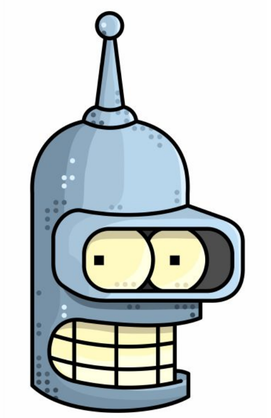

BENDER

A dependency management tool for hardware design projects

Fabian Schuiki

STATUS QUO

IPApprox / iptools

- Distinction between IPs/chips
- No transitive dependencies
  - **IPs don’t know their deps**
  - **Chips must list all deps**
- Tool embedded into chip repository
- Mixes:
  - IPs worked on by the user
  - IPs checked out by the tool

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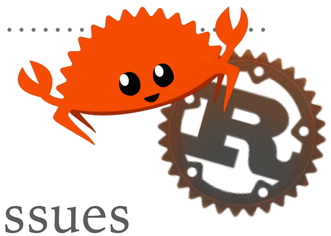
A SHOT AT SOMETHING NEW



Bender

- A replacement tool to fix these issues
- A joint effort by: Andreas Kurth, Francesco Conti, Stefan Mach, Florian Zaruba
- Repository and binaries: `github.com/fabianschuiki/bender`
- Or use cargo to build it

```
> cargo install bender
```

- Or build it yourself:

```
> git clone <url> bender
> cd bender
> cargo install
```

THE WISHLIST

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- Transitive dependencies

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- Tier-based, hands-off, opt-in policy
  - ⭐ **Tier 1:** Resolve package dependencies
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  - Reproducible builds
- Written in compiled language for static checks

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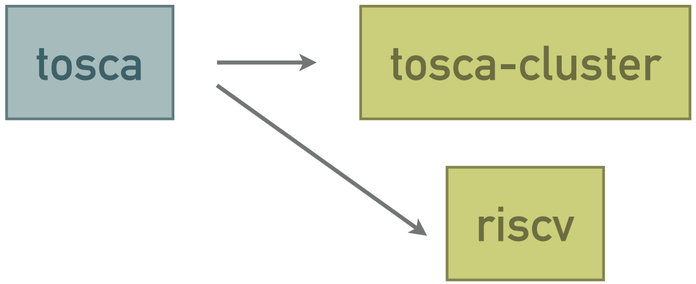

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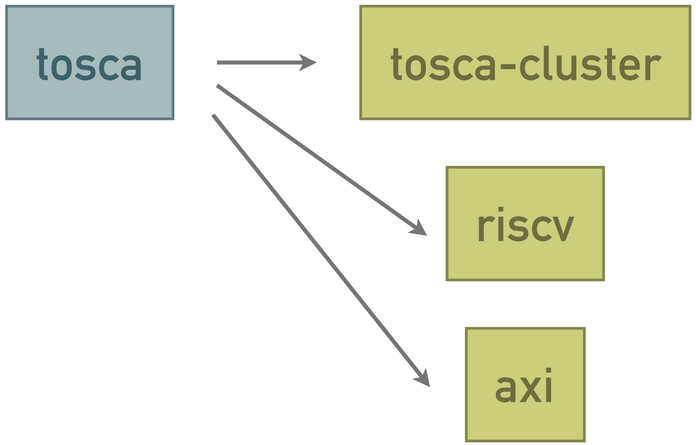

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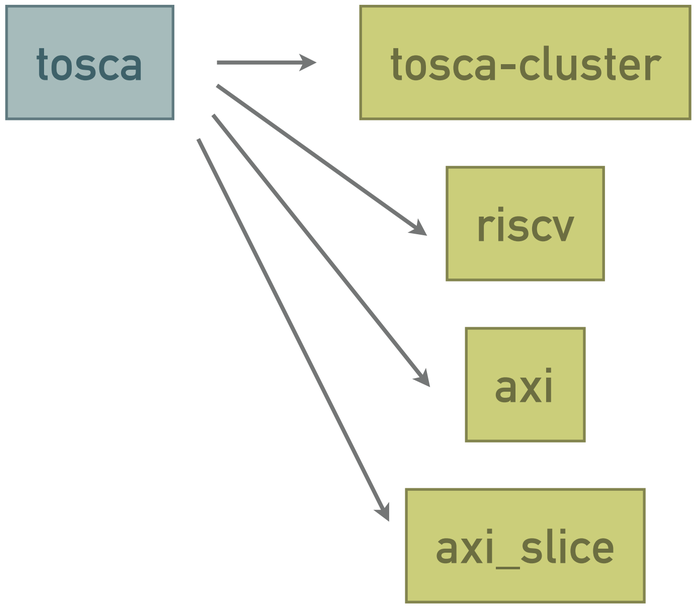

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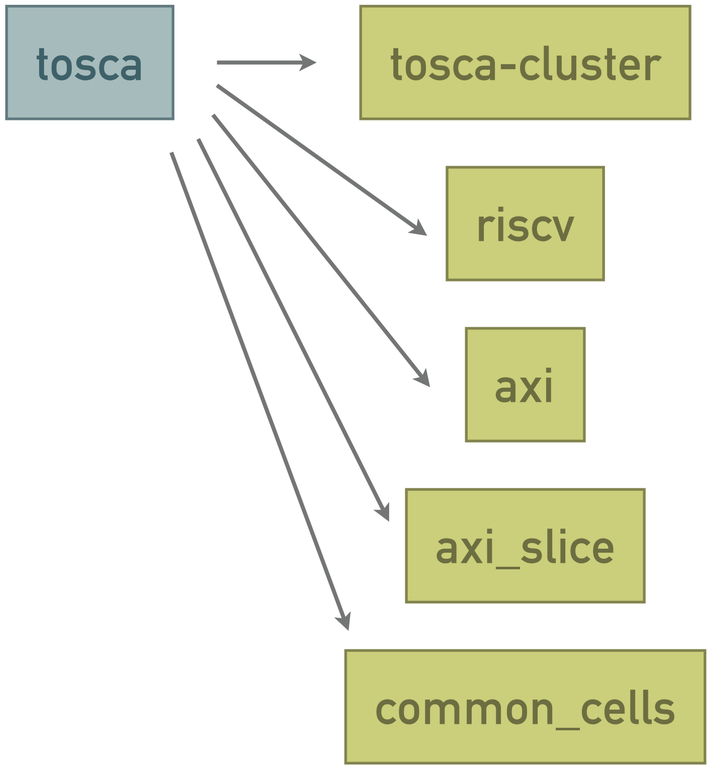

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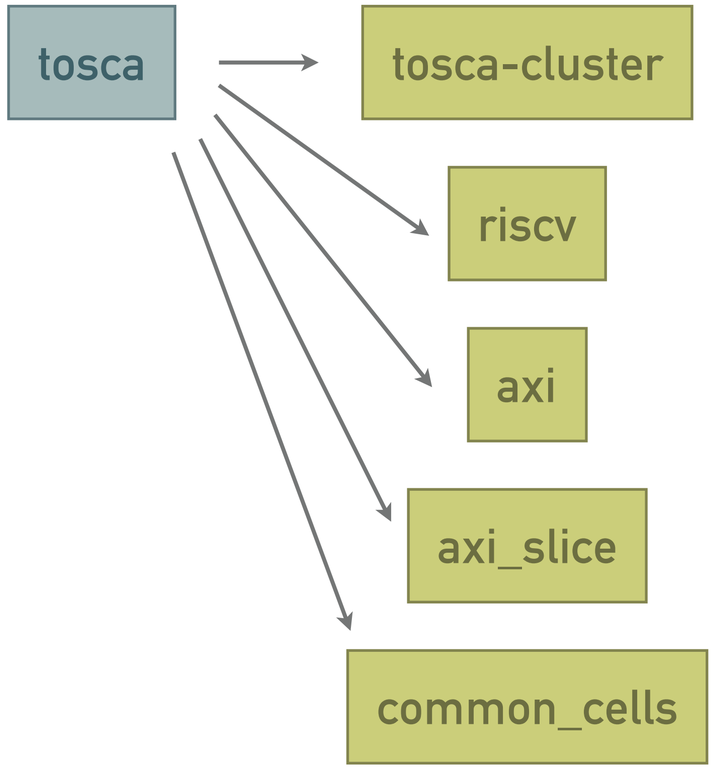

Current | *Bender*

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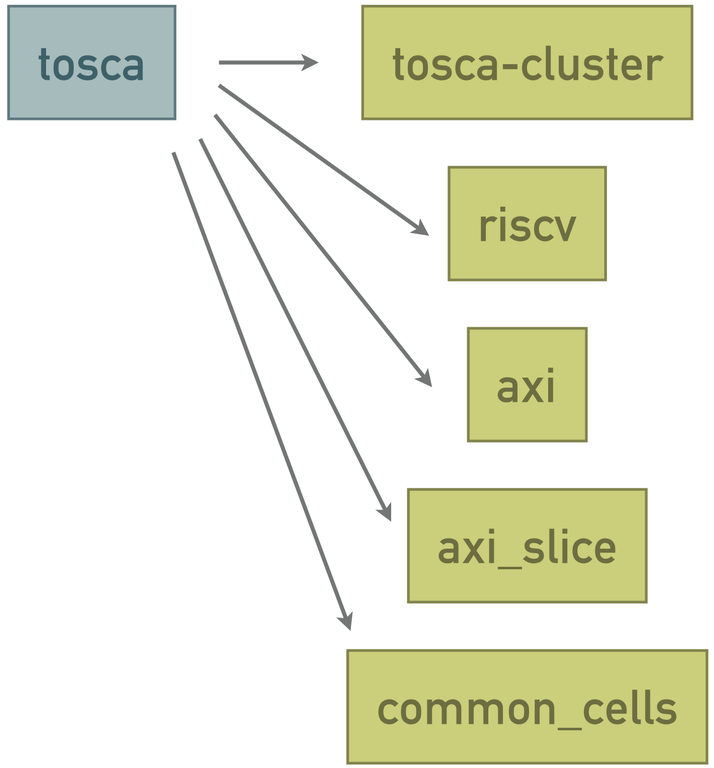

