



# FireSim

A Brief Tour of FireSim:  
The Manager & Compiler;  
Building an FPGA image

<https://fires.im>



@firesimproject

**MICRO 2021 Tutorial**

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**Berkeley Architecture Research**



# Agenda: What will we cover?

## 1) The Compiler → Golden Gate

- Invoke it on example RTL
- “Simulate the simulator” using Verilator

## 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/sims/firesim`

→ We will reference this as `$FDIR`



# Example commands:

```
$ 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/ → AWS FPGA/Vivado project definitions

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



# Agenda: What will we cover?

## 1) The Compiler → “Golden Gate”

- Invoke it on example RTL
- “Simulate the simulator” using Verilator

## 2) The Manager → `firesim`

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



# Example commands:

```
$ 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





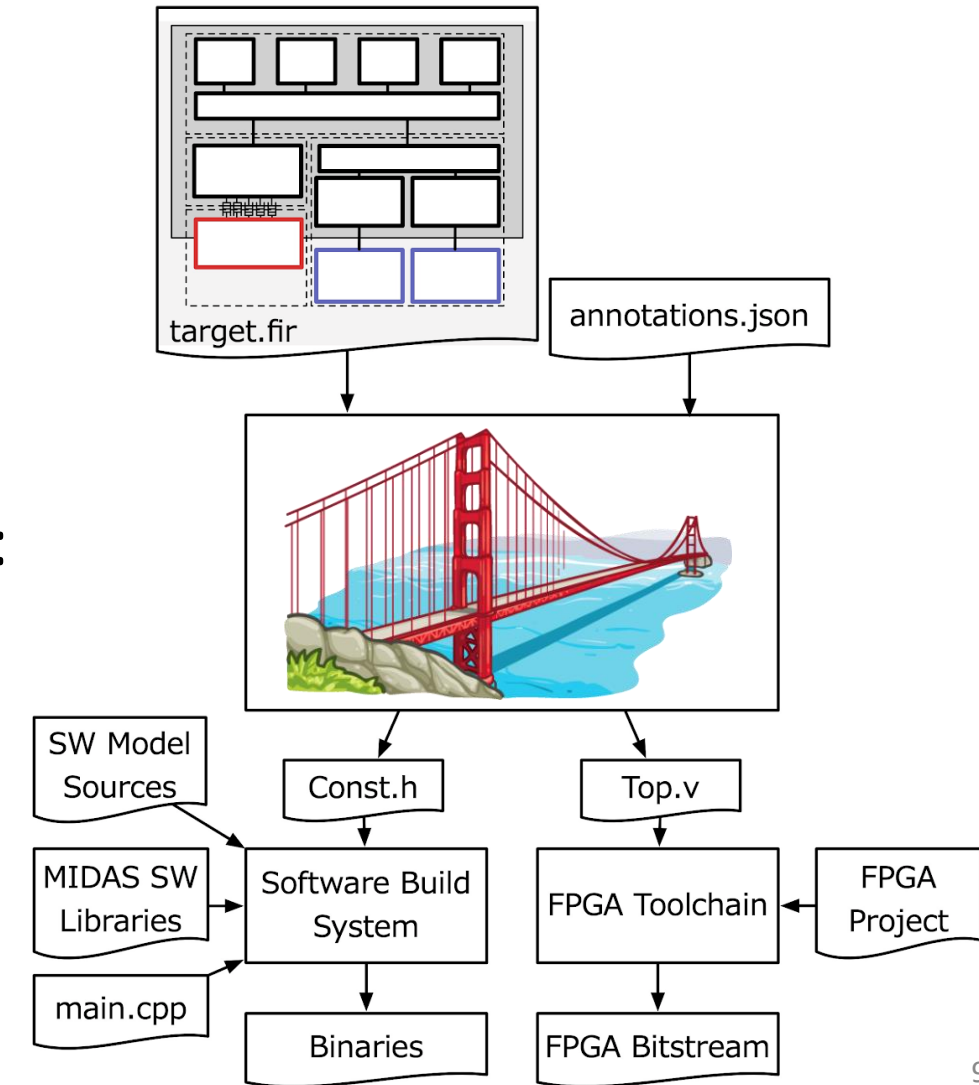
# Golden Gate Compiler

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*



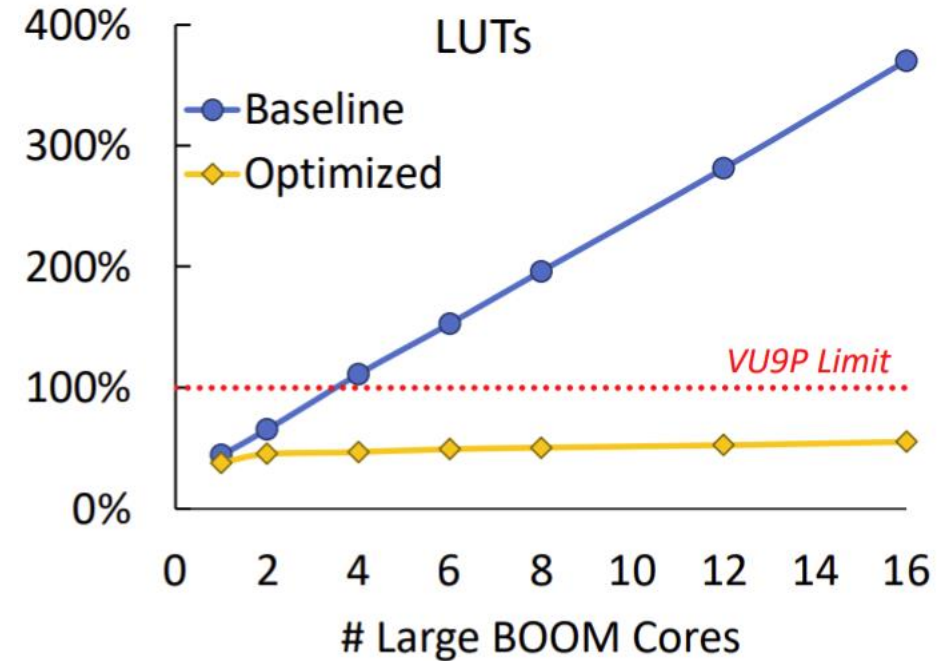


# Plug: IEEE MICRO Resource Optimizations

- Design doesn't fit?
  - Can't partition?
- Optimize!

IEEE Micro Punchline:

- Can fit 2x – 8x more BOOM cores on F1 FPGA
- think: “–Os for FireSim”





