instructions in the Dockerfile

```
$ docker run <image-name>
```

- This will **run** a **container** based off of the specified image

```
$ docker push or $ docker pull
```

Either **uploads** a local image to a registry or **downloads** an image from a registry



A **Dockerfile** is like a cake recipe. A **container** is like a cake!

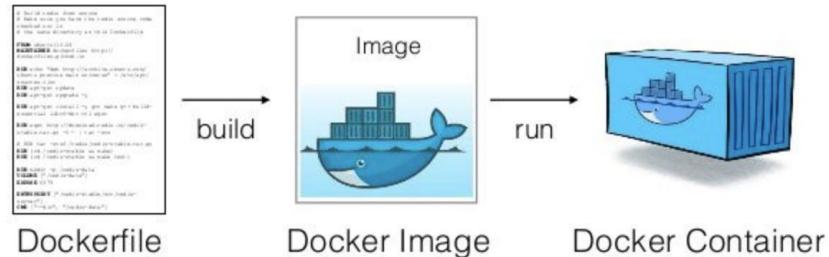
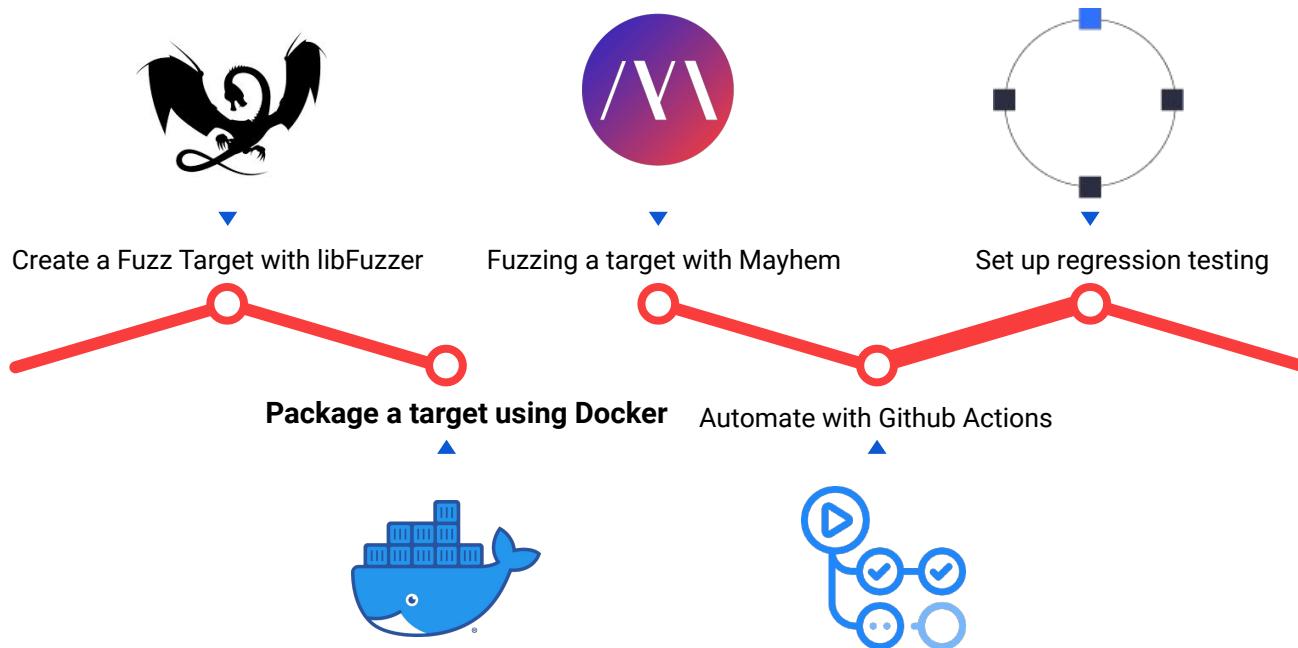


image source: <https://medium.com/platformer-blog/practical-guide-on-writing-a-dockerfile-for-your-application-89376f88b3b5>

Fuzzing CI/CD Pipeline



Mayhem Target Requirements

- Mayhem performs Dynamic Analysis
 - Runs a target, monitor its behavior. Requires dependencies to be present at runtime.
- Mayhem is fuzzing, what happens when an input does something destructive?
 - Isolation Needed
- Targets need to run the same way over and over.
- Successful fuzzing depends on throughput (i.e., how fast can I run the target?)

Docker + Mayhem Exercise

<https://github.com/mayhemheroes/hackathon-resources>

Go here

The screenshot shows a GitHub repository page with a dark theme. At the top, there's a navigation bar with a 'README.md' file icon and a pen icon for editing. The main content area has a title 'Hackathon Resources' and two sections: 'Useful Links' and 'Exercises'. The 'Useful Links' section contains a bulleted list of links: Mayhem Online GUI, Mayhem Documentation, Mayhem Community, Discord Invite, and Survey. The 'Exercises' section contains a numbered list of exercises: 1. lighttpd exercise, 2. Docker + Mayhem Exercise, 3. CMake Exercise, 4. libFuzzer Exercise, and 5. Mayhem GitHub Action Exercise. The second exercise, 'Docker + Mayhem Exercise', is highlighted with a red rectangular box and a red arrow points from the 'Click here' text to it.