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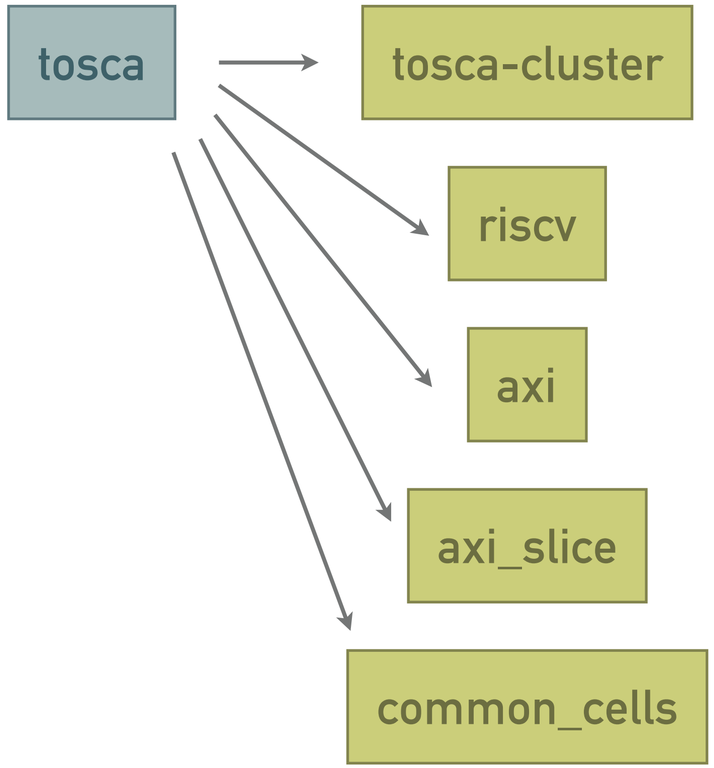

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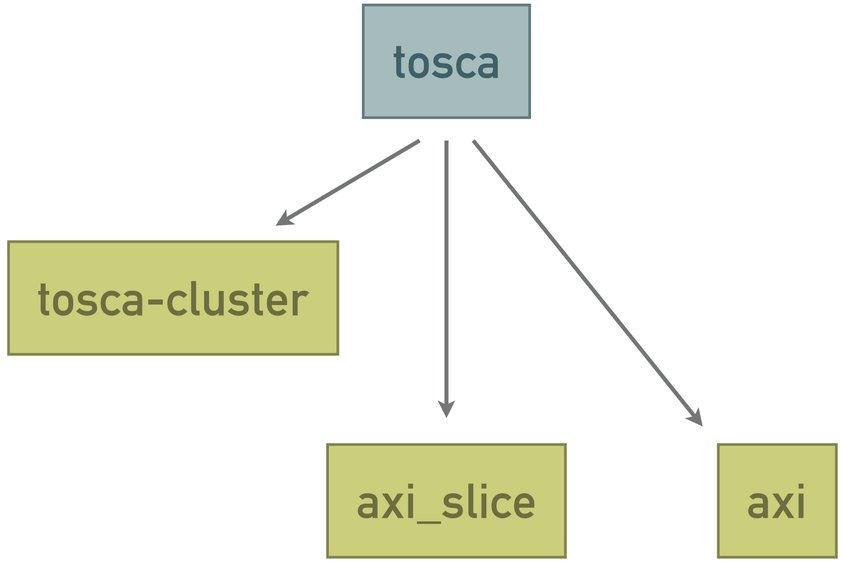

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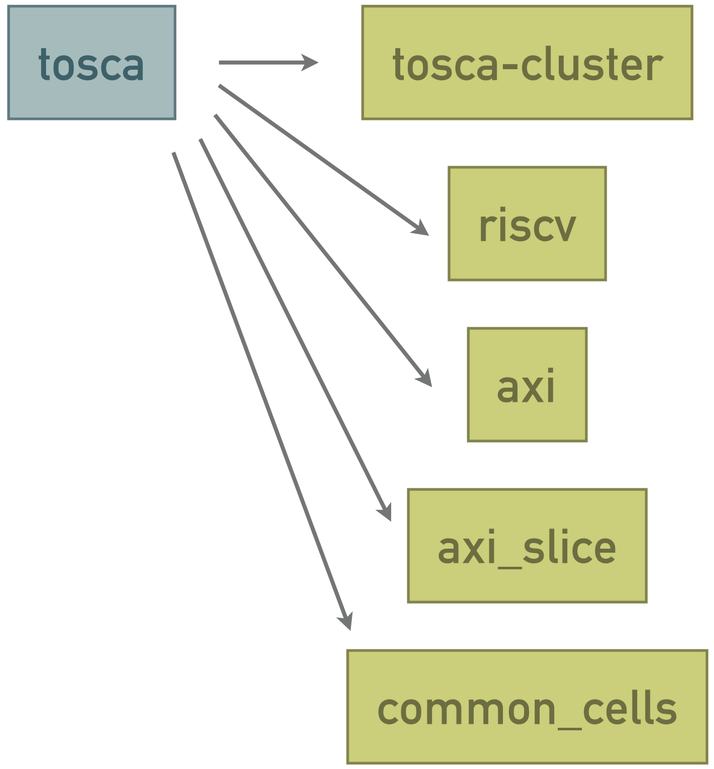

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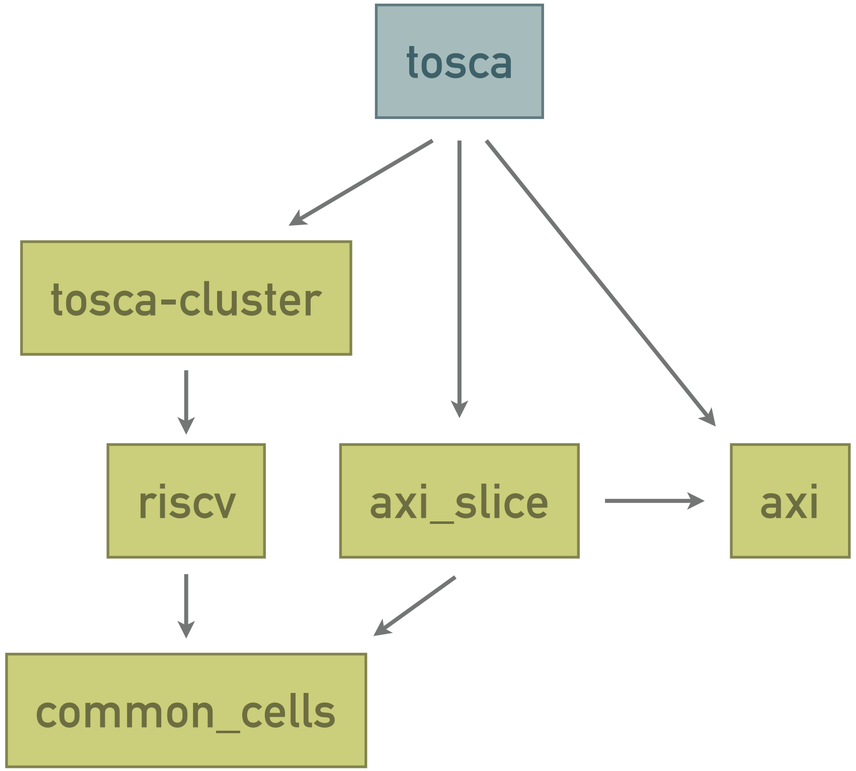

Bender

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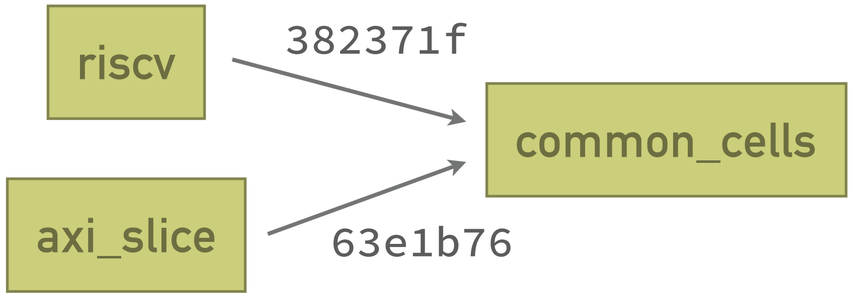

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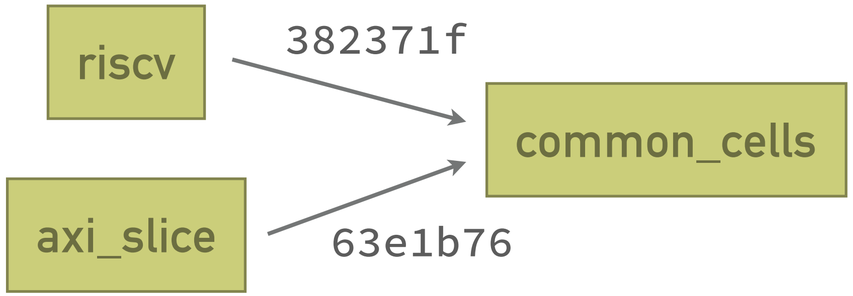

Are these commits compatible?