# 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



# Example commands:

```
$ 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

`FPGATop.v`

- The compiled simulator

`$DESIGN-const.h`

- Simulator's memory map

`runtime.conf`

- A default runtime configuration for simulation

Note: these names will change in 1.13 (see docs)



# Agenda: What will we cover?

## 1) The Compiler → Golden Gate

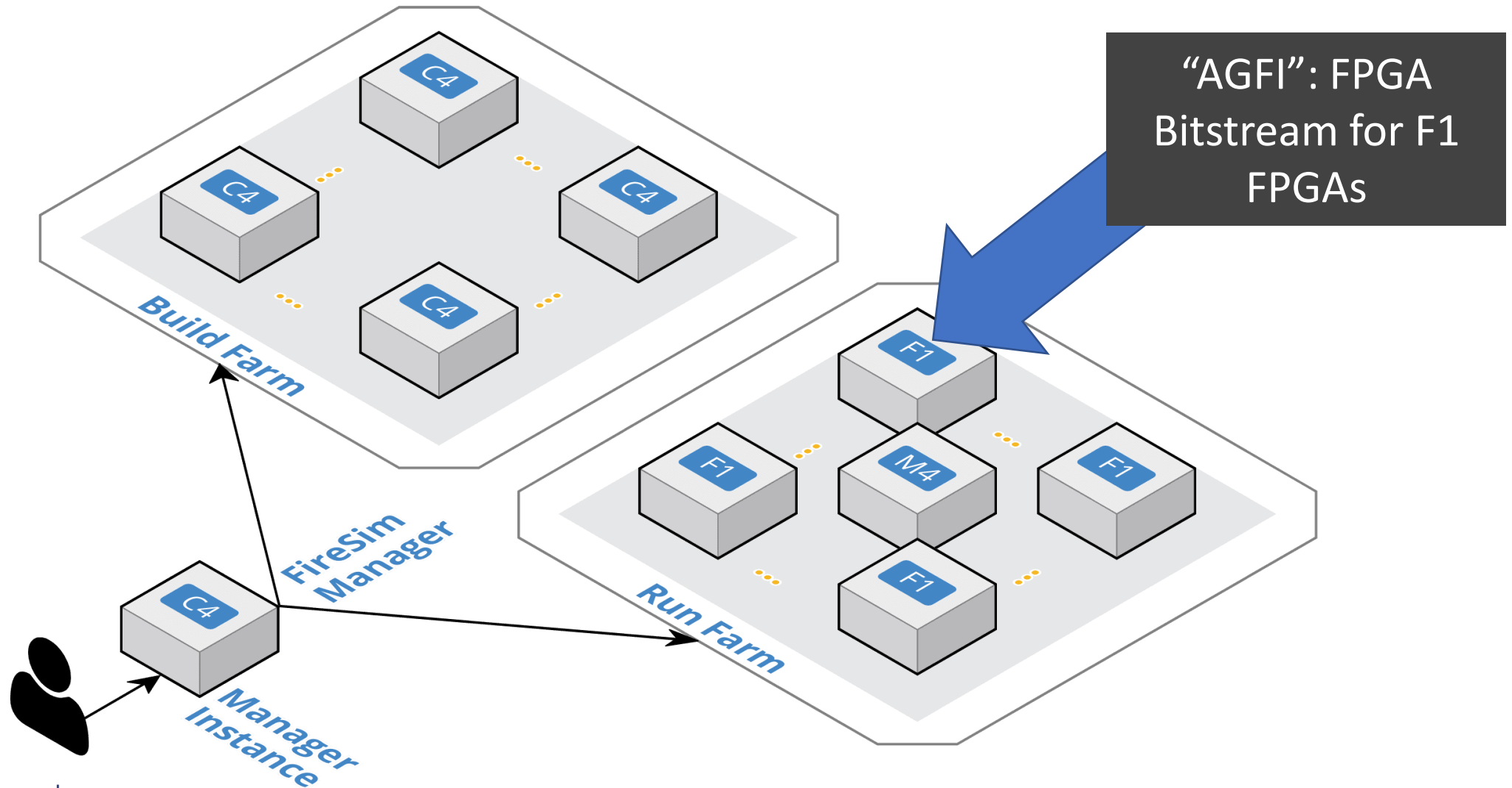
- Invoke it on example RTL
- Simulate the output in an RTL simulator

## 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 `$FDIR/sourceme-fl-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
```





# Example commands:

```
$ cd $FDIR/deploy
```

```
$ ls
```



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

config\_build\_recipes.ini

```
config_build_recipes.ini
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
2
3 # This file contains sections that describe hardware designs that /can/ be built.
4 # edit config_build.ini to actually "turn on" a config to be built when you run
5 # buildall
6
7 [firesim-singlecore-no-nic-lbp]
8 DESIGN=FireSimNIC
9 TARGET_CONFIG=FireSimRocketChipSingleCoreConfig
10 PLATFORM_CONFIG=FireSimConfig
11instancetype=C4.xlarge
12deploytriplet=None
13
14 [firesim-quadcore-nic-ddr3-1lc4mb]
15 DESIGN=FireSim
16 TARGET_CONFIG=FireSimRocketChipQuadCoreConfig
17 PLATFORM_CONFIG=FireSimDDR3FRFCPLL4MBConfig
18instancetype=C4.xlarge
19deploytriplet=None
20
21 [firesim-quadcore-no-nic-ddr3-1lc4mb]
22 DESIGN=FireSimNIC
23 TARGET_CONFIG=FireSimRocketChipQuadCoreConfig
24 PLATFORM_CONFIG=FireSimDDR3FRFCPLL4MBConfig
25instancetype=C4.xlarge
26deploytriplet=None
27
28 # BOOM-based targets
29 [fireboom-singlecore-no-nic-ddr3-1lc4mb]
30 DESIGN=FireSimNIC
31 TARGET_CONFIG=FireSimBooMConfig
32 PLATFORM_CONFIG=FireSimDDR3FRFCPLL4MBConfig
33instancetype=C4.xlarge
34deploytriplet=None
35
36 [fireboom-singlecore-nic-ddr3-1lc4mb]
37 DESIGN=FireBooM
38 TARGET_CONFIG=FireSimBooMConfig
39 PLATFORM_CONFIG=FireSimDDR3FRFCPLL4MBConfig
40instancetype=C4.xlarge
41deploytriplet=None
```

