FireMarshal:

Software Workload Management

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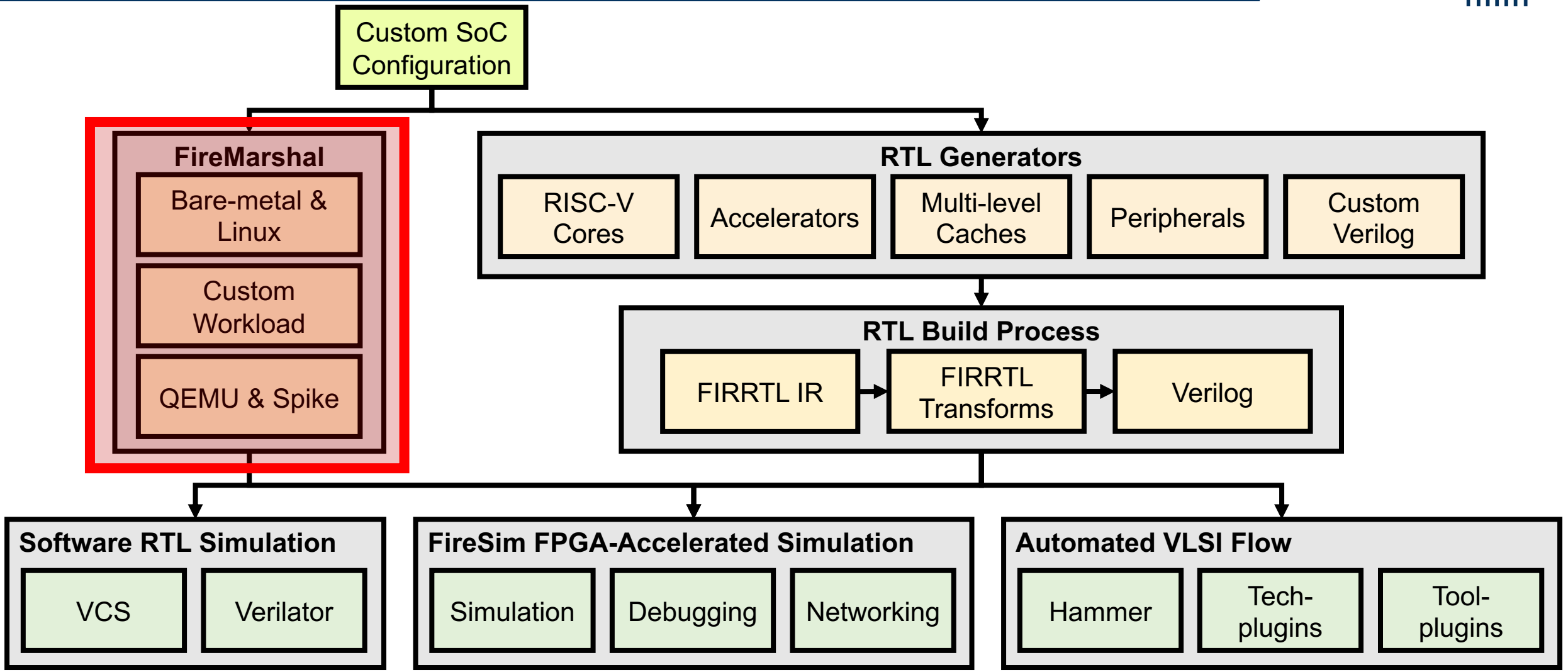
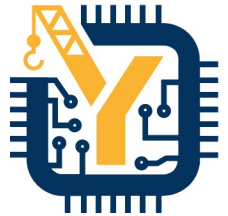
CHIPYARD

Berkeley Architecture Research

Tutorial Roadmap



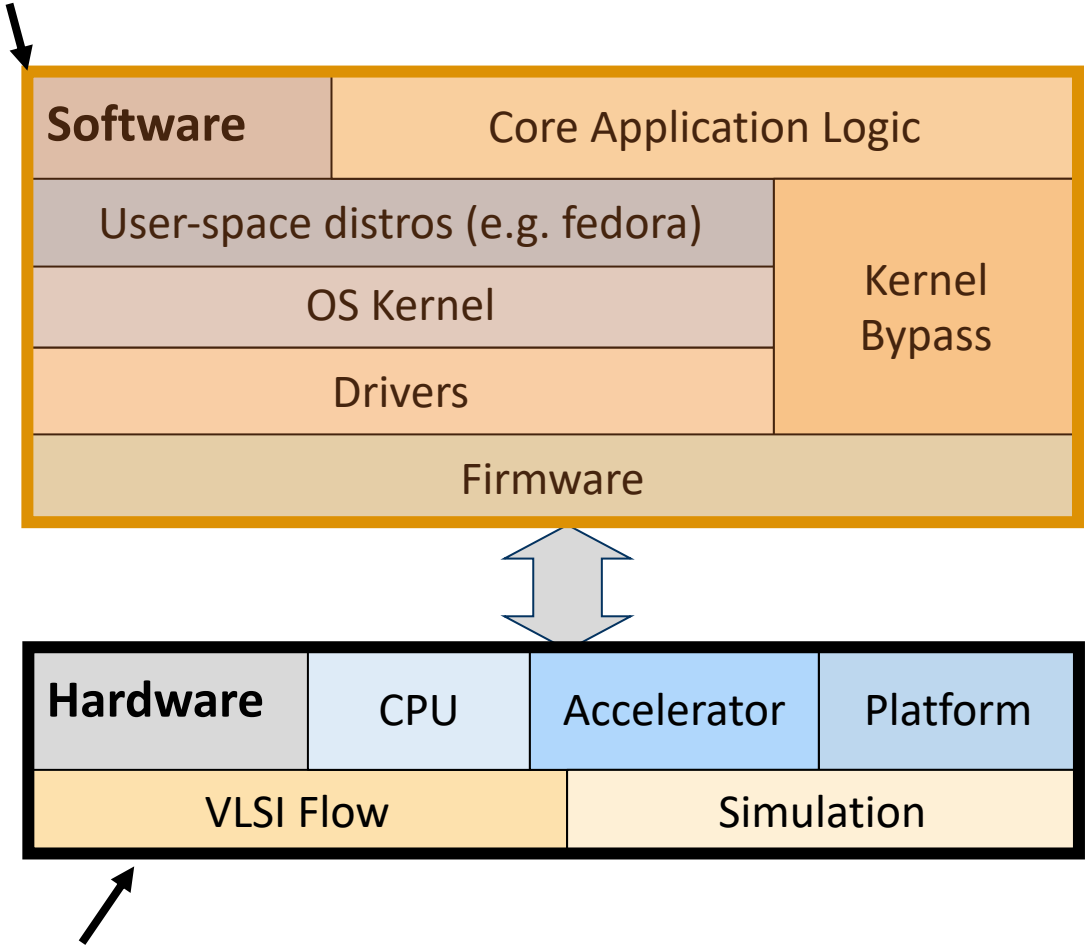
Software Workload Management



Workload Management Tasks:

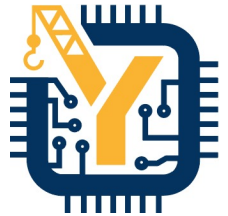
- Building Binaries and Filesystems
- Experiment Management
  - Inputs and outputs
  - Repeatable execution
  - Multiple levels of simulation
- Reproducibility and Reusability
  - Share workloads with the community

Provided by FireMarshal



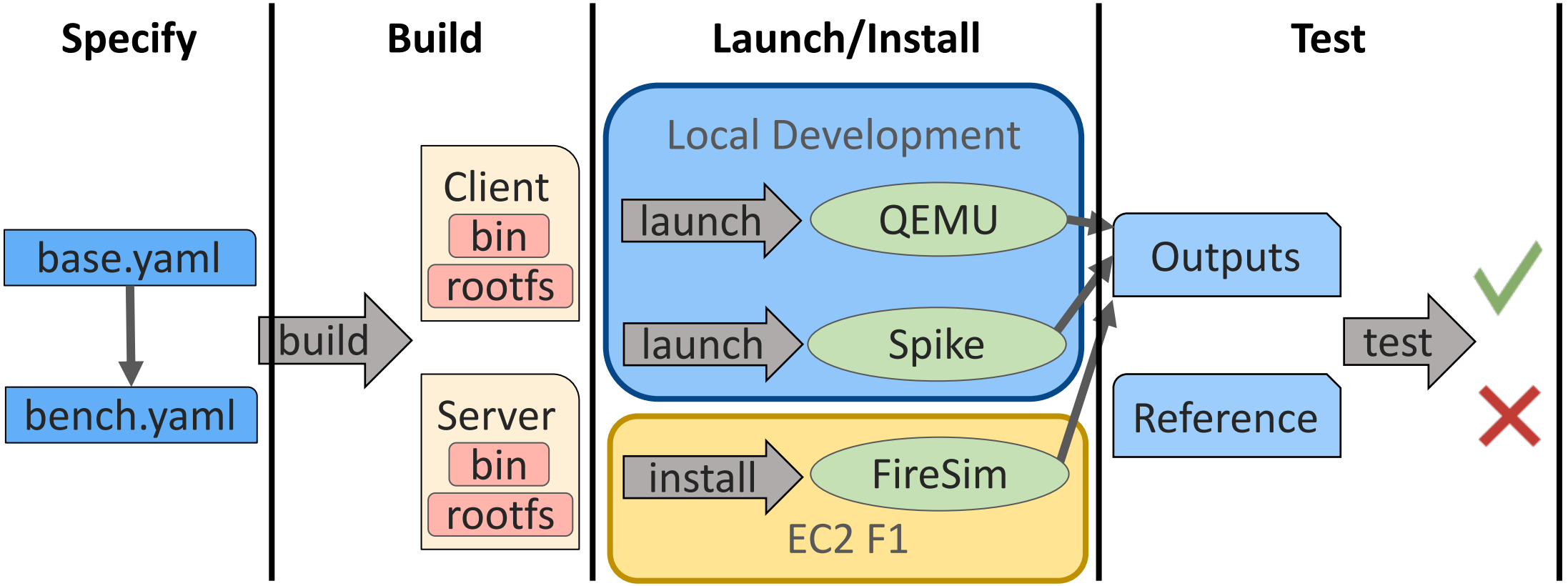
Provided by Chipyard

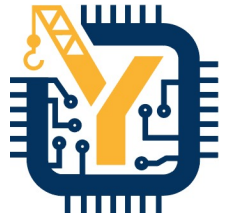
Overview Video



https://youtu.be/QzMm1YI5PTc

FireMarshal Overview
FireSim Install

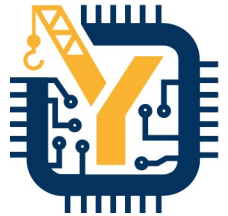




Sha3 Example Workloads

generators/sha3/software

Prerequisites / Setup



Chipyard v1.5.0

```
./scripts/init-submodules-no-riscv-tools.sh
./scripts/build-toolchains.sh esp-tools
source env.sh
```

Needed for sha3 functional model

FireMarshal

```
cd software/firemarshal
./init_submodules.sh
```

Example Workload: Sha3 Workload Directory

generators/sha3/software

marshal-configs/

- FireMarshal configuration files

test-reference/

- Reference outputs for FireMarshal workloads

tests/

- unit tests for bare-metal and Linux

jtr/

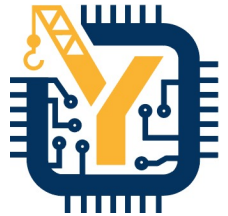
- An end-to-end benchmark

linux/

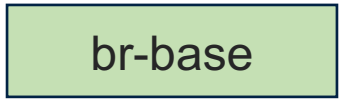
- A custom Linux kernel for our accelerator

```
[chipyard]$ ls generators/sha3/software/
benchmarks  build.sh  jtr  linux  marshal-configs  README.md  test_local.sh  test-reference
[chipyard]$
[chipyard]$
[chipyard]$ ls generators/sha3/software/marshal-configs/
sha3-bare-rocc.json  sha3-linux.json           sha3-linux-jtr.json       sha3-linux-test.json
sha3-bare-sw.json    sha3-linux-jtr-crack.json  sha3-linux-jtr-test.json  sha3-linux.yaml
[chipyard]$
[chipyard]$
[chipyard]$ ls generators/sha3/software/benchmarks/
bare  common.mk  linux  src
[chipyard]$
[chipyard]$
[chipyard]$ ls generators/sha3/software/linux/
arch     crypto         init     lib          modules.builtin          samples     tools
block    Documentation  ipc      LICENSES     modules.builtin.modinfo  scripts     usr
certs    drivers        Kbuild   MAINTAINERS  Module.symvers           security    virt
COPYING  fs             Kconfig  Makefile     net                      sound       vmlinux
CREDITS  include        kernel   mm           README                   System.map  vmlinux.o
[chipyard]$
[chipyard]$
[chipyard]$ ls generators/sha3/software/jtr/
bench.sh  build.sh  crack.sh  JohnTheRipper  overlay
[chipyard]$
[chipyard]$
```