Useful Links

- [Mayhem Online GUI](#)
- [Mayhem Documentation](#)
- [Mayhem Community](#)
- [Discord Invite](#)
- [Survey](#)

Exercises

1. [lighttpd exercise](#)
2. [Docker + Mayhem Exercise](#)
3. [CMake Exercise](#)
4. [libFuzzer Exercise](#)
5. [Mayhem GitHub Action Exercise](#)

Docker Review

- Pulled Image from Docker Hub and Created a Container
- Built our own Docker image and pushed it into GitHub's Registry.
- Started a Mayhem Run that uses our new Docker image.
- See the community Tips and Tricks, under General.

The screenshot shows the ForAllSecure website interface. At the top, there is a navigation bar with a search icon, a menu icon, and a logo. Below the navigation bar, there is a section titled "Announcements" with four cards:

- ANNOUNCEMENT: Fuzzing Essentials: Training for Federal Employees and Contractors
- ANNOUNCEMENT: Fuzz in Your Language
- ANNOUNCEMENT: The Role of Functional Testing in Application Security
- ANNOUNCEMENT: Carnegie Mellon University Hackathon

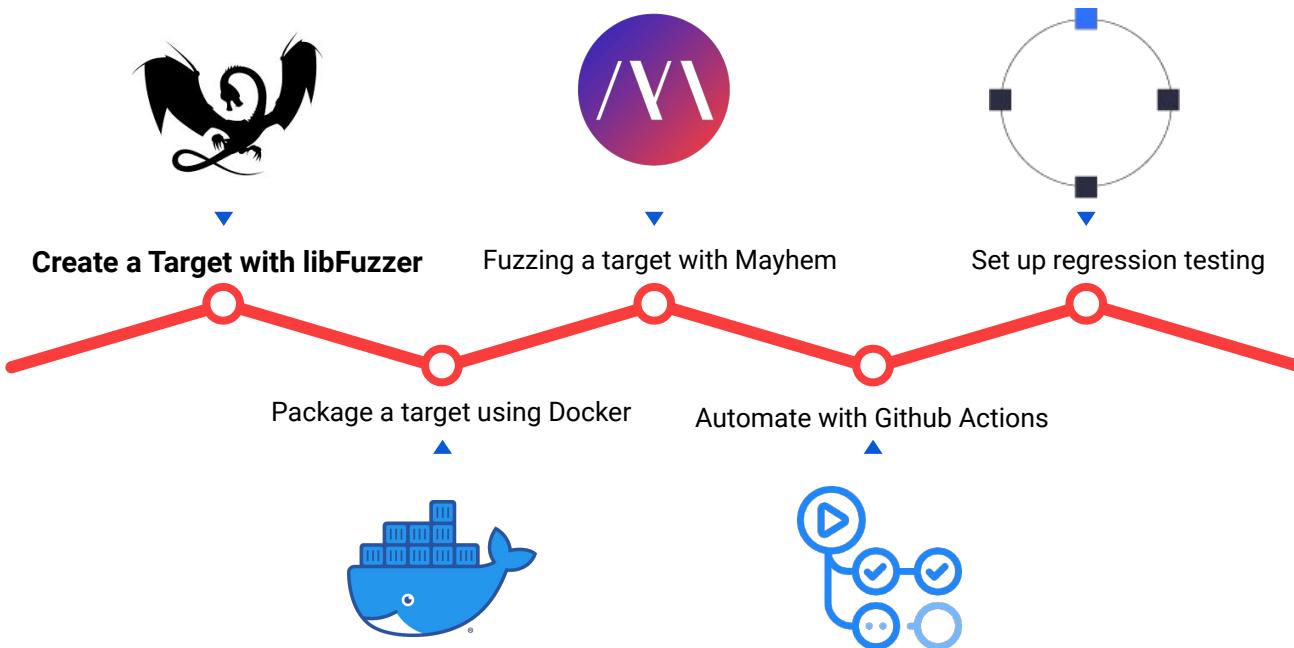
Below the announcements, a purple banner states: "To make launching your new site easier, you are in bootstrap mode. All new users will be granted trust level 1 and have daily email summary emails enabled. This will be automatically turned off when 50 users have joined." A blue header bar below the banner says "How to use Docker with Mayhem".

The main content area features a blog post by "mania" (11m ago). The post starts with an introduction to the Mayhem Tips and Tricks series, mentioning Docker integrations. It explains that real-world software relies on dependencies to provide functionality, so developers can focus on the domain in which their program operates. The post then provides instructions for setting up Docker integration with Mayhem, including links to documentation and examples of Dockerfile configurations. The code snippet shown in the post is:

```
version: '1.17'
baseimage: $MAYHEM_DOCKER_REGISTRY/forallsecure/lighttpd
project: mayhemuser/lighttpd
target: lighttpd
advanced_triage: true
-
```

The post concludes with a note about Mayhem's dependency analysis requirements and a final sentence expressing hope that the article was helpful.