config\_build.ini

```
config_build.ini
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
2
3 [build]
4 # BUILDTIME/AGFI management configuration for the FireSim Simulation Manager
5 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
6
7 [agfi]
8 # This section references builds defined in config_build_recipes.ini
9 # If you add a build here, it will be built when you run buildall
10firesim-singlecore-no-nic-lbp
11firesim-quadcore-no-nic-ddr3-1lc4mb
12firesim-quadcore-nic-ddr3-1lc4mb
13fireboom-singlecore-no-nic-ddr3-1lc4mb
14fireboom-singlecore-nic-ddr3-1lc4mb
15
16 [agfi]
17firesim-singlecore-no-nic-lbp
18firesim-quadcore-no-nic-ddr3-1lc4mb
19firesim-quadcore-nic-ddr3-1lc4mb
20fireboom-singlecore-no-nic-ddr3-1lc4mb
21fireboom-singlecore-nic-ddr3-1lc4mb
22
23 [sharewithaccounts]
24sharebodyname=123456789012
```

config\_hwdb.ini

```
config_hwdb.ini
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
2
3 # Hardware configs represent a combination of an agfi, a deploytriplet override
4 # (if needed), and a custom runtime config (if needed)
5
6 # The AGFIs provided below are public and available to all users.
7 # Only AGFIs for the latest release of FireSim are guaranteed to be available.
8 # If you are using an older version of FireSim, you will need to generate your
9 # own images.
10
11 [firesim-singlecore-no-nic-lbp]
12agfi=agfi-0584a1a71df6a005a
13deploytripletoverride=None
14customruntimeconfig=None
15
16 [firesim-quadcore-no-nic-ddr3-1lc4mb]
17agfi=agfi-06b9b705ab9af1238
18deploytripletoverride=None
19customruntimeconfig=None
20
21 [firesim-quadcore-nic-ddr3-1lc4mb]
22agfi=agfi-030b49bcebd5ef96
23deploytripletoverride=None
24customruntimeconfig=None
25
26 [fireboom-singlecore-nic-ddr3-1lc4mb]
27agfi=agfi-090491454199fb160
28deploytripletoverride=None
29customruntimeconfig=None
30
31 [fireboom-singlecore-no-nic-ddr3-1lc4mb]
32agfi=agfi-0d9101df7b7ff708
33deploytripletoverride=None
34customruntimeconfig=None
35
```

config\_runtime.ini

```
config_runtime.ini
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
2
3 [runtime]
4 # runtime configuration for the FireSim Simulation Manager
5
6 # The AGFIs provided below are public and available to all users.
7 # Only AGFIs for the latest release of FireSim are guaranteed to be available.
8 # If you are using an older version of FireSim, you will need to generate your
9 # own images.
10
11 [firesim-singlecore-no-nic-lbp]
12instancetype=C4.xlarge
13spotmaxprice=ondemand
14
15 [firesim-quadcore-no-nic-ddr3-1lc4mb]
16instancetype=C4.xlarge
17spotmaxprice=ondemand
18
19 [firesim-quadcore-nic-ddr3-1lc4mb]
20instancetype=C4.xlarge
21spotmaxprice=ondemand
22
23 [fireboom-singlecore-nic-ddr3-1lc4mb]
24instancetype=C4.xlarge
25spotmaxprice=ondemand
26
27 [fireboom-singlecore-no-nic-ddr3-1lc4mb]
28instancetype=C4.xlarge
29spotmaxprice=ondemand
30
31 [tracing]
32enable=on
33startcycles=10
34endcycles=1
35
36 [workload]
37workloadname=linux-uniform.json
38terminateoncompletion=on
```