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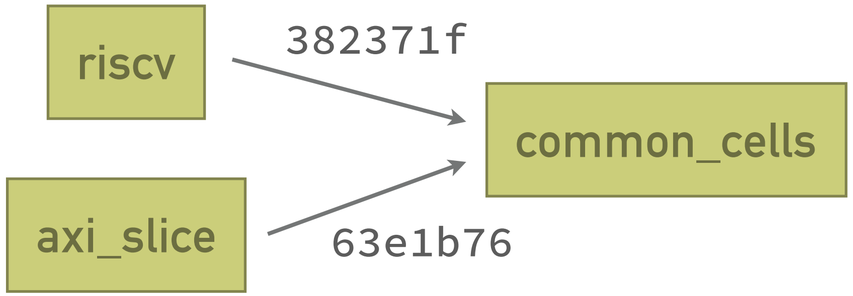

Are these commits compatible?

Which one do we pick?

- The solution: **Semantic Versioning** (semver.org)

- Increment *major* version on **breaking** changes
- Increment *minor* version on **backwards-compatible** changes
- Increment *patch* version otherwise

Be careful with HDLs… many changes are breaking.

SEMANTIC VERSIONING

- The problem with tr

riscv

38

axi_slice

compatible?

ck?

- The solution: Semar

1

Major Version

Mino

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n

anges

herwise

many changes

are breaking.

v0.3.0 - 2017-07-11

Added

- Set of five inferable, synchronous BRAM-based memories:
  - `SyncDpRam` (dual-port)
  - `SyncSpRam` (single-port)
  - `SyncSpRamBeNx32` (single-port N x 32bit with byte-wise enable)
  - `SyncSpRamBeNx64` (single-port N x 64bit with byte-wise enable)
  - `SyncTpRam` (two-port)

v0.2.3 - 2017-07-11

Fixed

- `src_files.yml`: added missing comma at the end of the `AxiToAxiLitePc` entry.

v0.2.2 - 2017-07-11

Fixed

REPRODUCIBLE BUILDS

lock files

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- Solution: Use a lock file!
  - Tracks exact hash of each dependency

Manifest

```
# Bender.yml
axi:        master
axi_slice:  master
axi_node:   v1.0.1
riscv:      fixes
axi2mem:    master
mem2axi:    34e598c
jtag:       master
```

Lock File

```
# Bender.lock
axi:        d1a671e
axi_slice:  f2e4abb
axi_node:   ac692ad
riscv:      352a9c6
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REPRODUCIBLE BUILDS

- Make sure you know exactly what dependency versions were used for tape out
- Software faces this problem as well (e.g. composer, cargo, etc.)
- Solution: Use a lock file!
  - Tracks exact hash of each dependency
- Dependencies only update …
  - to resolve version conflicts
  - when you ask for it