Fuzzing CI/CD Pipeline



Before we Begin: Build Systems

- OSS and Industry use build systems to enable automation and repeatability of compilation steps.
- Projects written in compiled languages need to be built before the code is run!
- Running the compiler manually or running IDE-specific project files don't automate well

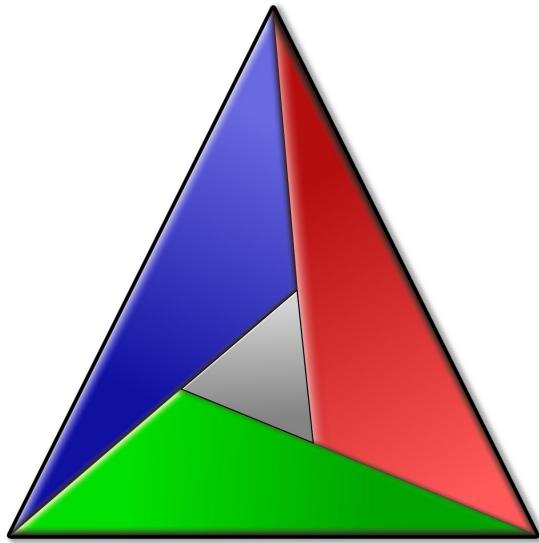
Common Patterns with Build Systems

1. Configure Step - Generates configuration or other build system files.
2. Build Step - Use the configuration files generated in the previous step to build an executable

Identifying Build Systems

- C, C++
 - autotools - look for a “configure” script.
 - CMake - look for a “CMakeLists.txt” file.
- Rust - Uses Cargo
 - Look for “Cargo.toml”
- Go - Uses “go” CLI.

CMake Example Usage



```
# Create directory for out-of-tree  
build.
```

```
$> mkdir build
```

```
# Change into build directory.
```

```
$> cd build/
```

```
# Generate Makefiles.
```

```
$> cmake ..
```

```
# Run make
```

```
$> make
```

CMake Exercise

<https://github.com/mayhemheroes/hackathon-resources>

Go here

The screenshot shows a GitHub repository page with a dark theme. At the top left is the file name 'README.md'. On the right side, there is an edit icon. The main content is titled 'Hackathon Resources' in large, bold, white font. Below it, there is a section titled 'Useful Links' with a list of links:

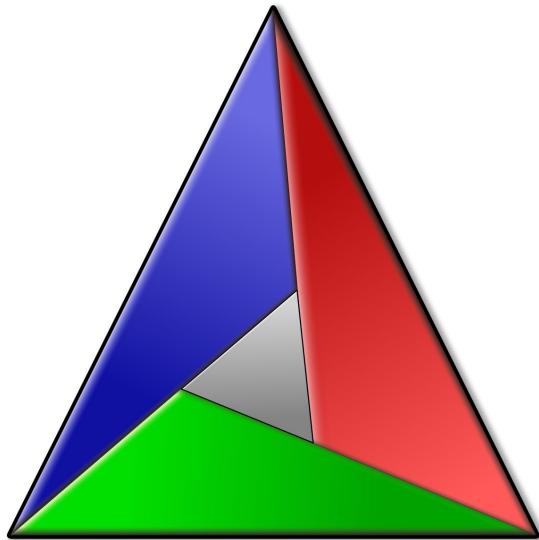
- Mayhem Online GUI
- Mayhem Documentation
- Mayhem Community
- Discord Invite
- Survey

Below this is another section titled 'Exercises' with a list of exercises:

1. lighttpd exercise
2. Docker + Mayhem Exercise
3. CMake Exercise
4. libFuzzer Exercise
5. Mayhem GitHub Action Exercise

A red arrow points from the text 'Go here' to the GitHub URL at the top of the slide. Another red arrow points from the text 'Click here' to the 'CMake Exercise' link in the 'Exercises' list.

CMake Review



- Generated Build Files with `cmake`.
- Used `make` to perform build.
- Ran an executable generated by a CMake build system.
- Pattern:
 - Generate Build Files\Configure Step
 - Build Step (usually `Make`)

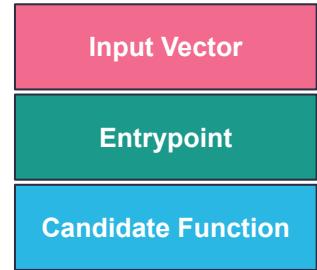
Mayhem + OSS Fuzzers

- Not only does Mayhem support binary-only analysis, but it also analyzes targets built with open source fuzzing technology.
 - AFL
 - Compile-time instrumentation with GCC/Clang (source required)
 - Works with programs that accept network or file input.
 - libFuzzer
 - Compile-time instrumentation with Clang (`clang -fsanitize=fuzzer`)
 - In-memory fuzzer (it runs really, really fast)
 - go fuzz, cargo fuzz
 - Open source fuzzers for Go and Rust - built into the language!
- Many of the repositories in the hackathon already have fuzzing targets. Bootstrap them in Mayhem!

libFuzzer

- Popular framework in Open Source and Industry for fuzzing.
- Part of the LLVM Project, requires clang\clang++.
- Requires the creation of a special function called: LLVMFuzzerTestOneInput
- Typically used with Address Sanitizer to find memory corruption bugs.
 - clang -fsanitize=address, fuzzer
- Vast majority of targets already have libFuzzer targets.

