FireSim

A Brief Tour of FireSim: The Manager & Compiler; Building Hardware Designs

https://fires.im

@firesimproject

Speaker: Sagar Karandikar

Berkeley Architecture Research

Agenda: What Will We Cover?

1) The Compiler → Golden Gate
- Invoke it on example RTL
- Inspect its outputs

2) The Manager → `firesim`
- Explain how it's configured
- Demonstrate how it's used to build bitstreams

Where is FireSim in Chipyard?

With the software RTL simulators!

`~/chipyard-afternoon/sims/firesim`

→ This has been exported as `$FDIR`

Interactive:

```
# <ssh back onto your ec2 instance>

$ tmux new -s afternoon

$ cd $FDIR

$ ls
```

FireSim's Directory Structure

`sim/`

- Golden Gate lives here
- Scala & C++ sources for additional FireSim models
- Make-based build system to invoke Golden Gate

`deploy/`

- Manager lives here
- FireSim workload definitions

`platforms/` → FPGA platform definitions (e.g. AWS FPGA for F1, Xilinx Vitis for U250)

`sw/` → target software & FireMarshal (more on this later)

Agenda: What Will We Cover?

1) The Compiler → "Golden Gate"

- Invoke it on example RTL
- Inspect its outputs

2) The Manager → `firesim`

- Explain how it's configured
- Demonstrate how it's used to build bitstreams

Interactive:

```
$ cd $FDIR/sim

$ make DESIGN=FireSim
```

An Analogy

- Golden Gate is like Verilator but for FPGA-accelerated simulation

Verilator generates C++ sources to simulate your design.

→ Compile and run on a CPU-host

Golden Gate generates C++ & Verilog to simulate your design.