Workload Inheritance



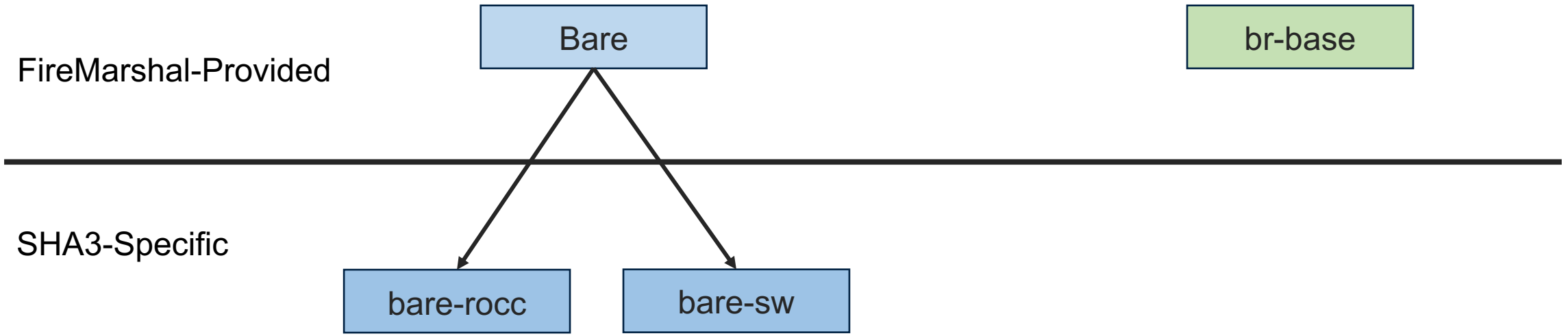
FireMarshal-Provided



SHA3-Specific

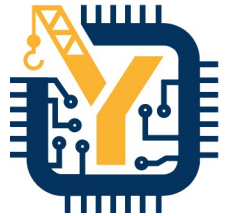
- FireMarshal provides several “base” workloads to act as starting points for user workloads.
- Today, we will use:
  - “br-base”: Interactive Buildroot-based Linux workload. This is used for FireSim’s “linux-uniform” default workload.
  - “bare”: A trivial workload used for bare-metal experiments

Workload Inheritance



Bare-metal unit tests

Example Workload:
Sha3 Bare-Metal Unit Test



sha3-bare-rocc.yaml

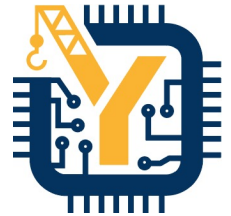
```
{
"name" : "sha3-bare-rocc",
"workdir" : "..",
"base" : "bare",
"host-init" : "build.sh",
"bin" : "tests/bare/sha3-rocc.riscv",
"spike-args" : "--extension=sha3"
}
```

Script to run when building this workload (build.sh cross-compiles the unit test)

Hard-coded binary to use (produced by build.sh)

Custom Spike boot arguments (to enable the sha3 functional model)

Example Workload:
Sha3 Bare-Metal Unit Test



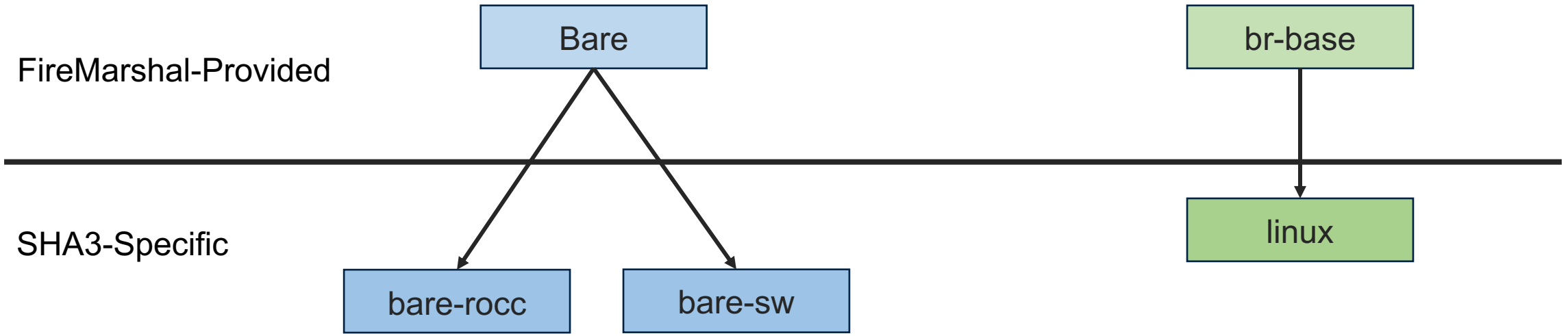
```
(base) [xarc@xarc0 firesim-software]$ ./marshal build workloads/sha3-bare.json
To check on progress, either call marshal with '-v' or see the live output at:
/data/repos/firesim-software/logs/sha3-bare-build-2019-08-29--00-24-07-67ARZD490JUNSSAX.log
Applying host-init: /data/repos/firesim-software/workloads/sha3/build.sh
.  /data/repos/firesim-software/workloads/sha3/bare/sha3-rocc.riscv
Log available at: /data/repos/firesim-software/logs/sha3-bare-build-2019-08-29--00-24-07-67ARZD490JUNSSAX.log
(base) [xarc@xarc0 firesim-software]$ ./marshal launch -s workloads/sha3-bare.json
To check on progress, either call marshal with '-v' or see the live output at:
/data/repos/firesim-software/logs/sha3-bare-launch-2019-08-29--00-24-16-E3KF36KFH8ZFUYNV.log
Running: /data/repos/firesim-software/workloads/sha3/spike-local/bin/spike --extension=sha3 -p4 -m16384 /data/repos/firesim-software/workloads/sha3/bare/sha3-rocc.riscv
start basic test 1.
output[0]:221 ==? results[0]:221
output[1]:204 ==? results[1]:204
output[2]:157 ==? results[2]:157
output[3]:217 ==? results[3]:217
output[4]:67 ==? results[4]:67
```

DEMO

```
$ cd generators/sha3/software/marshal-configs
$ marshal build sha3-bare-rocc.yaml
$ marshal launch -s sha3-bare-rocc.yaml
$ marshal test -s sha3-bare-rocc.yaml
```

```
output[25]:61 ==? results[25]:61
output[26]:3 ==? results[26]:3
output[27]:149 ==? results[27]:149
output[28]:137 ==? results[28]:137
output[29]:42 ==? results[29]:42
output[30]:57 ==? results[30]:57
output[31]:238 ==? results[31]:238
success!
```

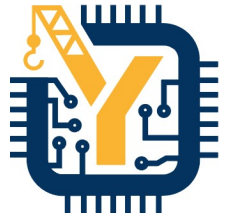
Workload Inheritance



Interactive Linux base workload

- Specifies all common settings for sha3 workloads

Example Workload:
SHA3 on Linux (interactive base workload)



sha3-linux.yaml

```
{
"name" : "sha3-linux",
"base" : "br-base.json",
"workdir" : "..",
"host-init" : "build.sh",
"files" : [
  ["tests/linux/sha3-sw.rv", "/root/sha3-sw"],
  ["tests/linux/sha3-rocc.rv","/root/sha3-rocc"],
],
"linux-src" : "linux",
"spike-args" : "--extension=sha3"
}
```

Run by Marshal at build time (cross-compiles the Linux benchmarks)

Files to copy into the guest root filesystem (the pre-compiled benchmarks in this case)

Custom Linux source to compile (needed in this case to manage the accelerator)

Example Workload: SHA3 on Linux

Skipped for Time
(try it out yourself!)