Example libFuzzer Target



```
#include <stdint.h>
#include <stdlib.h>

int fuzzme(char *buf)
{
    if(strlen(buf) >= 3)
        if(buf[0] == 'b')
            if(buf[1] == 'u')
                if(buf[2] == 'g') {
                    printf("You've got it!");
                    abort();
                }
    return 0;
}

int LLVMFuzzerTestOneInput( char* data, size_t len )
{
    fuzzme(data);
    return 0;
}
```

\$> clang -fsanitize=fuzzer -c example_target.c
\$> clang -fsanitize=fuzzer example_target.o -o example_target
\$> ./example_target

INFO: Seed: 705835306
INFO: Loaded 1 modules (1 inline 8-bit counters): 1 [0x4e8040, 0x4e8041],
INFO: Loaded 1 PC tables (1 PCs): 1 [0x4be930,0x4be940],
INFO: -max_len is not provided; libFuzzer will not generate inputs larger than 4096 bytes
INFO: A corpus is not provided, starting from an empty corpus
#2 INITED cov: 1 ft: 1 corp: 1/lb exec/s: 0 rss: 23Mb
#8388608 pulse cov: 1 ft: 1 corp: 1/lb lim: 4096 exec/s: 4194304 rss: 23Mb
#16777216 pulse cov: 1 ft: 1 corp: 1/lb lim: 4096 exec/s: 4194304 rss: 23Mb

libFuzzer Exercise

<https://github.com/mayhemheroes/hackathon-resources>

Go here

The screenshot shows a GitHub repository page for 'Hackathon Resources'. The page has a dark theme. At the top, there's a 'README.md' file icon and a edit pen icon. The main content is titled 'Hackathon Resources'.

Useful Links

- Mayhem Online GUI
- Mayhem Documentation
- Mayhem Community
- Discord Invite
- Survey

Exercises

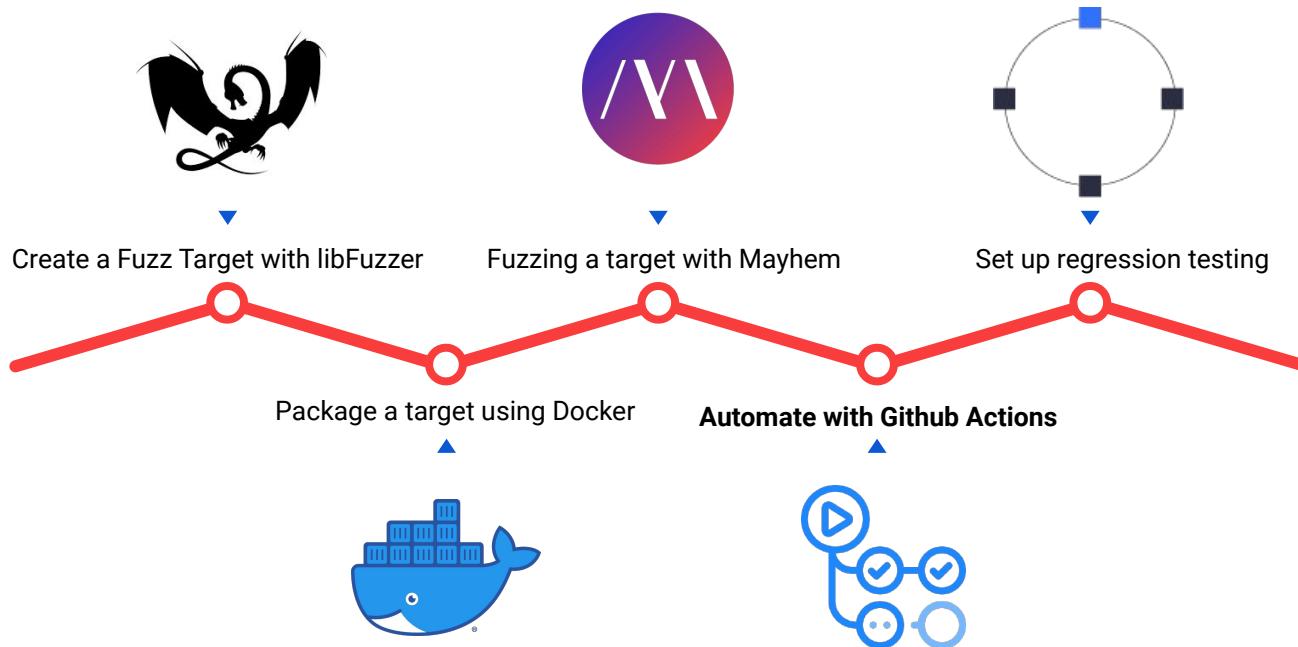
1. lighttpd exercise
2. Docker + Mayhem Exercise
3. CMake Exercise
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5. Mayhem GitHub Action Exercise