→ Compile and run on a hybrid CPU & FPGA host

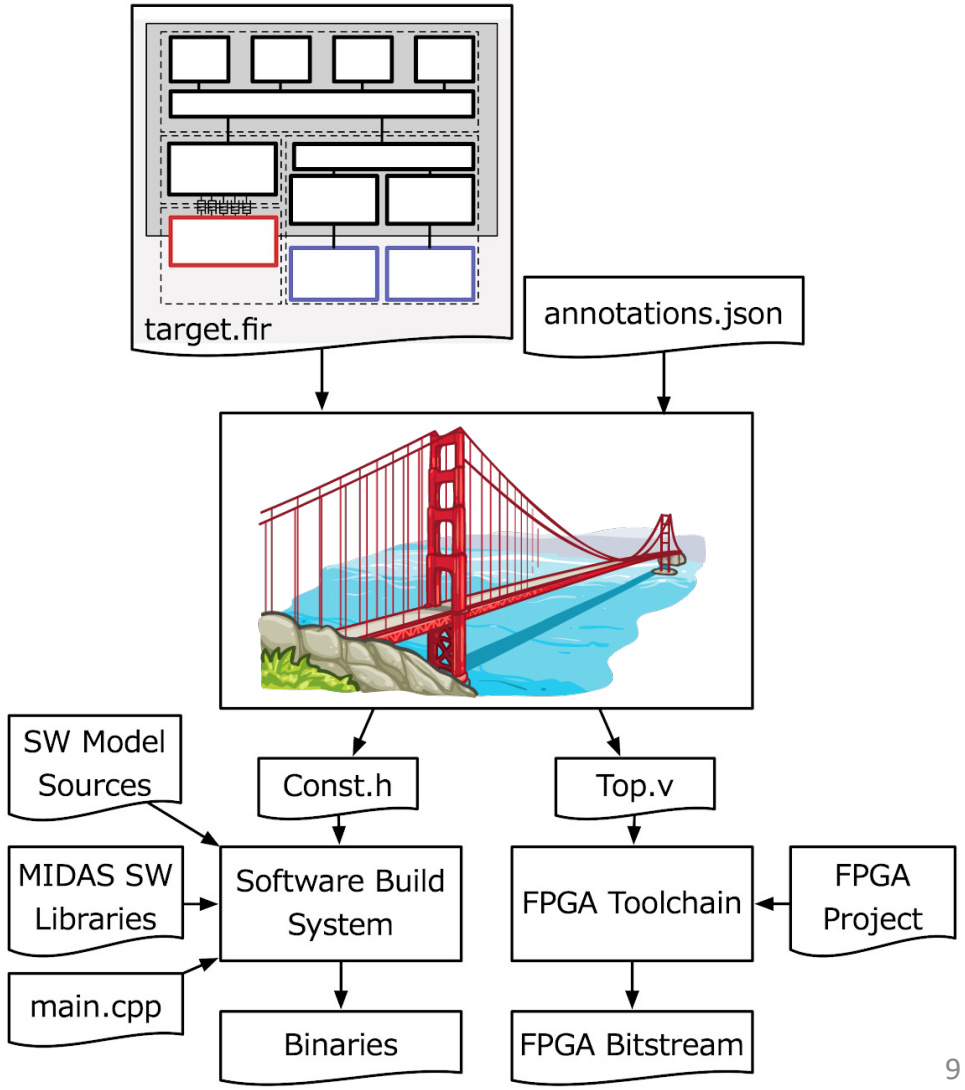
Golden Gate Compiler

Inputs:

- FIRRTL & annos from a Chipyard generator
- Compiler configuration

→ Produces sources for a simulator that are:

- deterministic
- support co-simulation of software models
- *area-optimized to fit more on the FPGA*



Interacting with Golden Gate via Make

- Make invokes Golden Gate with three variables (the “Tuple”):

DESIGN :

- The top level module → MODEL in Chipyard

TARGET_CONFIG:

- The generator’s config → CONFIG in Chipyard

PLATFORM_CONFIG:

- Compiler options passed to Golden Gate

Interactive:

```
$ cd $FDIR/sim/generated-src/f1

# here you'll find output directories for all builds

$ cd <any-directory-here>

$ ls
```

Inspecting the Outputs

`<long-name>.fir & <long-name>.anno.json`

- Target's FIRRTL & annotations

`FireSim-generated.sv`

- The compiled simulator

`FireSim-generated.const.h`

- Simulator's memory map

`FireSim-generated.runtime.conf`

- A default runtime configuration for simulation

Agenda: What Will We Cover?