```
> bender update
> bender update axi_slice
```

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Overview

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- Go through each dependency, determine which version to use
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As a hardware developer, you don't want to do this!

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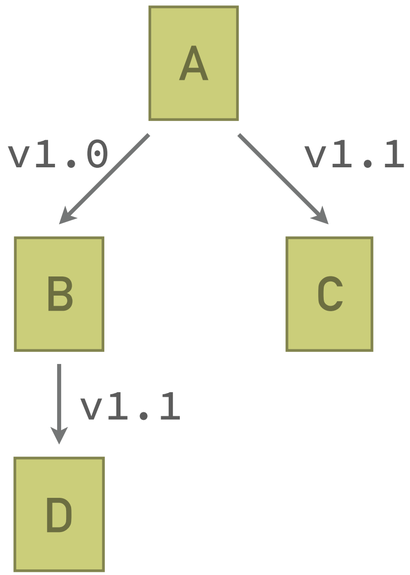

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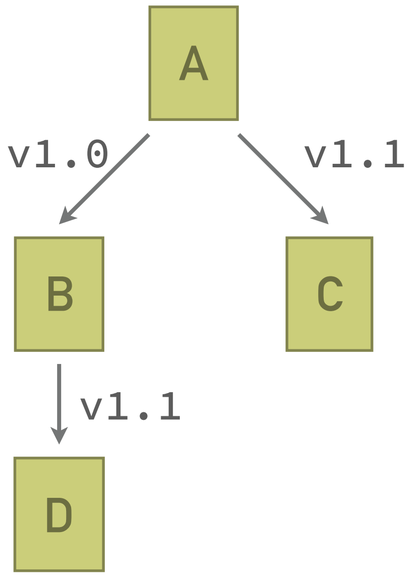

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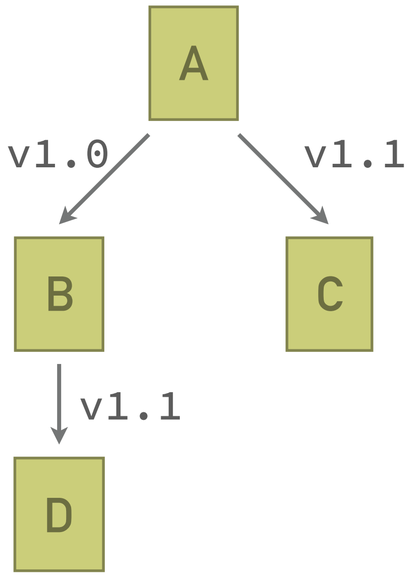

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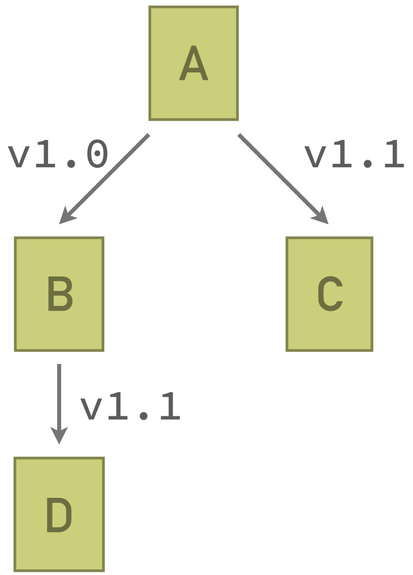

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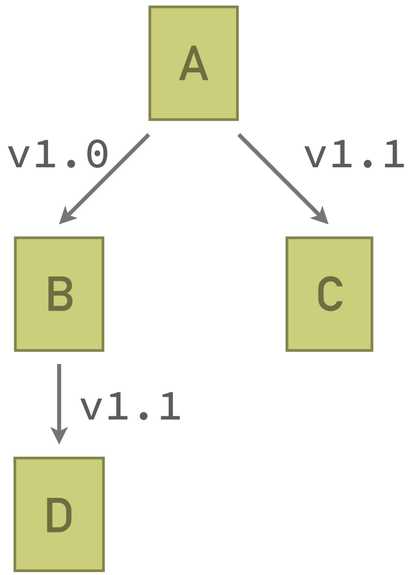

A

v1.0

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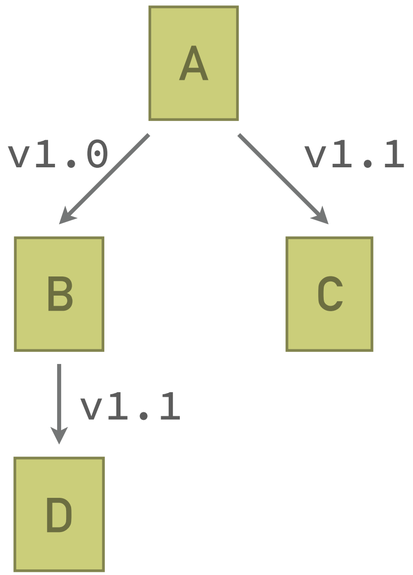

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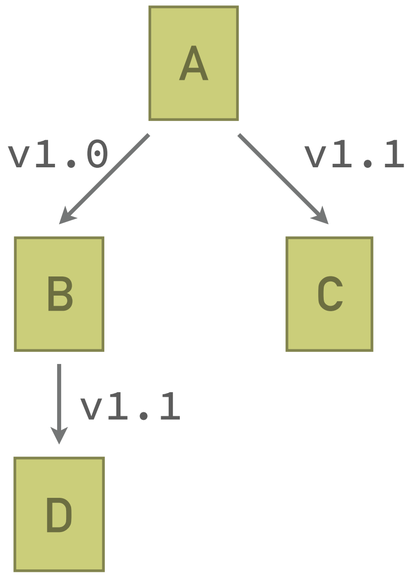

A	B	C
v1.0	*v1.1*	*v1.1*
	v1.0	*v1.0*

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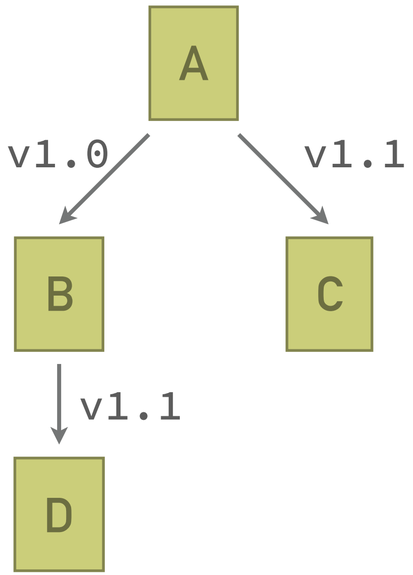

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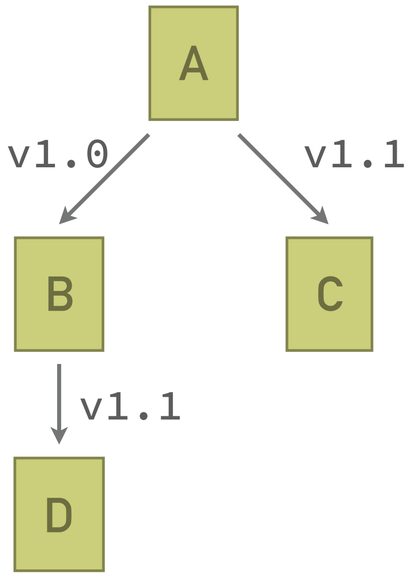