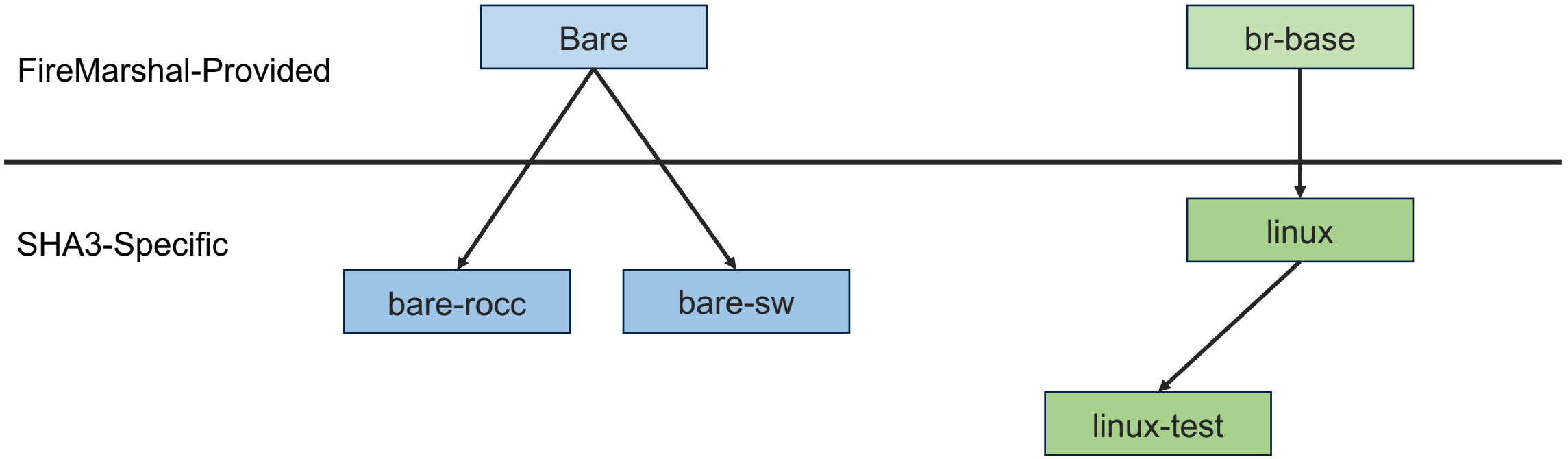
```
$ marshal -d build sha3-linux.yaml
$ marshal -d launch -s sha3-linux.yaml
```

In the target:

```
user: root
password: firesim
$ ./sha3-rocc
$ ./sha3-sw
$ poweroff -f
```

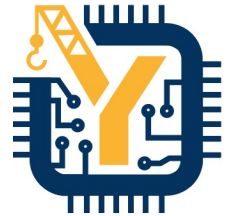
```
[ 0.627440] usbcore: registered new interface driver uas
[ 0.627780] usbcore: registered new interface driver usb-storage
mousedev: PS/2 mouse device common for all mice
driver usbhid
eling driver
Running FireMarshal
Loading FireMarshal platform drivers
[ 0.664
Calling
Startin
Startin
Running
Startin
Initial
done.
Startin
[ 1.
[ 1.
AH00558
global
Startin
launch
firesim
Welcome
buildro
root
Password:

# ./sha3-rocc
./sha3-rocc
Start basic test 1.
output[0]:203 ==? results[0]:203
output[1]:52 ==? results[1]:52
output[2]:27 ==? results[2]:27
output[3]:85 ==? results[3]:85
output[4]:46 ==? results[4]:46
output[5]:79 ==? results[5]:79
output[6]:152 ==? results[6]:152
output[7]:228 ==? results[7]:228
output[8]:86 ==? results[8]:86
output[9]:138 ==? results[9]:138
output[10]:201 ==? results[10]:201
```

Workload Inheritance



Linux-based automated unit test

Example Workload:
Linux-based Unit Test



sha3-linux-test.yaml

```
{
  "name" : "sha3-linux-test",
  "base" : "sha3-linux.yaml",
  "workdir" : "..",
  "command" : "/root/sha3-rocc"
  "testing" : {
    "refDir" : "test-reference/linux"
  }
}
```

Inherit everything we did for the basic sha3 workload, no need to repeat ourselves.

Run by the guest every time it boots. Target will shutdown after running the command.

Known-good output. Marshal will compare the run output against this when you test the workload