1) The Compiler → Golden Gate
- Invoke it on example RTL
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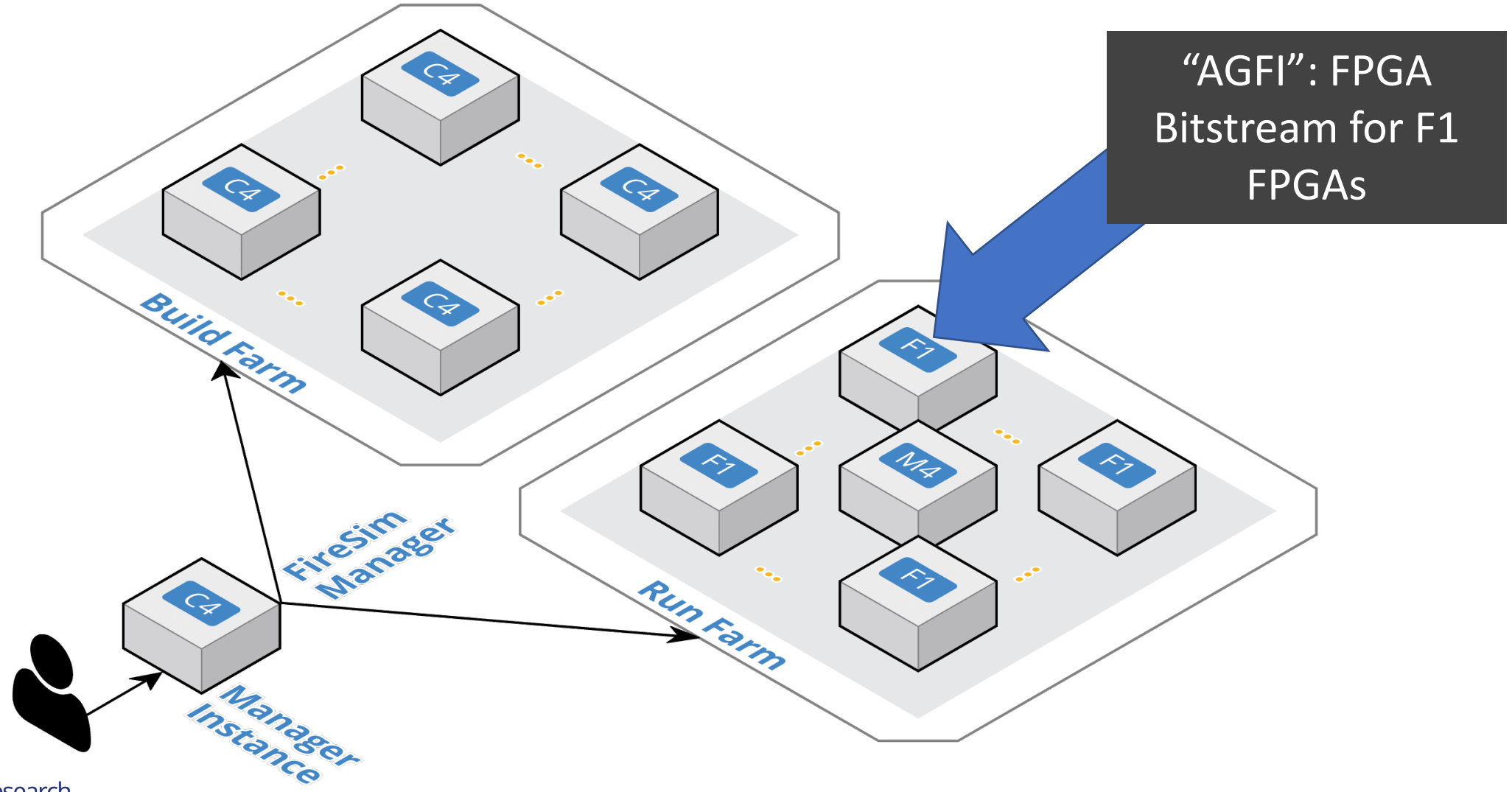
2) The Manager → `firesim`
- Explain how it's configured
- Demonstrate how it's used to build bitstreams

Background Terminology



Using the `firesim` Manager Command Line

- sourcing `sourceme-f1-manager.sh` puts `firesim` on your path
- can call `firesim` from anywhere on the instance
- it will always run from the directory:

`$FDIR/deploy/`

After a fresh clone, need to call:

```
firesim managerinit --platform f1
```

→ **You already did this at the start of the tutorial**

Interactive:

```
$ cd $FDIR/deploy

$ ls
```

Configuring the Manager. 4 files in `firesim/deploy/`

`config_build.yaml`

```
# Build-time build design / AGFI configuration for the FireSim
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager/M

# this refers to build farms defined in config_build_farm.yaml
build_farm:
  # managerinit replace start
  base_recipe: build-farm-recipes/aws_ec2.yaml
  # Uncomment and add args to override defaults.
  # Arg structure should be identical to the args given
  # in the base_recipe.
  #recipe_arg_overrides:
  #  <ARG>: <OVERRIDE>
  # managerinit replace end

builds_to_run:
    # this section references builds defined in config_build_r
    # if you add a build here, it will be built when you run b

    # Unnetworked designs use a three-domain configuration
    # Tiles: 1600 MHz
    #    <Rational Crossing>
    # Uncore: 800 MHz
    #    <Async Crossing>
    # DRAM : 1000 MHz
    - firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3

    # All NIC-based designs use the legacy FireSim frequency s
    # tiles and uncore running at 3.2 GHz to sustain 200Gb the
    - firesim_supernode_rocket_singlecore_nic_l2_lbp
    - firesim_rocket_quadcore_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_nic_l2_llc4mb_ddr3

    # Configs for tutorials
    # - firesim_rocket_singlecore_no_nic_l2_lbp
    # - firesim_rocket_singlecore_sha3_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3_p

agfis_to_share:
    - firesim_rocket_quadcore_nic_l2_llc4mb_ddr3
    - firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_nic_l2_llc4mb_ddr3

    - firesim_supernode_rocket_singlecore_nic_l2_lbp

    # Configs for tutorials
    # - firesim_rocket_singlecore_no_nic_l2_lbp
    # - firesim_rocket_singlecore_sha3_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3_p

share_with_accounts:
    # To share with a specific user:
    somebodysname: 123456789012
    # To share publicly:
    #public: public
```

`config_build_recipes.yaml`

```
# Build-time build recipe configuration for the FireSim Simulation Manag
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager/Manager-Con

# this file contains sections that describe hardware designs that /can/
# edit config_build.yaml to actually "turn on" a config to be built when
# buildafi

##########
# Schema:
##########
# <NAME>:
#     DESIGN: <>
#     TARGET_CONFIG: <>
#     PLATFORM_CONFIG: Config
#     deploy_triplet: null
#     post_build_hook: null
#     metasim_customruntimeconfig: "path to custom runtime config for meta
#     bit_builder_recipe:
#     # OPTIONAL: overrides for bit builder recipe
#     # Arg structure should be identical to the args given
#     # in the base_recipe.
#     #bit_builder_arg_overrides:
#     #  <ARG>: <OVERRIDE>

# Quad-core, Rocket-based recipes
# REQUIRED FOR TUTORIALS
firesim_rocket_quadcore_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: WithNIC_DDR3FRFCFSLLC4MB_WithDefaultFireSimBridges_Wi
    PLATFORM_CONFIG: WithAutoILA_F90MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml

# NB: This has a faster host-clock frequency than the NIC-based design,
# its uncore runs at half rate relative to the tile.
firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: DDR3FRFCFSLLC4MB_WithDefaultFireSimBridges_WithFireSi
    PLATFORM_CONFIG: WithAutoILA_F140MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml

# Single-core, BOOM-based recipes
# REQUIRED FOR TUTORIALS
firesim_boom_singlecore_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: WithNIC_DDR3FRFCFSLLC4MB_WithDefaultFireSimBridges_Wi
    PLATFORM_CONFIG: WithAutoILA_F65MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml

# NB: This has a faster host-clock frequency than the NIC-based design,
# its uncore runs at half rate relative to the tile.
firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: DDR3FRFCFSLLC4MB_WithDefaultFireSimBridges_WithFireSi
    PLATFORM_CONFIG: WithAutoILA_F65MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml
```

`config_hwdb.yaml`

```
# Hardware config database for FireSim Simulation Manager
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager

# Hardware configs represent a combination of an agfi, a dep
# (if needed), and a custom runtime config (if needed)

# The AGFIs provided below are public and available to all u
# Only AGFIs for the latest release of FireSim are guarantee
# If you are using an older version of FireSim, you will nee
# own images.

firesim_boom_singlecore_nic_l2_llc4mb_ddr3:
    agfi: agfi-0b969bdcc09663973
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3:
    agfi: agfi-0d9d8e9255c80dac5
    deploy_triplet_override: null
    custom_runtime_config: null

# DOCREF START: Example HWDB Entry
firesim_rocket_quadcore_nic_l2_llc4mb_ddr3:
    agfi: agfi-0c45d995a46cce5dc
    deploy_triplet_override: null
    custom_runtime_config: null
# DOCREF END: Example HWDB Entry

firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3:
    agfi: agfi-08719c613c2f314cc
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_supernode_rocket_singlecore_nic_l2_lbp:
    agfi: agfi-0b747b88806aeed5c
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_rocket_singlecore_no_nic_l2_lbp:
    agfi: agfi-0e27eb94672e2f5a9
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_rocket_singlecore_sha3_nic_l2_llc4mb_ddr3:
    agfi: agfi-064592b4699c8b4d4
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3:
    agfi: agfi-0d668a1f6883c7625
    deploy_triplet_override: null
    custom_runtime_config: null

firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3_printf:
    agfi: agfi-0b811d62bd5294f45
    deploy_triplet_override: null
    custom_runtime_config: null
```