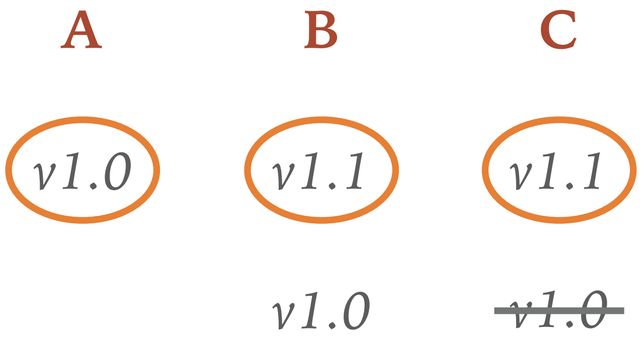

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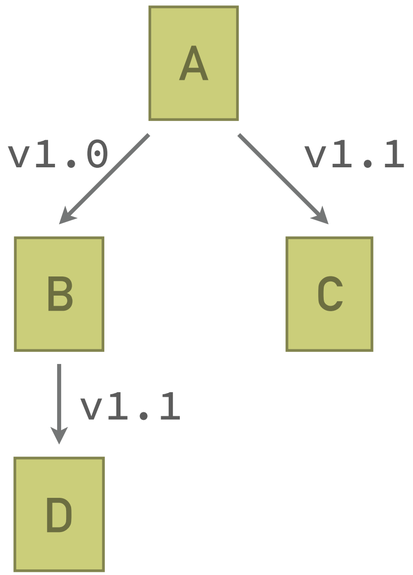

A	B	C	D
v1.0	*v1.1*	*v1.1*	*v1.2*
	v1.0	~~*v1.0*~~	*v1.1*
			v1.0

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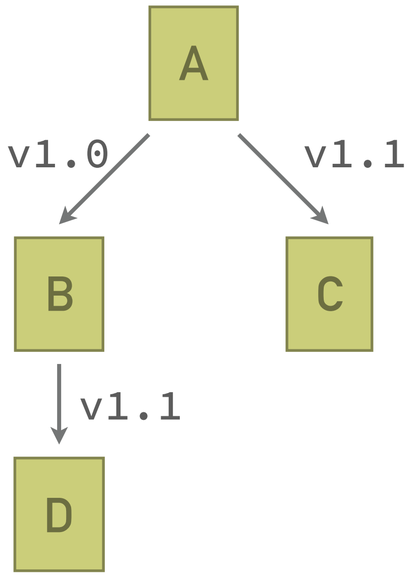

A	B	C	D
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	v1.0	~~*v1.0*~~	*v1.1*
			~~*v1.0*~~

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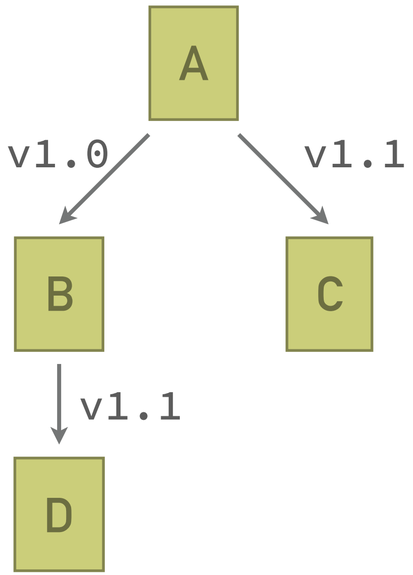

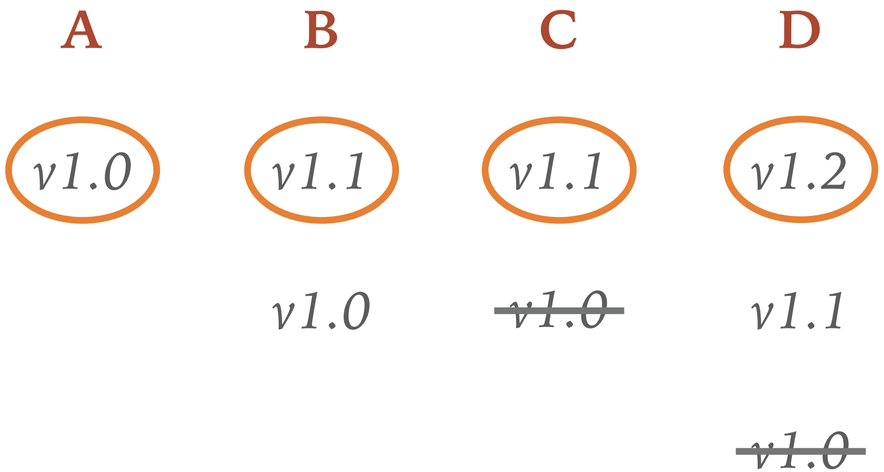

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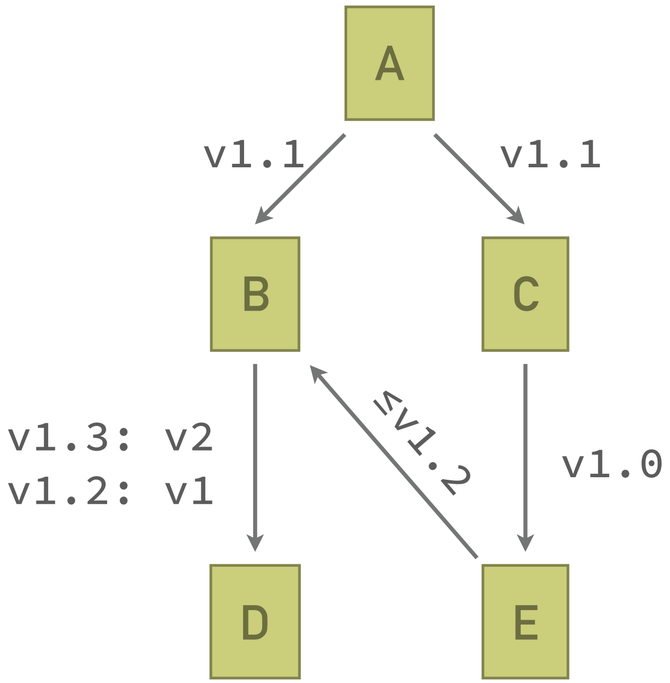

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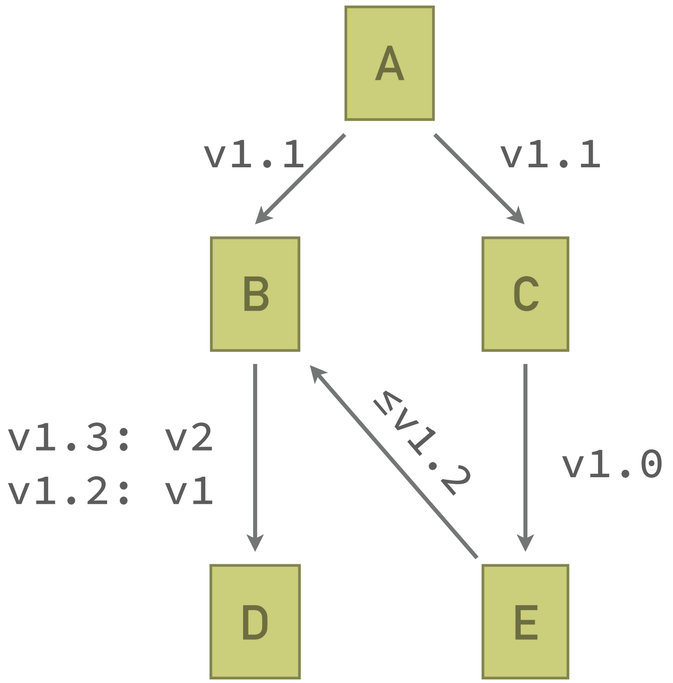

A

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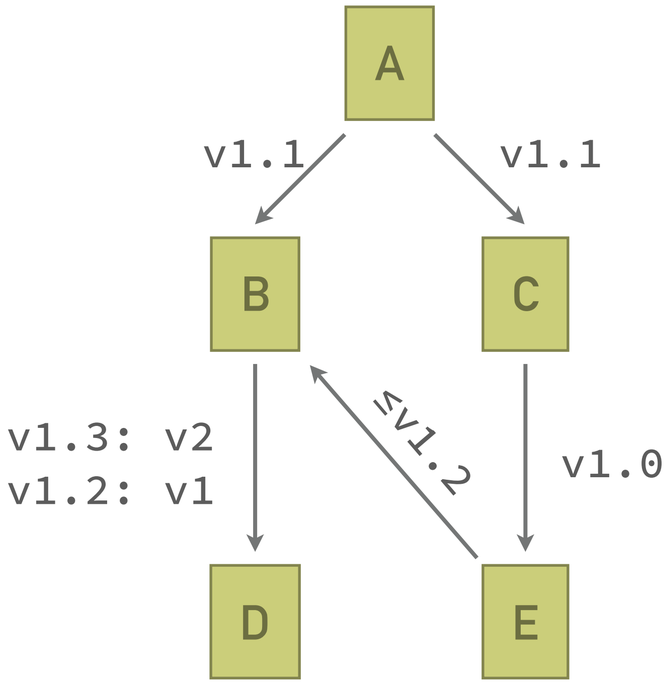

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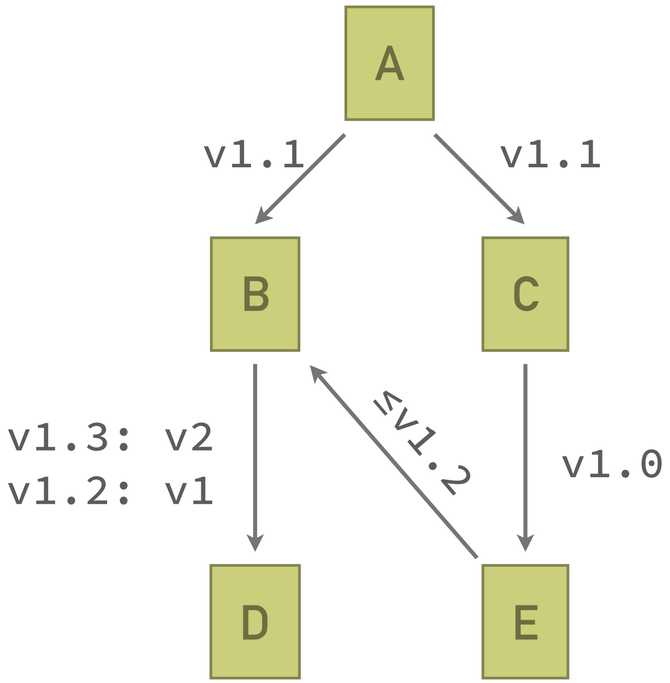

A	B	C
v1.0	*v1.3*	*v1.1*
	v1.2	*v1.0*
	v1.1	
	v1.0	

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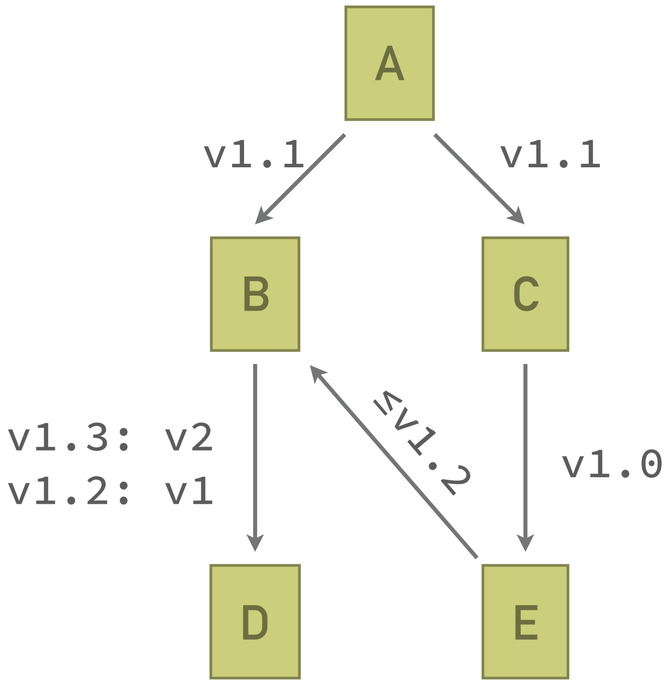

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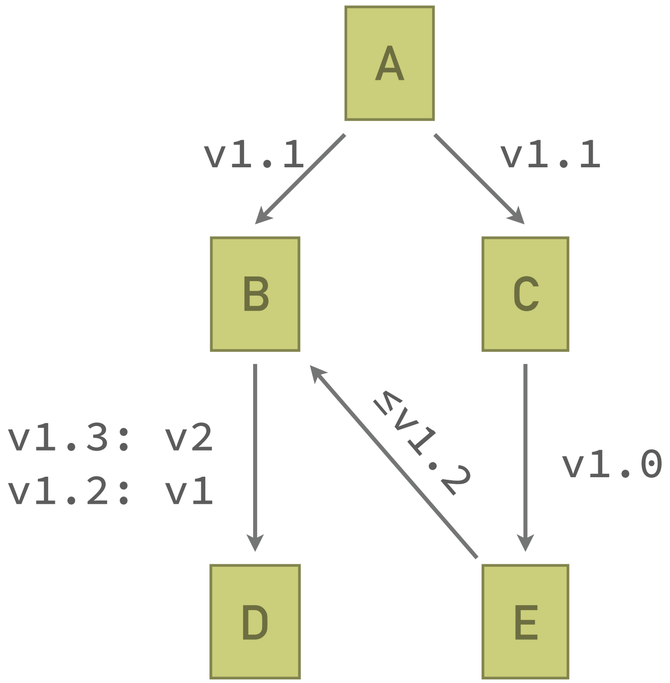

A	B	C