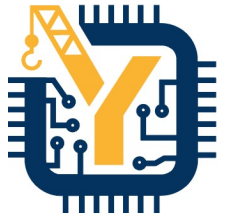
Example Workload: Linux Unit Test

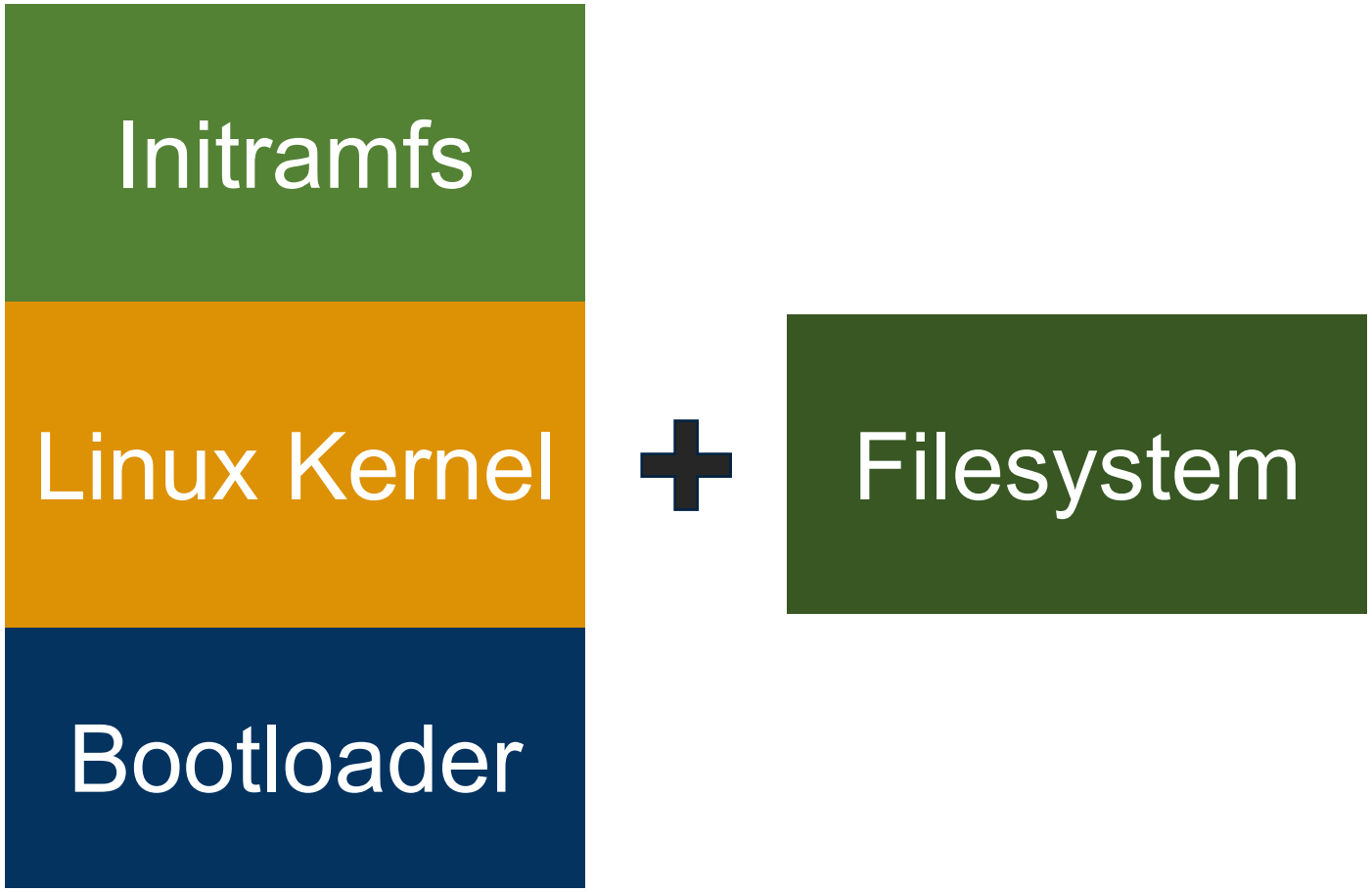
```
$marshal -dv test -s sha3-linux-test.yaml
```

Note: No need to ‘build’, the test command builds and runs automatically.

```
[    0.627445] Segment Routing with IPv6
[    0.627700] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[    0.628345] NET: Registered protocol family 17
[    0.628720] 9pnet: Installing 9P2000 support
[    0.629000] Key type dns_resolver registered
[    0.633885] Freeing unused kernel memory: 13872K
[    0.646840] Run /init as init process
Running FireMarshal nodisk init
Loading FireMarshal platform drivers
[    0.661085] icenet: loading out-of-tree module taints kernel.
Calling distro init
Starting syslogd: OK
Starting klogd: OK
Running sysctl: OK
Starting mdev: OK
Initializing random number generator... [    1.302665] random: dd: uninitialized urandom read (512 bytes read)
done.
Starting network: OK
[    1.390600] random: httpd: uninitialized urandom read (8 bytes read)
[    1.391000] random: httpd: uninitialized urandom read (8 bytes read)
AH00558: httpd: Could not reliably determine the server's fully qualified domain name, using 127.0.1.1. Set the 'Serve
globally to suppress this message
Starting dropbear sshd: OK
launching firesim workload run/command
Start basic test 1.
output[0]:203 ==? results[0]:203
output[1]:52 ==? results[1]:52
output[2]:27 ==? results[2]:27
output[3]:85 ==? results[3]:85
output[4]:46 ==? results[4]:46
output[5]:79 ==? results[5]:79
output[6]:152 ==? results[6]:152
output[7]:228 ==? results[7]:228
output[8]:86 ==? results[8]:86
output[9]:138 ==? results[9]:138
output[10]:201 ==? results[10]:201
output[11]:206 ==? results[11]:206
output[12]:253 ==? results[12]:253
output[13]:168 ==? results[13]:168
output[14]:255 ==? results[14]:255
output[15]:107 ==? results[15]:107
output[16]:122 ==? results[16]:122
output[17]:177 ==? results[17]:177
output[18]:65 ==? results[18]:65
output[19]:68 ==? results[19]:68
output[20]:231 ==? results[20]:231
output[21]:19 ==? results[21]:19
output[22]:70 ==? results[22]:70
output[23]:198 ==? results[23]:198
output[24]:64 ==? results[24]:64
output[25]:90 ==? results[25]:90
output[26]:192 ==? results[26]:192
output[27]:80 ==? results[27]:80
output[28]:206 ==? results[28]:206
output[29]:234 ==? results[29]:234
output[30]:168 ==? results[30]:168
output[31]:159 ==? results[31]:159
Success!
SHA execution took 8 cycles
[    1.545575] reboot: Power down
Testing outputs
Test Passed
Output available at: /data/repos/chipyard/software/firemarshal/runOutput/sha3-linux-test-test-2021-06-11--20-25-30-UEH

Log available at: /data/repos/chipyard/software/firemarshal/logs/sha3-linux-test-test-2021-06-11--20-25-30-UEHUTAIWSJP
SUCCESS: All Tests Passed (0 tests skipped)
[marshal-configs]$
```