`config_runtime.yaml`

```
# RUNTIME configuration for the FireSim Simulation Manager
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager/Manager-Co

run_farm:
  # managerinit replace start
  base_recipe: run-farm-recipes/aws_ec2.yaml
  # Uncomment and add args to override defaults.
  # Arg structure should be identical to the args given
  # in the base_recipe.
  #recipe_arg_overrides:
  #  <ARG>: <OVERRIDE>
  # managerinit replace end

metasimulation:
  metasimulation_enabled: false
  # vcs or verilator. use vcs-debug or verilator-debug for waveform gen
  metasimulation_host_simulator: verilator
  # plusargs passed to the simulator for all metasimulations
  metasimulation_only_plusargs: "+fesvr-step-size=128 +dramsim +max-cyc
  # plusargs passed to the simulator ONLY FOR vcs metasimulations
  metasimulation_only_vcs_plusargs: "+vcs+initreg+0 +vcs+initmem+0"

target_config:
    # Set topology: no net config to run without a network simulation
    topology: example_8config
    no_net_num_nodes: 2
    link_latency: 6405
    switching_latency: 10
    net_bandwidth: 200
    profile_interval: -1

    # This references a section from config_hwdb.yaml for fpga-accelera
    # or from config_build_recipes.yaml for metasimulation
    # In homogeneous configurations, use this to set the hardware confi
    # for all simulators
    default_hw_config: firesim_rocket_quadcore_nic_l2_llc4mb_ddr3

    # Advanced: Specify any extra plusargs you would like to provide wh
    # booting the simulator (in both FPGA-sim and metasim modes). This
    # a string, with the contents formatted as if you were passing the
    # at command line, e.g. "+a=1 +b=2"
    plusarg_passthrough: ""

tracing:
    enable: no

    # Trace output formats. Only enabled if "enable" is set to "yes" ab
    # 0 = human readable; 1 = binary (compressed raw data); 2 = flamegr
    # unwinding -> Flame Graph)
    output_format: 0

    # Trigger selector.
    # 0 = no trigger; 1 = cycle count trigger; 2 = program counter trig
    # instruction trigger
    selector: 1
    start: 0
    end: -1

autocounter:
    read_rate: 0

workload:
    workload_name: linux-uniform.json
    terminate_on_completion: no
    suffix_tag: null

host_debug:
    # When enabled (=yes), Zeros-out FPGA-attached DRAM before simulati
```

Configuring a Build

config_build.yaml

```
# Build-time build design / AGFI configuration for the FireSim
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager/M

# this refers to build farms defined in config_build_farm.yaml
build_farm:
  # managerinit replace start
  base_recipe: build-farm-recipes/aws_ec2.yaml
  # Uncomment and add args to override defaults.
  # Arg structure should be identical to the args given
  # in the base_recipe.
  #recipe_arg_overrides:
  #  <ARG>: <OVERRIDE>
  # managerinit replace end

builds_to_run:
    # this section references builds defined in config_build_r
    # if you add a build here, it will be built when you run b

    # Unnetworked designs use a three-domain configuration
    # Tiles: 1600 MHz
    #    <Rational Crossing>
    # Uncore: 800 MHz
    #    <Async Crossing>
    # DRAM : 1000 MHz
    - firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3

    # All NIC-based designs use the legacy FireSim frequency s
    # tiles and uncore running at 3.2 GHz to sustain 200Gb the
    - firesim_supernode_rocket_singlecore_nic_l2_lbp
```