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	v1.1	
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DEPENDENCY RESOLUTION

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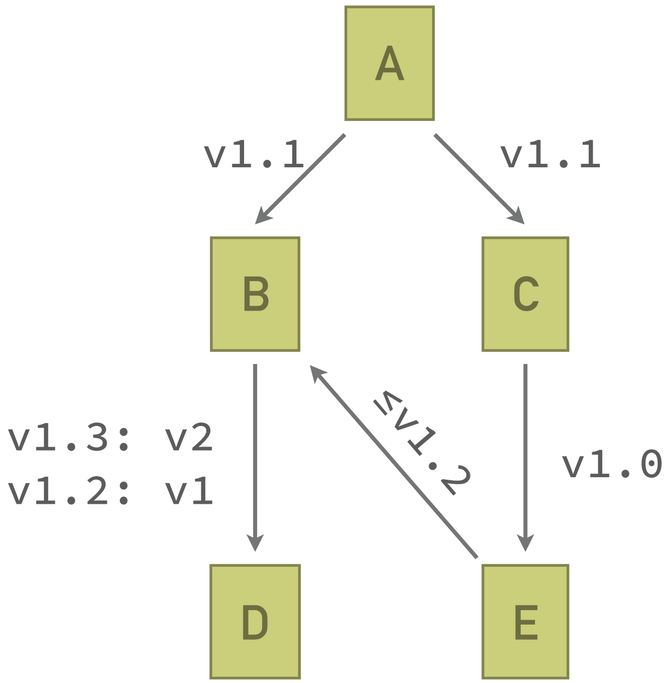

A	B	C	D	E
v1.0	*v1.3*	*v1.1*	*v2.0*	*v1.0*
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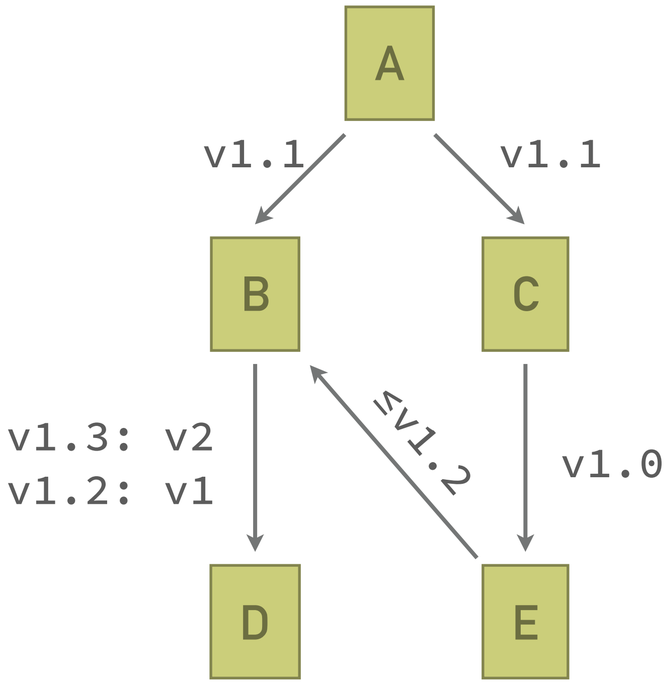

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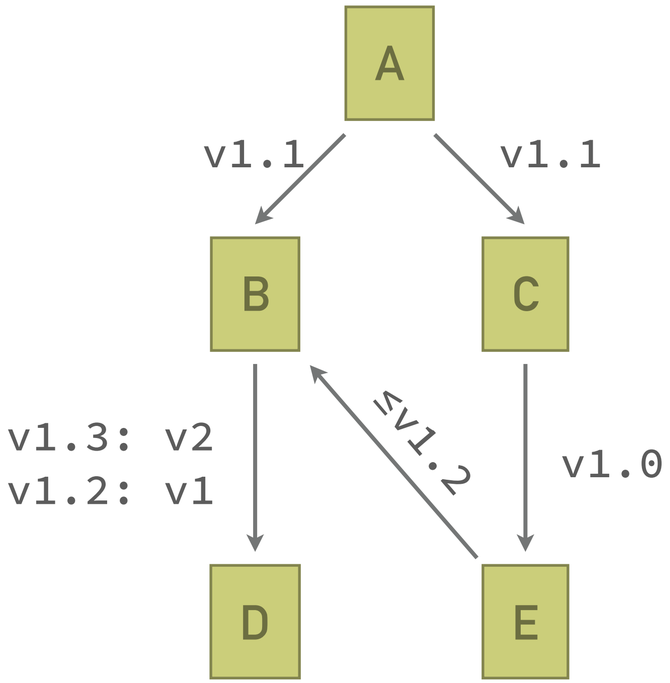

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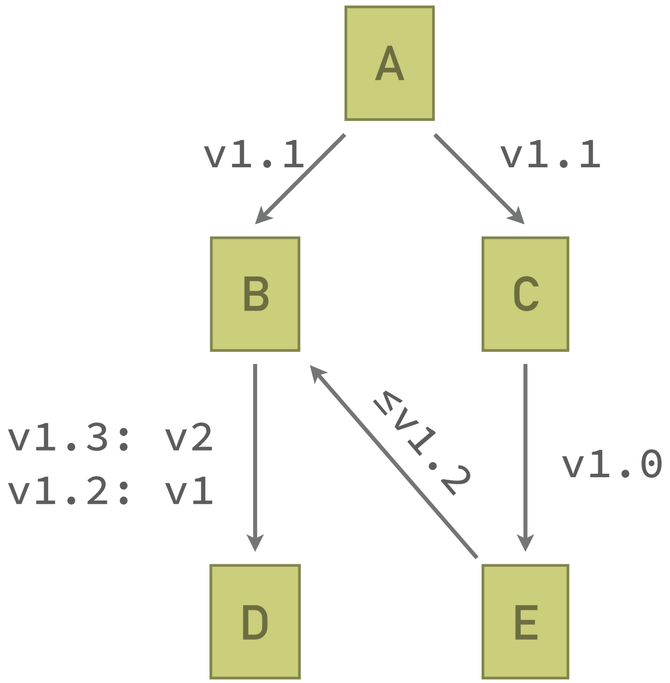

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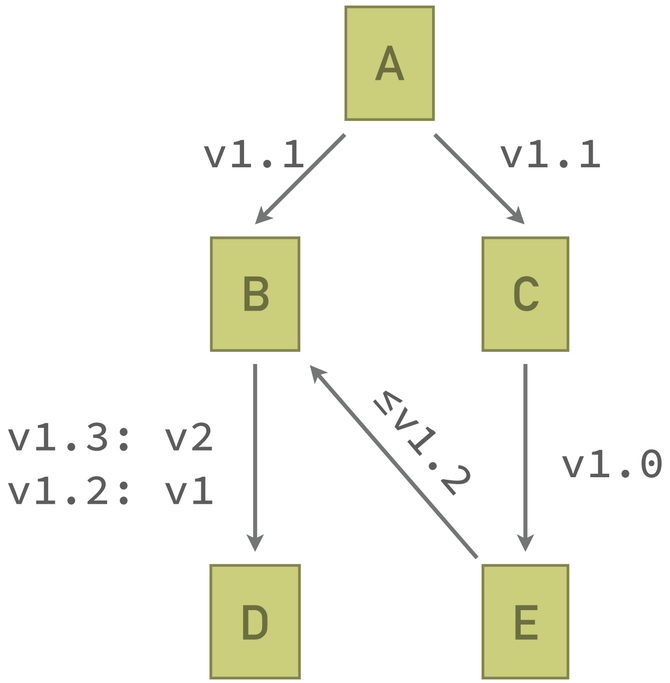

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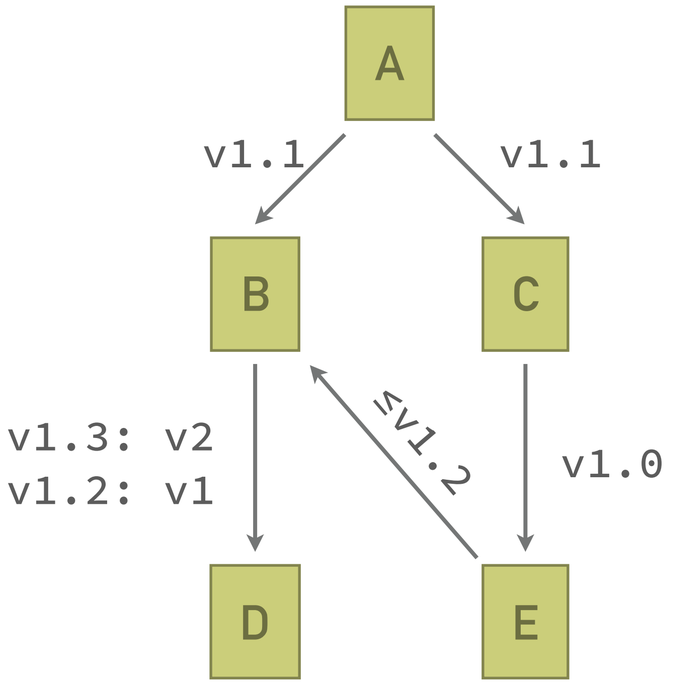

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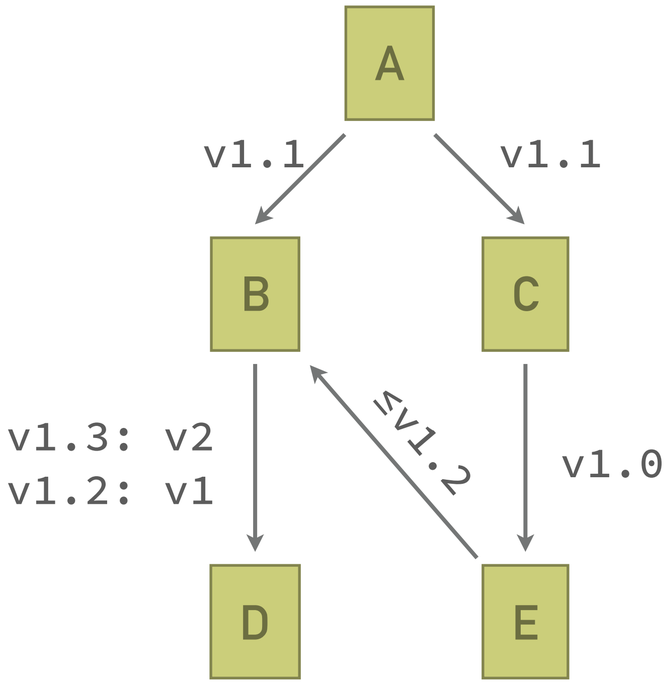

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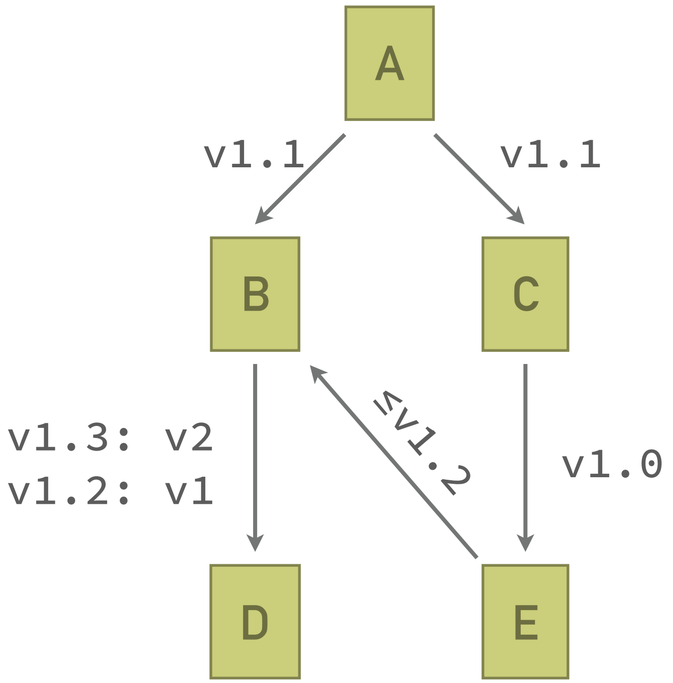

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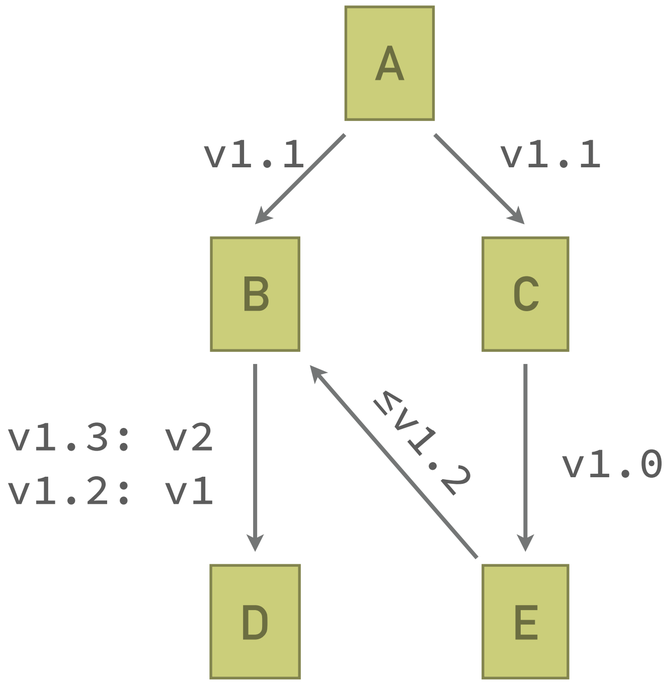

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```
# Bender.yml
dependencies:
  …
sources:
  - src/axi_pkg.sv
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  - src/axi2mem.sv
  - src/mem2axi.sv
```