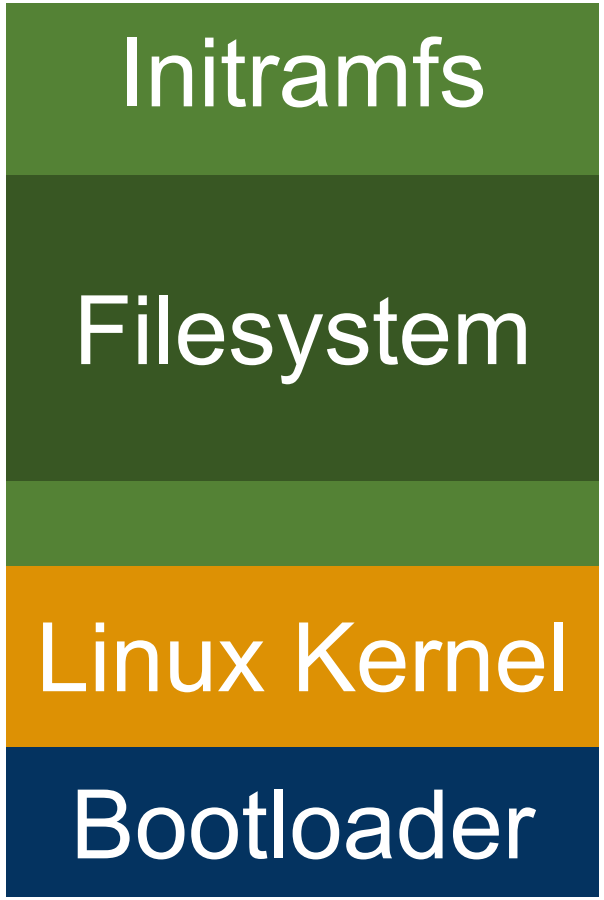
Linux Build Internals:
Diskless Designs





- Problem: Not every platform has a working disk device (e.g. spike)

Linux Build Internals:
Diskless Designs

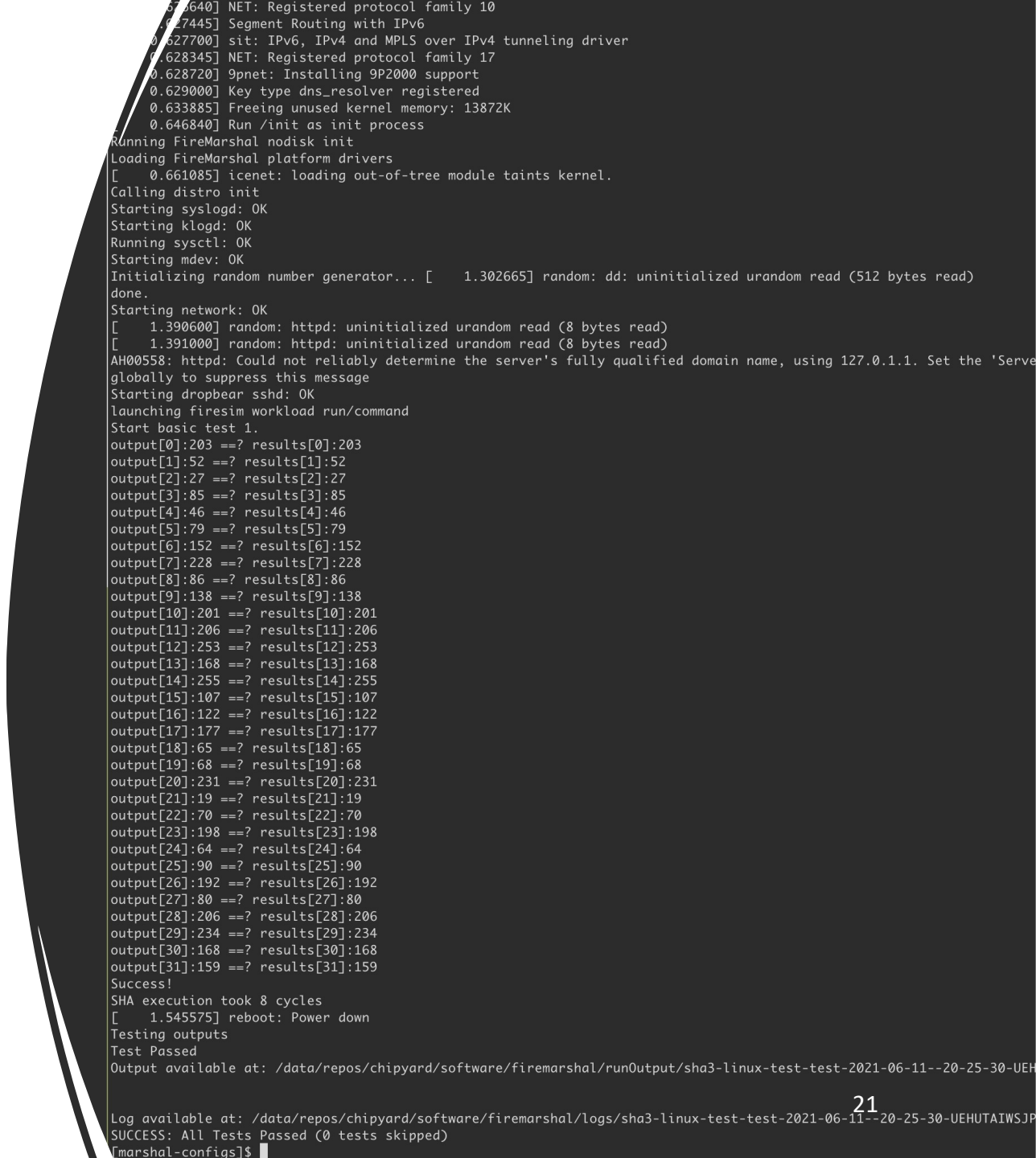


- Problem: Not every platform has a working disk device (e.g. spike)
- Solution: Compile the whole rootfs into the binary image!
  - ‘./marshal –no-disk …’

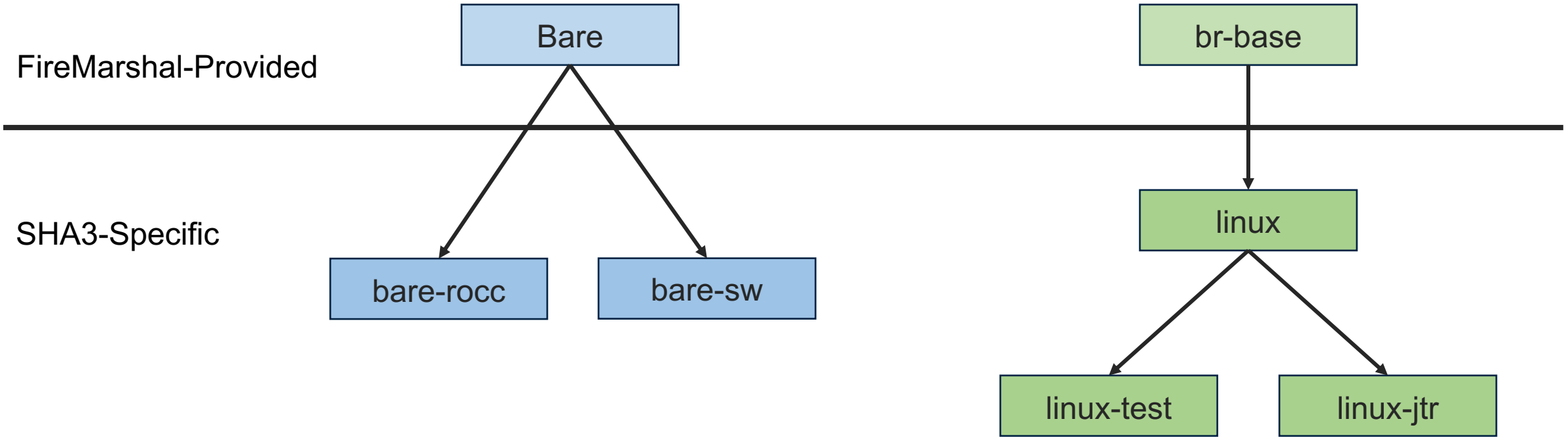
Example Workload: Linux Unit Test

```
$marshal -dv test -s sha3-linux-test.yaml
```

Note: No need to ‘build’, the test command builds and runs automatically.