config_build_recipes.yaml

```
# Build-time build recipe configuration for the FireSim Simulation Manage
# See https://docs.fires.im/en/stable/Advanced-Usage/Manager/Manager-Conf

# this file contains sections that describe hardware designs that /can/ b
# edit config_build.yaml to actually "turn on" a config to be built when
# buildafi

###########
# Schema:
###########
# <NAME>:
#     DESIGN: <>
#     TARGET_CONFIG: <>
#     PLATFORM_CONFIG: Config
#     deploy_triplet: null
#     post_build_hook: null
#     metasim_customruntimeconfig: "path to custom runtime config for meta
#     bit_builder_recipe:
#     # OPTIONAL: overrides for bit builder recipe
#     # Arg structure should be identical to the args given
#     # in the base_recipe.
#     #bit_builder_arg_overrides:
#     #  <ARG>: <OVERRIDE>

# Quad-core, Rocket-based recipes
# REQUIRED FOR TUTORIALS
firesim_rocket_quadcore_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: WithNIC_DDR3FRFCFSLLC4MB_WithDefaultFireSimBridges_Wit
    PLATFORM_CONFIG: WithAutoILA_F90MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml
```

Anatomy of a Build Recipe

`config_build_recipes.yaml`

```
firesim_rocket_quadcore_nic_l2_llc4mb_ddr3:
    DESIGN: FireSim
    TARGET_CONFIG: WithNIC_DDR3FRFCFSLLC4MB_WithDefaultFi
    PLATFORM_CONFIG: WithAutoILA_F90MHz_BaseF1Config
    deploy_triplet: null
    post_build_hook: null
    metasim_customruntimeconfig: null
    bit_builder_recipe: bit-builder-recipes/f1.yaml
```

Consists of:

- A label
- The tuple from before
- Platform-specific bitstream generation parameters

Defining a Build Job: `config_build.yaml`

```
build_farm:
  # managerinit replace start
  base_recipe: build-farm-recipes/aws_ec2.yaml
  # Uncomment and add args to override defaults.
  # Arg structure should be identical to the args given
  # in the base_recipe.
  #recipe_arg_overrides:
  #  <ARG>: <OVERRIDE>
  # managerinit replace end

builds_to_run:
    # this section references builds defined in config_build_r
    # if you add a build here, it will be built when you run b

    # Unnetworked designs use a three-domain configuration
    # Tiles: 1600 MHz
    #    <Rational Crossing>
    # Uncore: 800 MHz
    #    <Async Crossing>
    # DRAM : 1000 MHz
    - firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3

    # All NIC-based designs use the legacy FireSim frequency s
    # tiles and uncore running at 3.2 GHz to sustain 200Gb the
    - firesim_supernode_rocket_singlecore_nic_l2_lbp
    - firesim_rocket_quadcore_nic_l2_llc4mb_ddr3
```

Consists of:

- Build host platform configuration
- A list of recipes you'd like to batch out to a build farm

Defining a Build Job: `config_build.yaml`

```
    - firesim_rocket_quadcore_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_nic_l2_llc4mb_ddr3

    # Configs for tutorials
    # - firesim_rocket_singlecore_no_nic_l2_lbp
    # - firesim_rocket_singlecore_sha3_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3_p

agfis_to_share:
    - firesim_rocket_quadcore_nic_l2_llc4mb_ddr3
    - firesim_rocket_quadcore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_no_nic_l2_llc4mb_ddr3
    - firesim_boom_singlecore_nic_l2_llc4mb_ddr3

    - firesim_supernode_rocket_singlecore_nic_l2_lbp

    # Configs for tutorials
    # - firesim_rocket_singlecore_no_nic_l2_lbp
    # - firesim_rocket_singlecore_sha3_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3
    # - firesim_rocket_singlecore_sha3_no_nic_l2_llc4mb_ddr3_p

share_with_accounts:
    # To share with a specific user:
    somebodysname: 123456789012
    # To share publicly:
    #public: public
```