# Configuring a Build

```
0 / mosh-client (tmux) #1
config_build_recipes.ini buffers
1 # Build-time design configuration for the FireSim Simulation Manager
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
2
3 # this file contains sections that describe hardware designs that /can/ be built.
4 # edit config_build.ini to actually "turn on" a config to be built when you run
5 # buildafi
6
7 [firesim-singlecore-no-nic-lbp]
8 DESIGN=FireSimNoNIC
9 TARGET_CONFIG=FireSimRocketChipSingleCoreConfig
10 PLATFORM_CONFIG=FireSimConfig
11 instancetype=c4.4xlarge
12 deploytriplet=None
13
14 [firesim-quadcore-nic-ddr3-1lc4mb]
15 DESIGN=FireSim
16 TARGET_CONFIG=FireSimRocketChipQuadCoreConfig
17 PLATFORM_CONFIG=FireSimDDR3FRFCFSLLC4MBConfig
18 instancetype=c4.4xlarge
19 deploytriplet=None
20
21 [firesim-quadcore-no-nic-ddr3-1lc4mb]
22 DESIGN=FireSimNoNIC
23 TARGET_CONFIG=FireSimRocketChipQuadCoreConfig
24 PLATFORM_CONFIG=FireSimDDR3FRFCFSLLC4MBConfig
25 instancetype=c4.4xlarge
26 deploytriplet=None
27
28 # BOOM-based targets
29 [fireboom-singlecore-no-nic-ddr3-1lc4mb]
30 DESIGN=FireBoomNoNIC
31 TARGET_CONFIG=FireSimBoomConfig
32 PLATFORM_CONFIG=FireSimDDR3FRFCFSLLC4MBConfig
33 instancetype=c4.4xlarge
34 deploytriplet=None
35
36 [fireboom-singlecore-nic-ddr3-1lc4mb]
37 DESIGN=FireBoom
38 TARGET_CONFIG=FireSimBoomConfig
```

```
0 / mosh-client (tmux) #1
config_build.ini buffers
2 # BUILDTIME/AGFI management configuration for the FireSim Simulation Manager
1 # See docs/Advanced-Usage/Manager/Manager-Configuration-Files.rst for documentation of all of
  these params.
3
4 [afibuild]
5 s3bucketname=firesim-721179603761
6 buildinstancemarket=ondemand
7 spotinterruptionbehavior=terminate
8 spotmaxprice=ondemand
9
10 [builds]
11 # this section references builds defined in config_build_recipes.ini
12 # if you add a build here, it will be built when you run buildafi
13 firesim-singlecore-no-nic-lbp
14 firesim-quadcore-no-nic-ddr3-1lc4mb
15 firesim-quadcore-nic-ddr3-1lc4mb
16 fireboom-singlecore-no-nic-ddr3-1lc4mb
17 fireboom-singlecore-nic-ddr3-1lc4mb
18
19 [agfistoshare]
20 firesim-singlecore-no-nic-lbp
21 firesim-quadcore-no-nic-ddr3-1lc4mb
22 firesim-quadcore-nic-ddr3-1lc4mb
23 fireboom-singlecore-no-nic-ddr3-1lc4mb
24 fireboom-singlecore-nic-ddr3-1lc4mb
25
26 [sharewithaccounts]
27 somebodyaname=123456789012
28
29 ~
30 ~
31 ~
32 ~
33 ~
34 ~
35 ~
36 ~
37 ~
38 ~
```