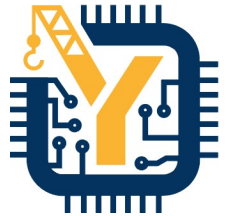


Workload Inheritance



End-to-end Benchmark: John The Ripper

Example Workload:
Linux-based Benchmark – John the Ripper



sha3-linux-jtr.yaml

```
{
  "name" : "sha3-linux-jtr",
  "base" : "sha3-linux.yaml",
  "workdir" : "..",
  "distro" : {
    "name": "br",
    "opts": {
      "configs" : [ "jtr/buildroot-config" ],
      "environment" : {
        "BR2_EXTERNAL":
"${SHA3_LINUX_JTR_PATH}/jtr/buildroot-
external"
      }
    }
  },
  "overlay" : "jtr/overlay"
}
```

Inherit from sha3-linux again. Only need to specify that stuff once.

Add John The Ripper to our underlying buildroot distro

John The Ripper must be installed to work correctly. The overlay allows us to specify a complex directory structure.

Example Workl
End-to-end Benchmark

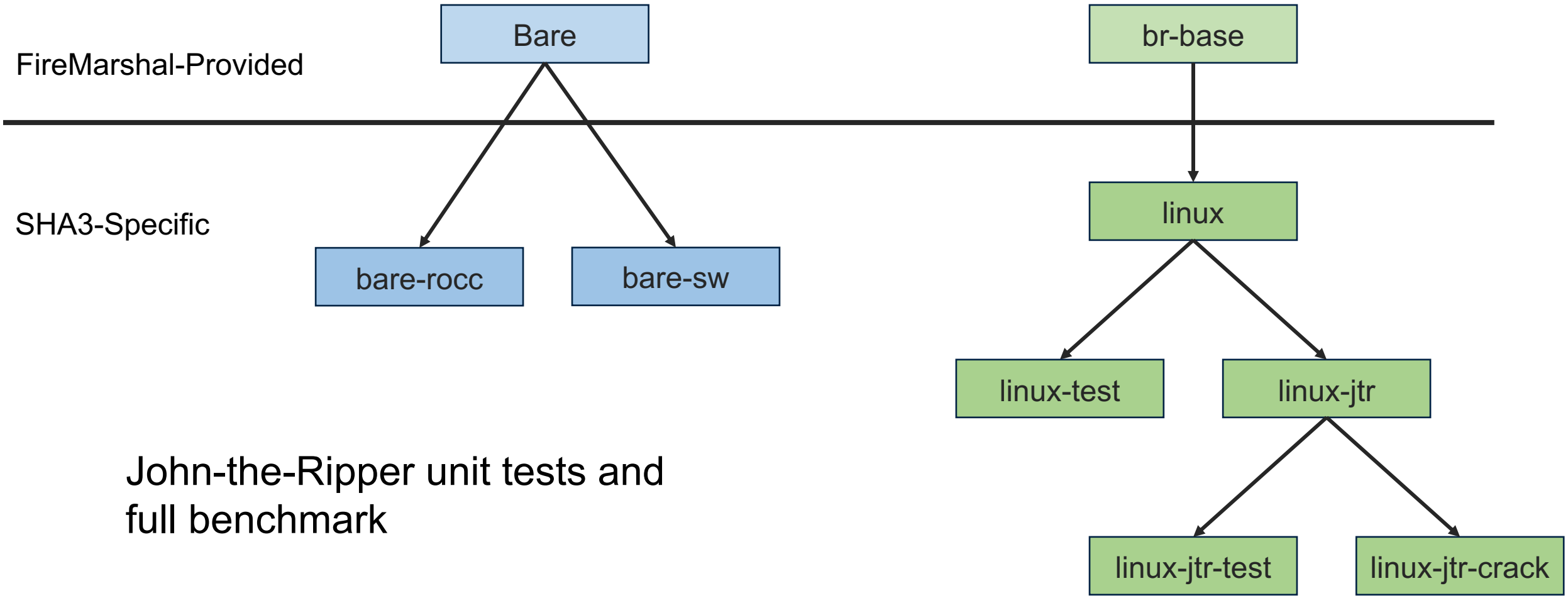
Skipped for Time
(try it out yourself!)

In the target:

```
user: root
password: firesim
$ cd sha3
$ john --format=Raw-SHA3-256-rocc short.txt
$ poweroff -f
```

```
$ marshal -d build sha3-linux-jtr.yaml
$ marshal -d launch -s sha3-linux-jtr.yaml
```

Workload Inheritance



John-the-Ripper unit tests and full benchmark

Example Workload:
Linux-based Benchmark – John the Ripper

Skipped for Time
(try it out yourself!)

sha3-linux-jtr-test.yaml

```
{
  "name" : "sha3-linux-jtr-test",
  "base" : "sha3-linux-jtr.yaml",
  "workdir" : "..",
  "run" : "jtr/bench.sh",
  "testing" : {
    "refDir" : "test-reference/linux-jtr"
  }
}
```

Test the benchmark

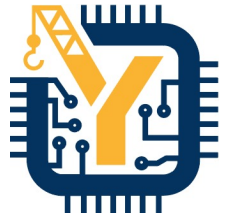
```
marshal -d test -s sha3-linux-jtr-test.yaml
```

sha3-linux-jtr-crack.yaml

```
{
  "name" : "sha3-linux-jtr-crack",
  "base" : "sha3-linux-jtr.yaml",
  "workdir" : "..",
  "run" : "jtr/crack.sh"
}
```

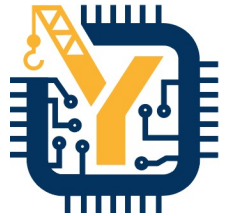
Run the full benchmark

```
marshal -d launch -s sha3-linux-jtr-crack.yaml
```



More Complex Use-Cases

Multi-Node Workloads
(“jobs”)