Click here

libFuzzer Review

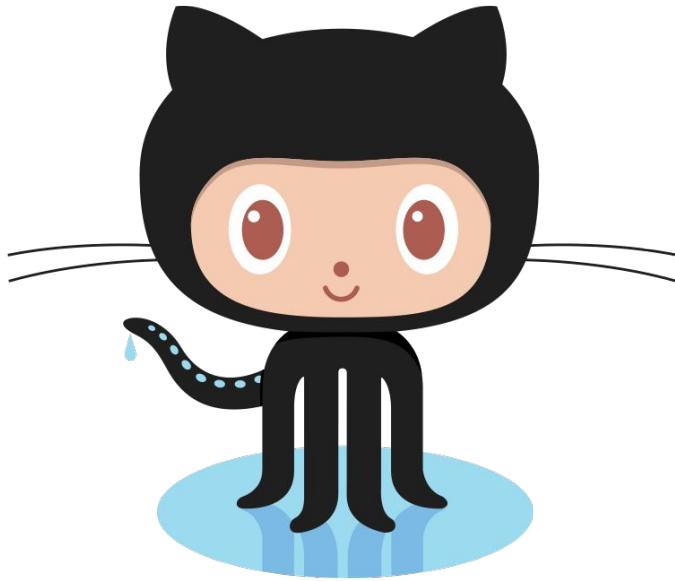
- Created a libFuzzer target that tests a function “fuzzme”.
- Updated our CMake build system to handle a libFuzzer target.

Modern CI/CD Pipeline

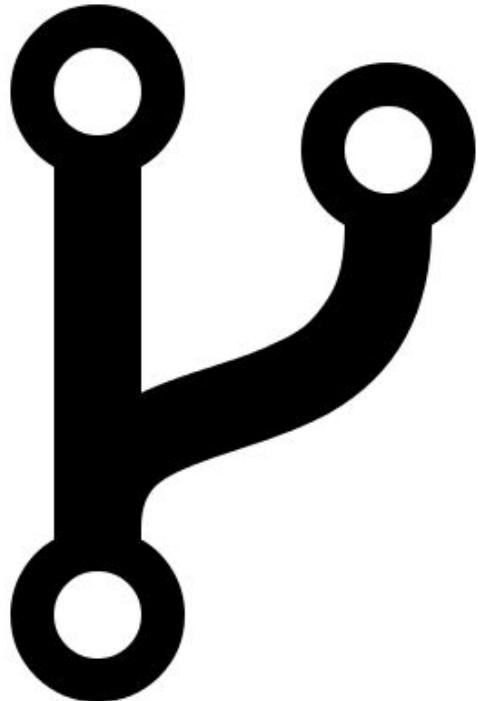


What is GitHub? Why does the Industry use it?

- Hosts Git repositories many open source projects.
- More than just a code repository.
 - Organizations
 - Issue Tracking
 - Continuous Integration (GitHub actions).
- Our objective: scale up fuzzing across popular projects hosted on GitHub!
 - Open Source projects are part of the supply chain for everyday products and services.



Contributing to OSS on GitHub



- OSS Developers store their work-in-progress code on “fork” repositories.
- Forks are copies of repos owned by someone other than the original developer or organization.
- Once a contributor has finished their changes, they submit a pull request to the original project.
 - Once approved, the changes are incorporated back into the project.

Continuous Integration/Delivery

- Open and closed source development projects usually have a test suite to ensure the software behaves as intended.
- CI/CD usually runs the test suites automatically whenever a developer pushes to a project.
- Helps to maintain software quality and takes some of the monotony out of certain developer workflows.



Continuous Integration/Delivery

- GitHub Actions are workflows that run in response to project events (e.g., push to a repository, pull requests, etc).
- GitHub Actions can integrate with other tools, like Mayhem!
- Now, let's work through setting up CI/CD for our example CMake project.



GitHub Action Exercise

<https://github.com/mayhemheroes/hackathon-resources>

Go here

The screenshot shows a dark-themed GitHub README.md page. At the top left is the file name 'README.md'. On the right side is a small edit icon. The main content is titled 'Hackathon Resources' in large bold letters. Below it is a section titled 'Useful Links' with a horizontal line. A bulleted list follows:

- Mayhem Online GUI
- Mayhem Documentation
- Mayhem Community
- Discord Invite
- Survey

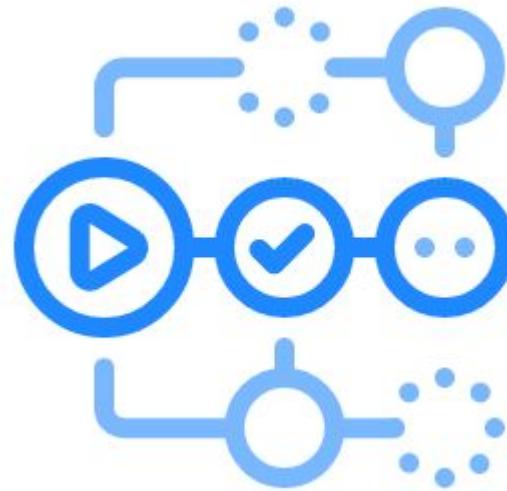
Below this is another section titled 'Exercises' with a horizontal line. An ordered list follows:

1. lighttpd exercise
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5. Mayhem GitHub Action Exercise

A red arrow points from the text 'Go here' to the top of the screenshot. Another red arrow points from the text 'Click here' to the fifth item in the 'Exercises' list.

GitHub Actions Review

- Created a workflow that runs in response to push events.
- Automatically built a target
- Automatically started fuzzing run against target.



Conclusions

Now What?

- We've worked through setting up Mayhem, CMake, OSS Fuzzers, and GitHub Actions.
- There are a lot of topics not covered here that might apply to specific targets. Google is your friend!
- If in doubt, ask in the community.