Once you're done with builds:

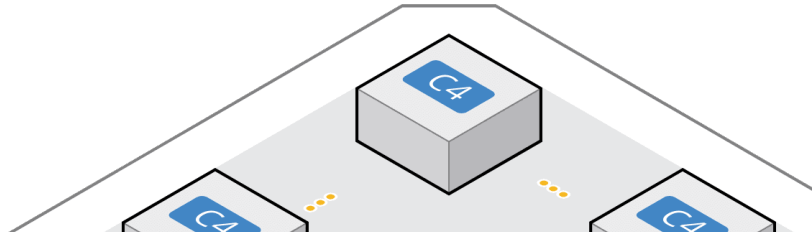
- A list of recipes you'd like to share with other users

Running builds

- Once we've configured ***what*** we want to build, let's build it

```
$ firesim buildbitstream
```

- This completely automates the process. For each design, in-parallel:
  - Launch a build instance (c5.4xlarge)
  - Generate target RTL & invokes Golden Gate
  - Ship infrastructure to build instances, run Vivado FPGA builds in parallel
  - Collect results back onto manager instance
    - $FDIR/deploy/results-build/<TIMESTAMP>-<tuple>/
  - Email you the entry to put into config_hwdb.yaml
  - Terminate the build instance



AWS Notifications <no-reply@sns.amazonaws.com>
to me

Your AGFI has been created!
Add

firesim_rocket_singlecore_no_nic_l2_lbp:
agfi: agfi-0e27eb94672e2f5a9
deploy_triplet_override: null
custom_runtime_config: null

to your config_hwdb.yaml to use this hardware configuration.

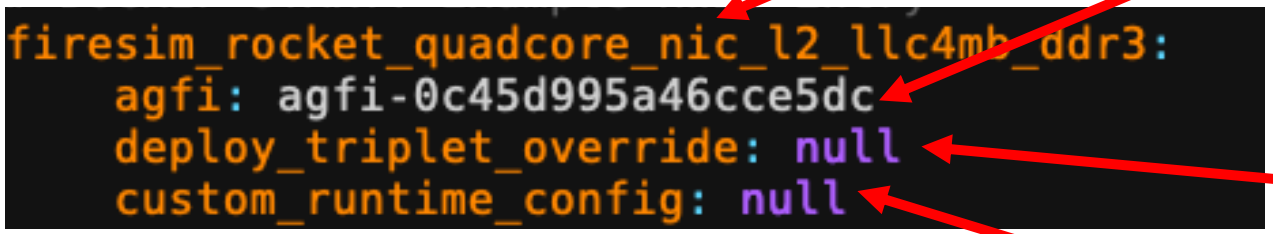
Interactive:

```
$ cd $FDIR/deploy

# Should print the FPGA image from the AM

$ cat built-hwdb-entries/*
```

Anatomy of a HWDB Entry



- Same label as before
- The FPGA image

Hooks to change:

- Software models
- Runtime arguments

→ *Without FPGA recompilation*

Interactive:

```
# Prefetching for the next section

$ cd ~/chipyard-afternoon/generators/sha3/software/

$ marshal -d \
    build marshal-configs/sha3-linux-test.yaml
```

Summary

- Don’t fret if you didn’t catch everything, everything we showed you today is documented in excruciating detail at https://docs.fires.im
- We learned how to:
  - Build FireSim FPGA images for a set of targets
    - https://docs.fires.im/en/stable/Building-a-FireSim-AFI.html