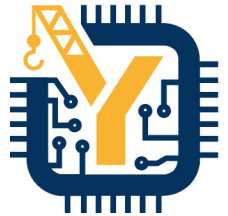


job-example.yaml

```
{
  "name" : "job-example",
  "base" : "br-base.json",
  "jobs" : [
    { "name" : "node0",
      "command" : "ping -c 1 172.16.0.3",
    },
    { "name" : "node1",
      "command" : "ping -c 1 172.16.0.2",
    }
  ]
}
```

- Each job runs on a single node in multi-node simulations.
- Described the same as any workload
  - implicitly ‘base’d on the enclosing workload
- Can run one at a time in SW simulation.
  - Must use FireSim to use the network

Native Initialization
(“guest-init”)



guest-init-example.yaml

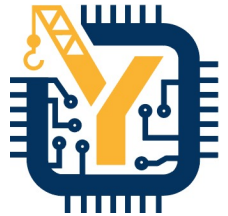
```
{
  ”name” : “guest-init-example”,
  “base” : “fedora-base.json”,
  “guest-init” : “init.sh”
}
```

init.sh

```
#!/bin/bash
yum install -y blas python3 …

cd cafe2_src/
make
```

- “guest-init” script is run once on the guest during build
  - Run in QEMU
  - Can access internet
- Useful for installing packages and/or natively compiling benchmarks

Automatic Results Processing
(“post-run-hook”)



results-example.yaml

```
{
  ”name” : “results-example”,
  “base” : “mytest.yaml”,
  “outputs” : [“/root/res.csv”],
  “post-run-hook” : “results.py”
}
```

“post-run-hook” executed on the host after every run

- Good for post-processing of more complex experiments

results.py

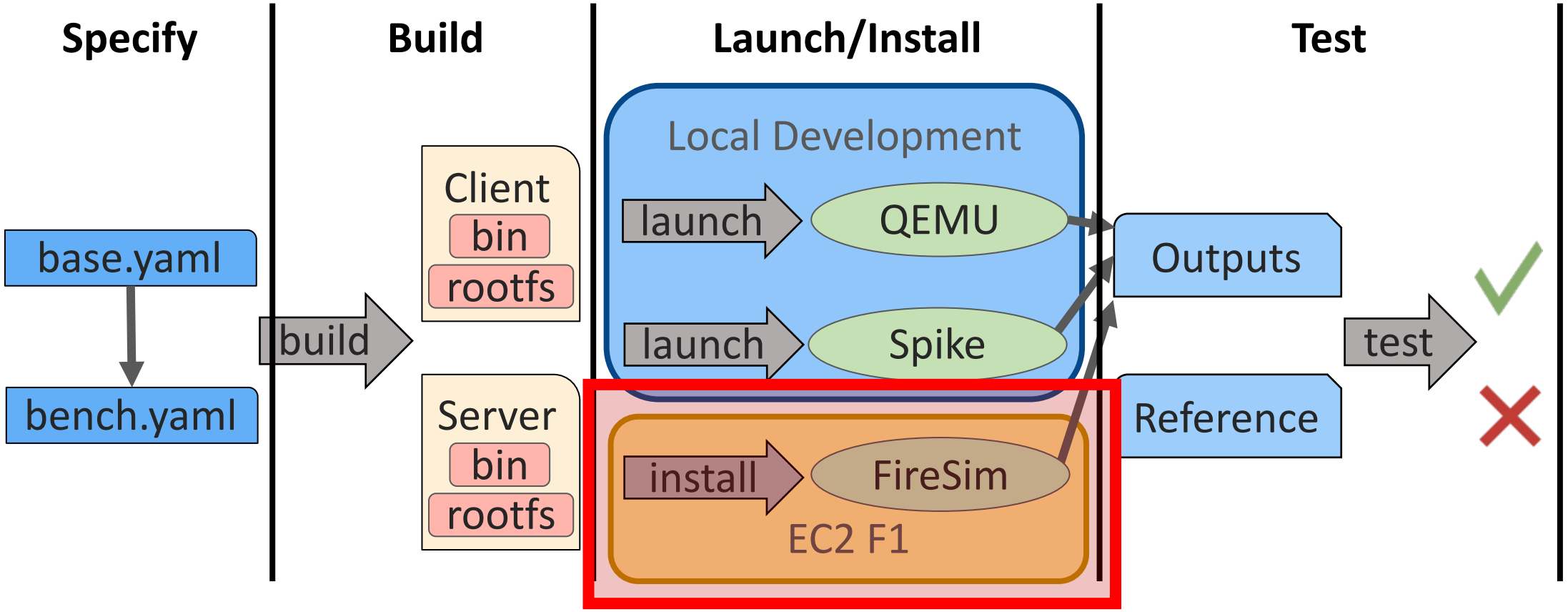
```
#!/usr/bin/env python
from pathlib import Path
import csv

resultPath = Path(sys.argv[1]) /
  ‘results-example’ / ‘res.csv’

processResult(resultPath)
```

Path to the results directory passed to the script

Do anything you want with the results. For example, copy to a known location, or sanity check

Running Workloads on FireSim

FireMarshal Overview
FireSim Install



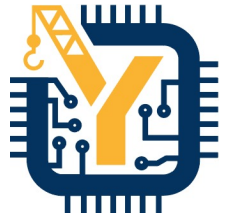
- Generates FireSim-native workload configuration from FireMarshal

- After running install, you can use FireSim to launch the workload on the real RTL
  - Note: unlike functional simulation, FireSim makes a copy of the rootfs before running.

Installing Workloads to FireSim

$ marshal install sha3*.yaml
$ cd ~/chipyard/sims/firesim/deploy/workloads/
$ cat workloads/sha3-linux.json

```
rshal-configs]$ marshal install *.yaml
 check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-bare-rocc-i
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-bare-sw-ins
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-linux-jtr-c
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-linux-jtr-t
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-linux-jtr-i
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-linux-test-
Workload installed to FireSim at /data/repos/chipyard/sims/fire
To check on progress, either call marshal with '-v' or see the
/data/repos/chipyard/software/firemarshal/logs/sha3-linux-insta
Workload installed to FireSim at /data/repos/chipyard/sims/fire
Log available at: /data/repos/chipyard/software/firemarshal/log
[marshal-configs]$ cd ../../../../sims/firesim/deploy/workloads
[workloads]$ cat sha3-linux.json
{
        "benchmark_name": "sha3-linux",
        "common_simulation_outputs": [
                "uartlog"
        ],
        "common_bootbinary": "../../../../../software/firemarsh
        "common_rootfs": "../../../../../software/firemarshal/i
}[workloads]$
```



Lots More Features!

https://firemarshal.readthedocs.io/en/latest/