Mayhem Heroes

— Hackathon - Securing the World's Software

- **Goal:** Fuzz Open Source projects to help make the world's software more secure
- **Reward:** Up to \$1k for each GitHub repository integrated
- **Timeline:** Submissions must be made in the next five weeks.

Legalese: Payment through 1099 via bank transfer for students eligible to work in USA

— What New Repos Qualify?

- Over **100 stars**
- **Active** (has a commit from June of this year or later)
- **Not a part of OSS-Fuzz**
(<https://github.com/google/oss-fuzz/tree/master/projects>)
- **Nothing inappropriate** - if you're not sure, just ask
- Legalese: ForAllSecure reserves the right to reject any submission at its sole discretion.

— What Existing Repos Qualify?

- Repos eligible for improvement have already been forked under github.com/mayhemheroes
- You must add new harnessing or improve existing harnessing to these repositories
- Submissions will be graded on **added coverage** and **defects found**
- Legalese: ForAllSecure reserves the right to reject any submission at its sole discretion.

Hackathon - What do I get paid for?

- \$100 - Integration (10 test cases)
 - \$200 - 100+ test cases generated
 - \$200 - 100+ test per second
 - \$200 - Function(s) harnessed
 - \$300 - Defect(s) discovered
- } eligible on existing repos

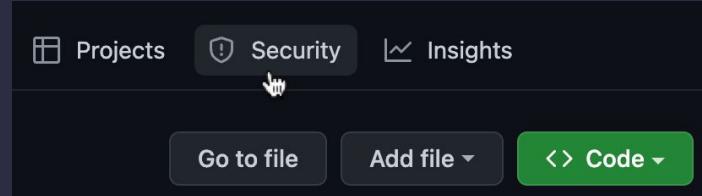
Hackathon - More Rules

- You can integrate - and get paid for - more than one Repo.
- If you and another student choose the same repo, the first student to submit a typeform gets paid (based on timestamp).
- You can work by yourself or in a group.
 - If working in a group, the group will split the payment.
 - When submitting as a group, group leader should inform ForAllSecure that this is a group submission.

Bonus! - Submitting CVEs

1. Confirm the defect is security relevant
2. Contact the maintainers
 - o GitHub Security tab may have a policy
 - o SECURITY.md / CONTRIBUTING.md / README.md
 - o Check GitHub profiles of maintainers
3. Show stack traces, fuzz harness, crashing inputs
4. Maintainers open a GitHub Security Advisory
 - a. You MUST include the following language: "**This issue was reported by [NAME] and found with ForAllSecure's Mayhem.**"
5. Coordinate fixing the issue, help confirm by re-fuzzing
6. GitHub can assign a CVE once the advisory is published

Note: Some larger projects such as Apache, have their own guidelines.





ForAllSecure

questions?

Addenda: Improving your Targets

What do I look for in a target?

1. Language
2. Build System
3. Target Binary (if any)
4. README.md!

The screenshot shows a GitHub repository page for 'tj Release 0.0.2'. The repository has 38 commits, 689 stars, 27 watching, and 27 forks. It includes sections for Releases, Packages, Contributors, and Languages.

- 1. Languages:** A progress bar at the bottom indicates 94.8% C and 5.2% Shell.
- 2. Build System:** A red circle highlights the 'Makefile' file in the commit list.
- 3. Target Binary (if any):** A red circle highlights the terminal output showing the execution of '\$ histo < data.txt'.
- 4. README.md:** A red circle highlights the 'Readme.md' file in the commit list.