SOURCE FILES

- We have established dependency tracking as first tier
- Let's track source files as well
- Allow for groups, include dirs, defines

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  …
sources:
  - src/axi_pkg.sv
  - src/axi_intf.sv
  - src/axi2mem.sv
  - src/mem2axi.sv
```

```
# Bender.yml
…
sources:
  - src/axi_pkg.sv
  - include_dirs:
      - src/include
    defines:
      FPGA_EMUL: 1
      SKIP_TRACE: 0
    files:
      - src/axi_intf.sv
      - src/axi2mem.sv
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```

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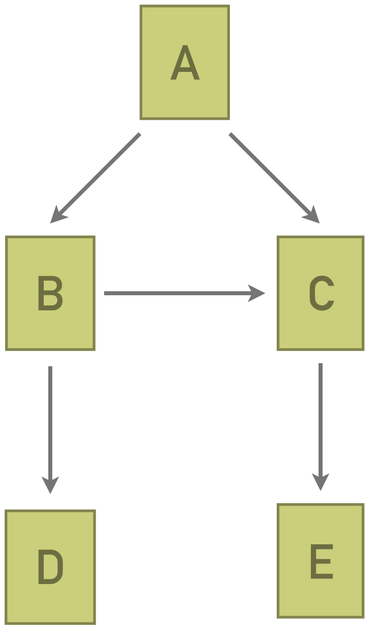

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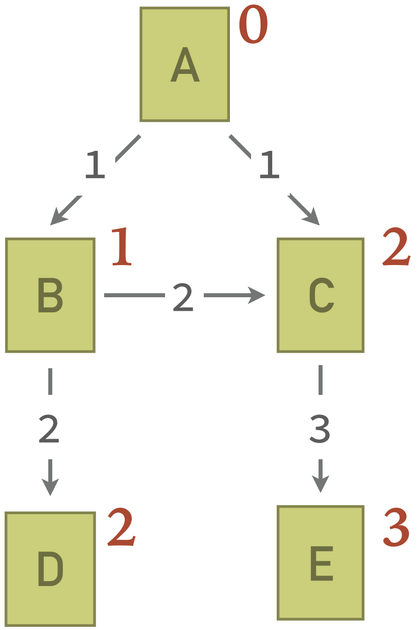

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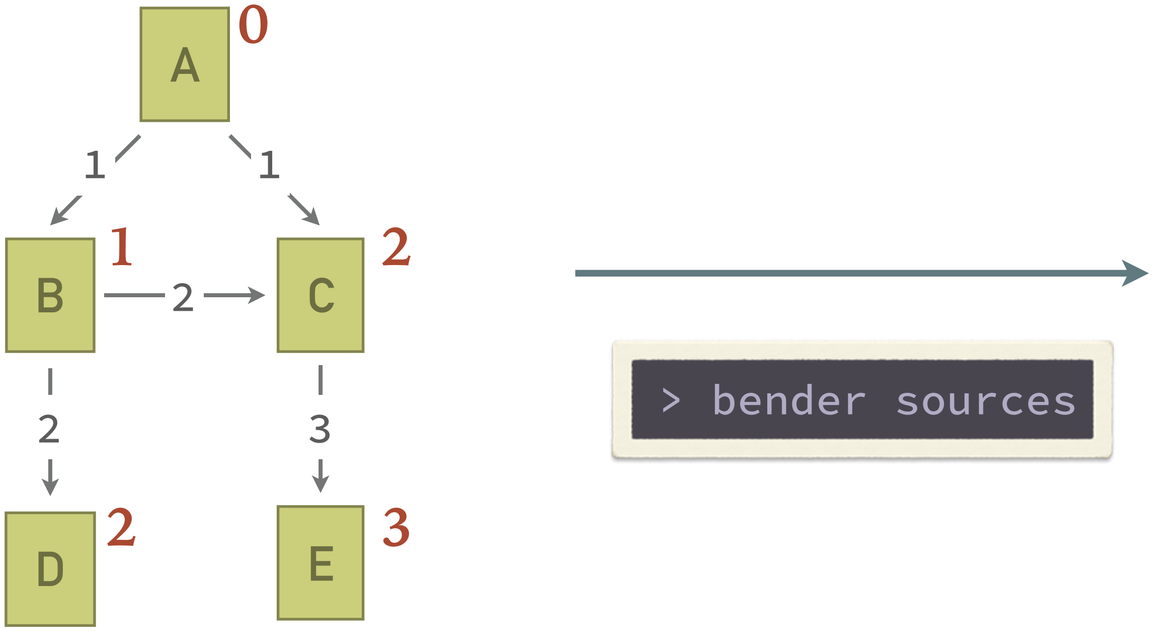


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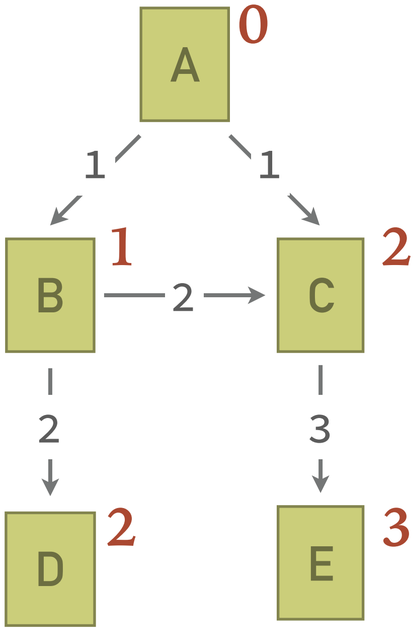


```
> bender sources
```

```
- E/top.sv
- E/pkg.sv
- C/foo.vhd
- C/bar.vhd
- D/ctrl.sv
- D/datapath.sv
- D/export.sv
- B/top.sv
- A/padframe.sv
- A/top.sv
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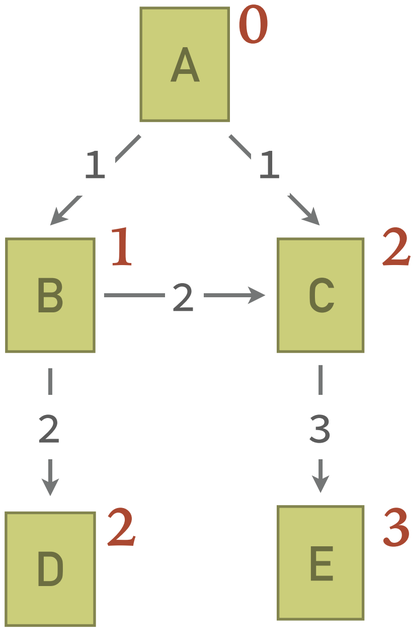

Tier 2

Don't want to do this by hand!

```
> bender sources
```

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- E/pkg.sv
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- D/ctrl.sv
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```
sources:
  - src/queue.sv
  - target: fpga
    files:
      - src/fifo_fpga.sv
  - target: not(fpga)
    files:
      - src/fifo_generic.sv
```

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    files:
      - src/fifo_fpga.sv
  - target: not(fpga)
    files:
      - src/fifo_generic.sv
```

Target Syntax:

```
Names:   fpga, asic, umc65
AND:     all(fpga, xilinx)
OR:      any(fpga, asic)
NOT:     not(fpga)
```

EXAMPLE

- Let’s make a simple package without dependencies:

common_cells

```
# Bender.yml
package:
  name: common_cells
  author: [“John Doe <john@doe.com>"]

sources:
  - src/generic_fifo.sv
  - src/round_robin.sv
  - src/leading_zero.sv
```

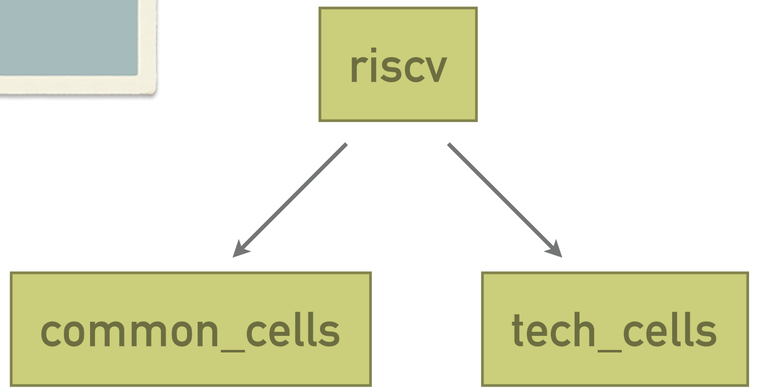
```
> tree
Bender.yml
LICENSE
README.md
src/
  generic_fifo.sv
  round_robin.sv
  leading_zero.sv
```

EXAMPLE

- A RISC-V core that depends on a few other repositories:

```
# Bender.yml
package:
  name: riscv
  author: [“John Doe <john@doe.com>"]
dependencies:
  common_cells: { git: “…/common_cells.git”, version: 1.0.2 }
  tech_cells: { git: “…/tech_cells.git”, version: 0.5.3 }
sources:
  - src/riscv_core.sv
  - src/riscv_ctrl.sv
```

```
> tree
Bender.yml
LICENSE
README.md
src/
  riscv_core.sv
  riscv_ctrl.sv
```

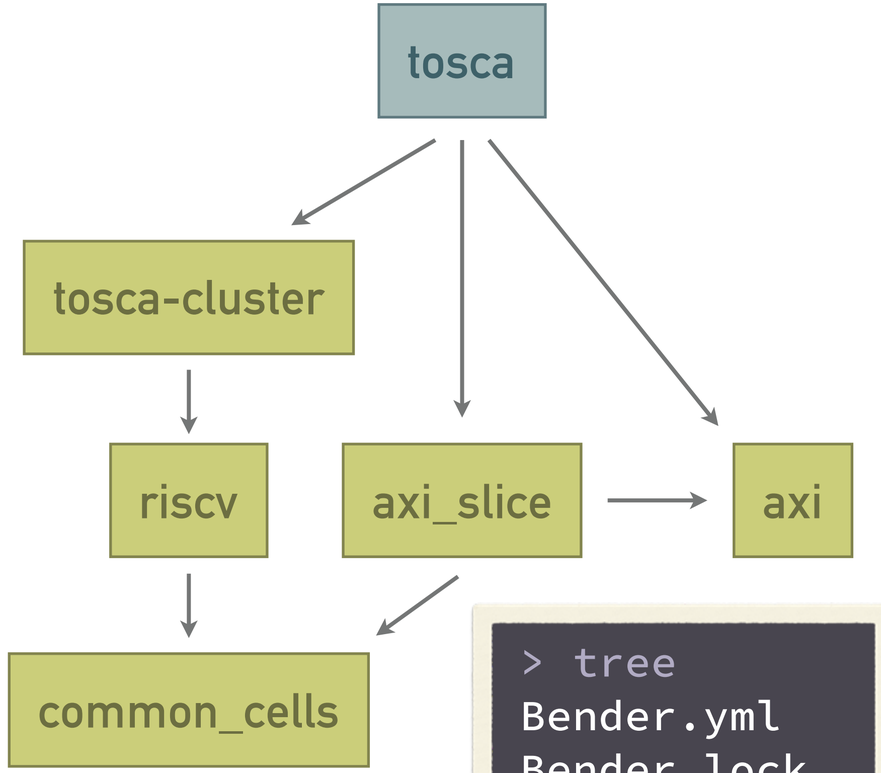


EXAMPLE

An entire chip

- A chip repository that will be taped out
  - Before: Put *Bender.lock* in .gitignore
  - Here: **Commit** *Bender.lock* to get **reproducible** builds!

```
# Bender.yml
package:
  name: tosca
  author: [“John Doe <john@doe.com>"]
dependencies:
  tosca-cluster: { git: … }
  axi: { git: … }
  axi_slice: { git: … }
sources:
  - src/top.sv
  - src/padframe.sv
```




```
> tree
Bender.yml
Bender.lock
LICENSE
README.md
src/
  top.sv
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```

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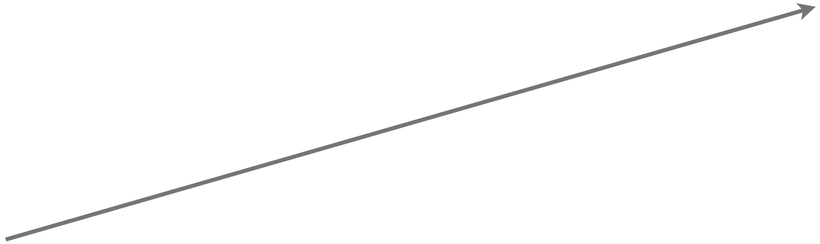

```
> bender sources
{
  “include_dirs”: […],
  “defines”: {…},
  “files”: […],
}
```

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- Can be done manually
- Or have Bender do it for you…

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> bender script vsim > compile.tcl
```

```
# compile.tcl
vlog +define+TARGET_VSIM \
    “src/riscv_top.sv” \
    …
```

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  - QuestaSim compile scripts

```
> bender script synopsys > analyze.tcl
```

```
# analyze.tcl
lappend search_path "src/include"
analyze -format sv -define { \
    TARGET_SYNOPSYS \
    TARGET_SYNTHESIS \
} [list \
    “src/riscv_top.sv” \
]
```

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```
# compile.tcl
vlog +define+TARGET_VSIM \
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SCRIPT GENERATION

- Bender can maintain tool scripts for you
- Currently supported targets:
  - Synopsys Design Compiler “analyze” scripts
  - QuestaSim compile scripts
- Experimental support for edalize
- Scripts can be checked into version control
  - Takes bender out of the EDA loop
  - Can share environment with collaborators that do not have bender installed

Opt-in!

```
> bender script synopsys > analyze.tcl
```

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# analyze.tcl
lappend search_path "src/include"
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plugins:
  vsim: “do_stuff.sh”
```

```
#!/bin/bash
# do_stuff.sh

SOURCES=`$BENDER sources`
for FILE in $SOURCES; do
  vlog-10.6b $FILE
done

echo “run -all” | vsim-10.6b -c
```

TESTING

One-button testing

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```
> bender test --all
All 4 tests passed.
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  1. Compilation tests with installed tools
     - ➤ vsim/ncsim
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  2. Run unit/regression tests
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Ensures that IP is compatible with different tools.

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All 4 tests passed.
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Future!

```
# Bender.yml
package:
  name: bender-vsim
  author: [“John Doe <john@doe.com>"]

test:
  compile: [vsim, vivado, synopsys]
  benches:
    - test/tb_one.sv
    - test/tb_two.sv
  cases:
    a: [tb_one, NUM_MASTER=[1,2,3]],
    b: [tb_two, NUM_SLAVE=[3,4,9]],
```

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common_cells: { git: “…/common_cells.git”, version: 1.0.2 }
tech_cells:   { git: “…/tech_cells.git”,   version: 0.5.3 }
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- Solution: Create a registry!
  - Simply a file on a web server which lists Git repositories
  - Can have multiple registries (pulp-restricted vs. pulp-open)

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common_cells: 1.0.2
tech_cells:   0.5.3
axi:          0.2
```

- Helps with open-source releases

I HATE YOUR TOOL!

I HATE YOUR TOOL!

Alternatives

- Bazel

{Fast, Correct} - Choose two

I HATE YOUR TOOL!

{Fast, Correct} - Choose two

- Bazel
- The award-winning FuseSoC

I HATE YOUR TOOL!

{Fast, Correct} - Choose two

- Bazel
- The award-winning FuseSoC
- npm?

I HATE YOUR TOOL!

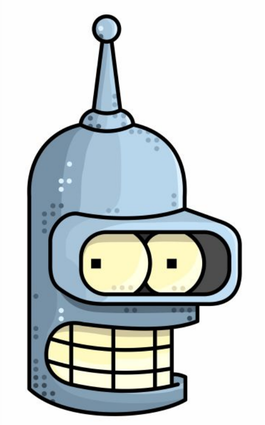
{Fast, Correct} - Choose two

- Bazel
- The award-winning FuseSoC
- npm?
- others?

FUTURE WORK

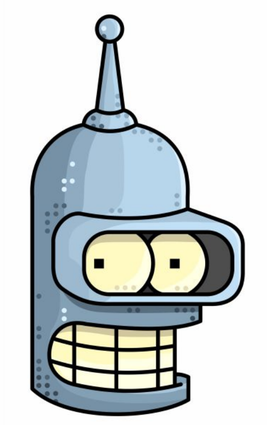
- Integration with FuseSoC/edalize? 🙂
- Add support for more tools
- Features
- Automation/conventions for unit tests

CONCLUSION



*Bender is here to help **you**!*

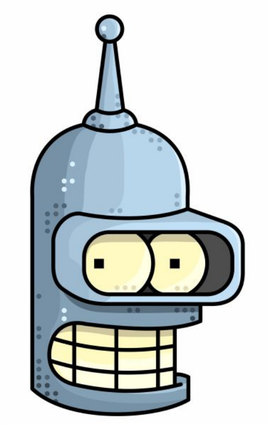
CONCLUSION



*Bender is here to help **you**!*

1. Transitive dependency resolution

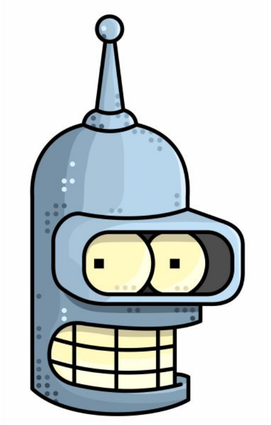
CONCLUSION



Bender is here to help you!

1. Transitive dependency resolution
2. Source file ordering and management

CONCLUSION



Bender is here to help you!

1. Transitive dependency resolution
2. Source file ordering and management
3. Registry and feeding the tools

Thanks!

https://github.com/fabianschuiki/bender

— and —

```
> cargo install bender
```

— and —

```
> git clone <url> bender
> cd bender
> cargo install
```