# Anatomy of a Build Recipe

Consists of:

```
[firesim-singlecore-no-nic-lbp]  
DESIGN=FireSimNoNIC  
TARGET_CONFIG=FireSimRocketChipSingleCoreConfig  
PLATFORM_CONFIG=FireSimConfig  
instancetype=c4.xlarge  
deploytriplet=None
```

- A label
- The tuple from before
- The EC2 instance type you'd like to use



# Defining a Build Job: config\_build.ini

```
1 [afibuild]
2 s3bucketname=firesim-721179603761
3 buildinstancetype=ondemand
4 spotinterruptionbehavior=terminate
5 spotmaxprice=ondemand
6
7 [builds]
8 # this section references builds defined in config_build_recipes.ini
9 # if you add a build here, it will be built when you run buildafi
10 firesim-singlecore-no-nic-lbp
11 firesim-quadcore-no-nic-ddr3-llc4mb
12 firesim-quadcore-nic-ddr3-llc4mb
13 fireboom-singlecore-no-nic-ddr3-llc4mb
14 fireboom-singlecore-nic-ddr3-llc4mb
15
16 [agfistoshare]
17 firesim-singlecore-no-nic-lbp
18 firesim-quadcore-no-nic-ddr3-llc4mb
19 firesim-quadcore-nic-ddr3-llc4mb
20 fireboom-singlecore-no-nic-ddr3-llc4mb
21 fireboom-singlecore-nic-ddr3-llc4mb
22
23 [sharewithaccounts]
24 somebodyname=123456789012
25
26
```

Consists of:

- More instance configurations
- A list of recipes you'd like to batch out to a build farm

Once you're done with builds:

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



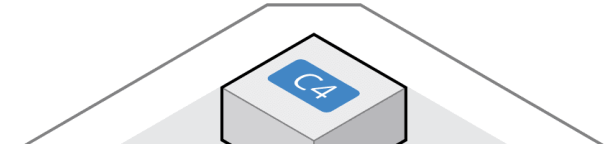


# Running builds

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

```
$ firesim buildafi
```

- This completely automates the process. For each design, in-parallel:
  - Launch a build instance
  - 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.ini`
  - Terminate the build instance



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

Your AGFI has been created!

Add

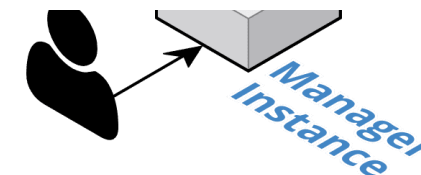
[firesim-singlecore-sha3-l2-no-nic-ddr3-llc4mb]

agfi=agfi-0679d5d17ba885886

deploytripletoverride=None

customruntimeconfig=None

to your `config_hwdb.ini` to use this hardware configuration.





# Example commands:

```
$ cd $FDIR/deploy
```

```
$ cd results-build/<name>/cl_firesim
```

```
$ ls
```



# Captured Build Outputs

design/

- The source files for the build;

build/scripts/<timestamp>.vivado.log

- Log of the entire vivado build process

build/reports/

- Timing and utilization reports from various stages

build/checkpoints/

- Design checkpoints (\*.dcp); can reopen in Vivado to debug a build





# Example commands:

```
$ cd $FDIR/deploy
```

```
$ cat built-hwdb-entries/* >> config_hwdb.ini
```

```
$ tail config_hwdb.ini
```



# Anatomy of a HWDB Entry

```
[fireboom-singlecore-no-nic-ddr3-1lc4mb]  
agfi=agfi-0df9101df7b7ff708  
deploytripletooverride=None  
customruntimeconfig=None
```

- Same label as before
- The FPGA image

Hooks to change:

- Software models
- Runtime arguments

→ *Without FPGA recompilation*





# Simulating the Simulator (Meta-simulation)

- Can simulate Golden Gate's output *without* doing an FPGA-build
  - Runs with all the same models you'd have on the FPGA
  - Should produce target-cycle-exact behavior as an FPGA simulation
- outputs in output/f1/<tuple>



# Summary

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



# Backup Slides