Releases
No packages published

Contributors 3

- tj TJ Holowaychuk
- onenoc Alexander Moreno
- jblaine Jeff Blaine

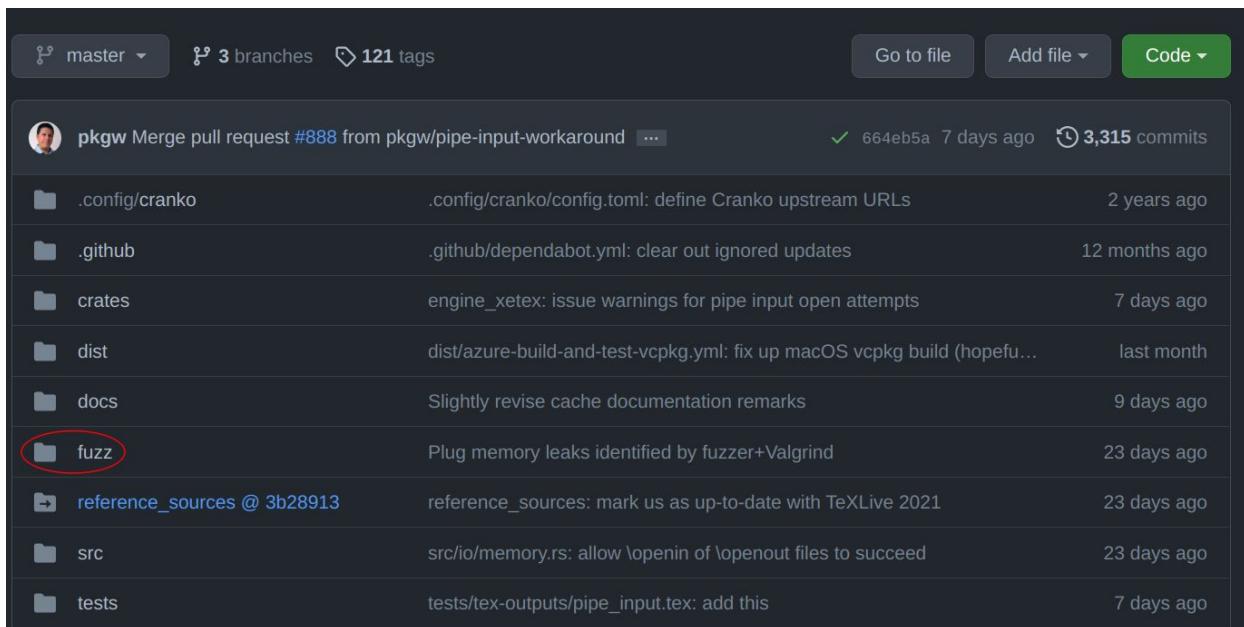
Languages

C 94.8% Shell 5.2%

If it has a “fuzz/” folder...

Great! This should be easy. Integrate Mayhem with the existing fuzz target(s) underneath the fuzz/ folder

Current fuzz targets may not find new defects, however



master			3 branches	121 tags	Go to file	Add file	Code
	pkgw	Merge pull request #888 from pkgw/pipe-input-workaround	...	 664eb5a 7 days ago	 3,315 commits		
	.config/cranko	.config/cranko/config.toml: define Cranko upstream URLs			2 years ago		
	.github	.github/dependabot.yml: clear out ignored updates			12 months ago		
	crates	engine_xetex: issue warnings for pipe input open attempts			7 days ago		
	dist	dist/azure-build-and-test-vcpkg.yml: fix up macOS vcpkg build (hopefu...			last month		
	docs	Slightly revise cache documentation remarks			9 days ago		
	fuzz	Plug memory leaks identified by fuzzer+Valgrind			23 days ago		
	reference_sources @ 3b28913	reference_sources: mark us as up-to-date with TeXLive 2021			23 days ago		
	src	src/io/memory.rs: allow \openin of \openout files to succeed			23 days ago		
	tests	tests/tex-outputs/pipe_input.tex: add this			7 days ago		

If it has a “fuzz/” folder...

Great! This should be easy. Integrate Mayhem with the existing fuzz target(s) underneath the fuzz/ folder

Hint: It might not be in the top level directory! Try searching for the word “fuzz”...

fuzz

Pull requests Issues Marketplace Explore

Sort: Best match ▾

42 code results in [ElementsProject/lightning](#)
or view [all results on GitHub](#)

doc/FUZZING.md

```
1 # Fuzz testing
2
3 C-lightning currently supports coverage-guided fuzz testing using [LLVM's libfuzzer]
   (https://www.llvm.org/docs/LibFuzzer.html)
...
14 and for more about 'libfuzzer' in particular see [here]
   (https://www.llvm.org/docs/LibFuzzer.html).
15
16
17 ## Build the fuzz targets
18
19 In order to build the C-lightning binaries with code coverage you will need a recent
```

Markdown 3

C 28

Makefile 2

JSON 2

Shell 1

Python 5

Ignore List 1

Advanced search Cheat sheet

tests/fuzz/Makefile

```
1 LIBFUZZ_SRC := tests/fuzz/libfuzz.c
2 LIBFUZZ_HEADERS := $(LIBFUZZ_SRC:.c=.h)
3 LIBFUZZ_OBJS := $(LIBFUZZ_SRC:.c=.o)
4
5
6 FUZZ_TARGETS_SRC := $(wildcard tests/fuzz/fuzz-*.*.c)
7 FUZZ_TARGETS_OBJS := $(FUZZ_TARGETS_SRC:.c=.o)
```

If it has a target binary that takes input

Via *STDIN* or a File

Also great! You should be able to send fuzzed data to the binary directly!

Usage

```
usage: lzbench [options] input [input2] [input3]

where [input] is a file or a directory and [options] are:
-b#   set block/chunk size to # KB (default = MIN(filesize,1747626 KB))
-c#   sort results by column # (1=algnname, 2=ctime, 3=dtime, 4=comprsize)
-e#   #=compressors separated by '/' with parameters specified after ',' (deflt=fast)
-iX,Y set min. number of compression and decompression iterations (default = 1, 1)
-j    join files in memory but compress them independently (for many small files)
-l    list of available compressors and aliases
-m#   set memory limit to # MB (default = no limit)
-o#   output text format 1=Markdown, 2=text, 3=text+origSize, 4=CSV (default = 2)
-p#   print time for all iterations: 1=fastest 2=average 3=median (default = 1)
-r    operate recursively on directories
-s#   use only compressors with compression speed over # MB (default = 0 MB)
-tX,Y set min. time in seconds for compression and decompression (default = 1, 2)
-v    disable progress information
-x    disable real-time process priority
-z    show (de)compression times instead of speed
```

Binary Fuzzed Data?

Example usage:

```
lzbench -ezstd filename = selects all levels of zstd
```

If it has a target binary that opens a port...

Via TCP/UDP

This is just like lighttpd!
You should be able to
send fuzzed data to the
network port

Usage

Proxy

The recommended installation method is via Docker:

```
# This will expose an FF proxy on UDP port 1234 on the host and port 100 in the container
docker run --rm -it \
    -p 1234:100/udp \
    timetogo/ff \
    --port 100 \
    -vvv
```

Or it can be installed locally from the source.

Arguments

Argument	Required	Description
--port <port>	Yes	The UDP port to listen for incoming requests
--ip-address <ip>	No	The IP address for which to accept incoming packets, defaulting to IPv4 wildcard address: 0.0.0.0
--ipv6-v6only	No	When listening on IPv6 don't accept IPv4 connections
--pre-shared-key <key>	No	The pre-shared key used to decrypt incoming requests

If all else fails

You might need to develop the fuzz target yourself.

1. Look for a tests/ or examples/ folder. You can usually leverage this code to create a fuzz target!
2. Read the README.md! It usually has all of the information you need to understand the repository
3. Ask for help!

Is my target being fuzzed well?

Analysis

All Findings

Regression Testing

Behavior Testing



0

Defects Found ②



0

Crashing Test Cases ②



0

Runtime Errors ②

0.35 ②

Tests Run Per Second ②

slow execution

1

Test Suite Size ②

low test case count

56,454

Edges Covered ②



Test Cases Processed
1

Elapsed Testing Time
2 min 25 sec

Set Behavior Testing Duration
Fixed Time - 1 min 30 sec

Elapsed CPU Seconds
206

Adding a Seed Corpus

I can habeus corpus?

[dvyukov / go-fuzz-corpus](#)

Code Issues Pull requests Actions Security Insights

master 1 branch 0 tags Go to file Add file Code

josharian fmt: cap input at 16k ... c42c1b2 on Sep 20, 2019 231 commits

aes	change copyright from me to all project authors	3 years ago
asm	change copyright from me to all project authors	3 years ago
asn1	change copyright from me to all project authors	3 years ago
bmp	change copyright from me to all project authors	3 years ago
bson	change copyright from me to all project authors	3 years ago
bzip2	change copyright from me to all project authors	3 years ago
csv	change copyright from me to all project authors	3 years ago
elf	change copyright from me to all project authors	3 years ago
elliptic	change copyright from me to all project authors	3 years ago
flag	change copyright from me to all project authors	3 years ago
flatbuffers	change copyright from me to all project authors	3 years ago
... 1 more commit	... 1 more commit	... 1 more commit

About

Corpus for github.com/dvyukov/go-fuzz examples

Readme Apache-2.0 License

Releases

No releases published

Packages

No packages published

Contributors 6



Does it help?



Improve Target Speed

Bad

```
// Entry point for LibFuzzer.  
  
extern "C" int LLVMFuzzerTestOneInput(const uint8_t* data,  
size_t size) {  
  
    initialization on every run  
  
    startServer();  
  
    uLongf buffer_length = static_cast<uLongf>(sizeof(buffer));  
    if (Z_OK != uncompress(buffer, &buffer_length, data,  
                           static_cast<uLong>(size))) {  
        std::cerr << "Error!" << endl;  
    }  
    return 0;  
}
```

unnecessary I/O

Good

```
// Entry point for LibFuzzer.  
  
extern "C" int LLVMFuzzerTestOneInput(const uint8_t* data,  
size_t size) {  
  
    one-time init  
  
    static bool running = startServer();  
  
    if(running) {  
        uLongf buffer_length = static_cast<uLongf>(sizeof(buffer));  
        if (Z_OK != uncompress(buffer, &buffer_length, data,  
                               static_cast<uLong>(size))) {  
            return 0; //ignore  
        }  
        return 0;  
    }  
}
```

no unnecessary I/O

That looks better!

Analysis

All Findings

Regression Testing

Behavior Testing



0

Defects Found ?



0

Crashing Test Cases ?



0

Runtime Errors ?

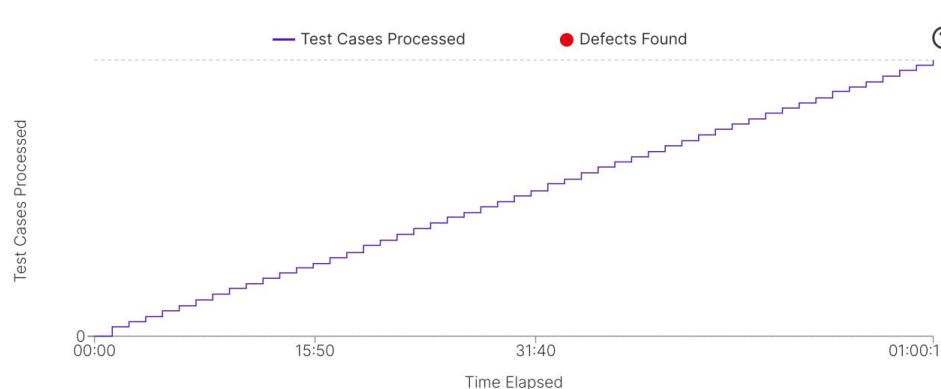
826.94
Tests Run Per Second ?

fast!

380
Test Suite Size ?

good coverage!

2,652
Edges Covered ?



Test Cases Processed
380

Elapsed Testing Time
1 hr 0 min 12 sec

Set Behavior Testing Duration
Fixed Time - 1 hr 0 min 0 sec

Elapsed CPU Seconds
7,218