Paying Off Technical Debt of SoC Code-Bases Through Standards and Good Practices

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Disclaimer

- Many possible solutions
- Simplifications were made

- Don’t hesitate to ask questions during of after the presentation: clyde.laforge@cern.ch

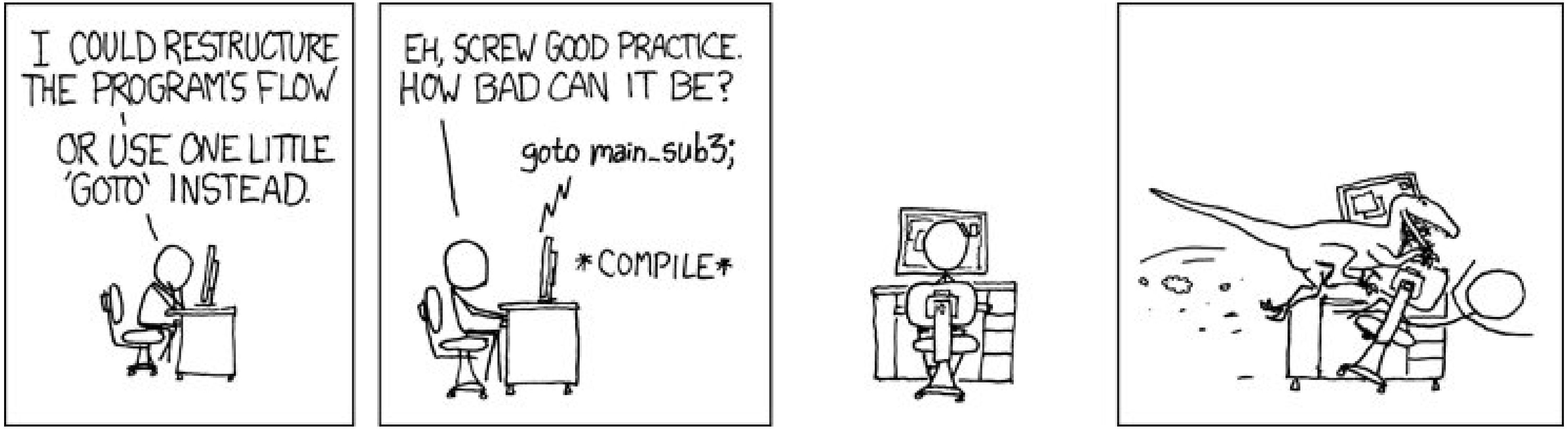
Goals

- Present concept of technical debt
- Present tools and methods used in the CROME project keeping it in check

Technical Debt

Technical Debt

In software development, technical debt [. . .] is the implied cost of additional rework caused by choosing an easy (limited) solution now instead of using a better approach that would take longer.


I COULD RESTRUCTURE THE PROGRAM'S FLOW
OR USE ONE LITTLE 'GOTO' INSTEAD.
EH, SCREW GOOD PRACTICE. HOW BAD CAN IT BE?
goto main_sub3;
COMPILE

©xkcd

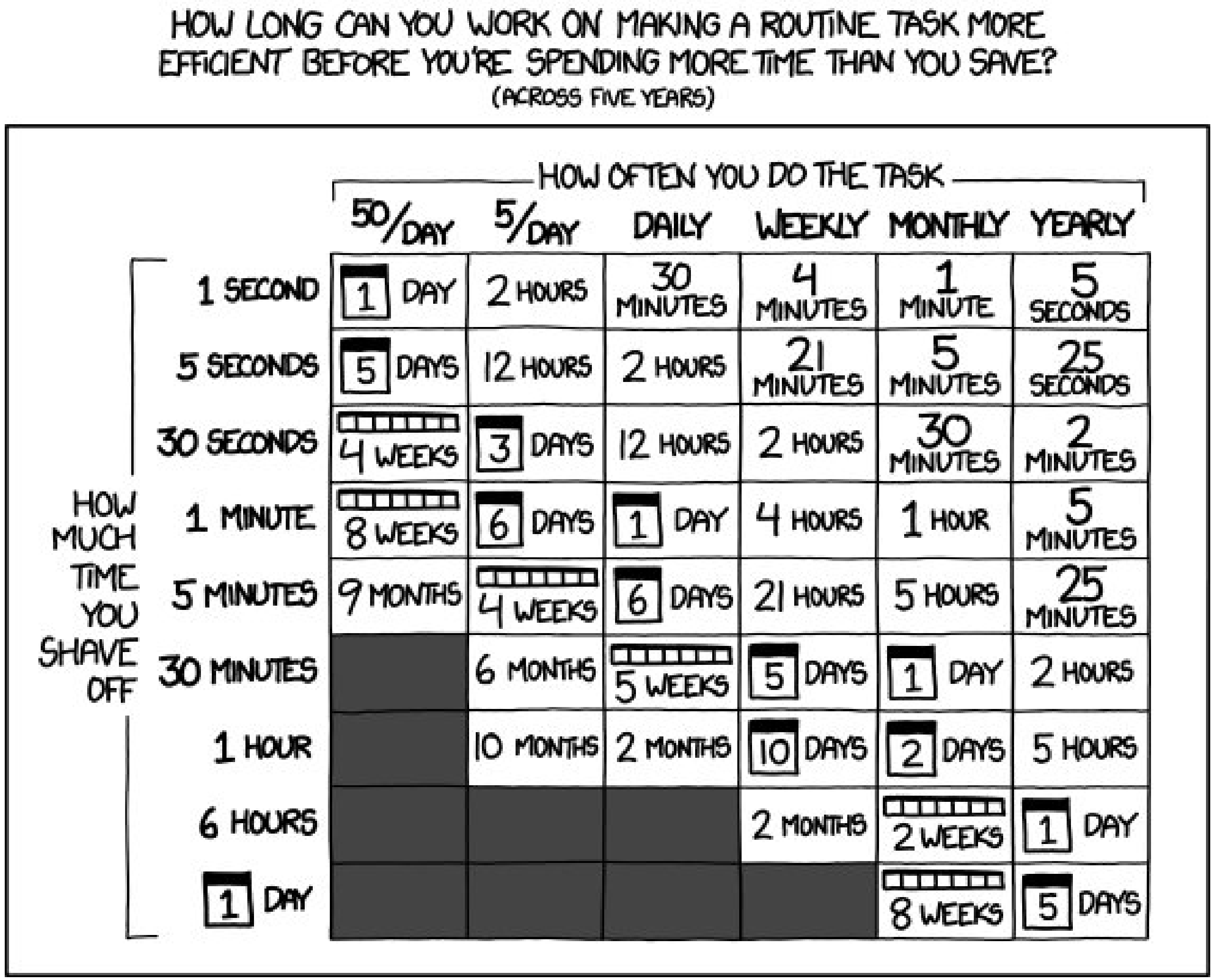
Technical Debt: continued

Causes:

- Unexpected evolution of the project
- Time constraints
- Lack of oversight
- ...

Consequences

- Shorter time to market
- Hinders further development
- Incurs interests



HOW LONG CAN YOU WORK ON MAKING A ROUTINE TASK MORE EFFICIENT BEFORE YOU'RE SPENDING MORE TIME THAN YOU SAVE?
(ACROSS FIVE YEARS)

		HOW OFTEN YOU DO THE TASK					
		50/DAY	5/DAY	DAILY	WEEKLY	MONTHLY	YEARLY
HOW MUCH TIME YOU SHAVE OFF	1 SECOND	1 DAY	2 HOURS	30 MINUTES	4 MINUTES	1 MINUTE	5 SECONDS
	5 SECONDS	5 DAYS	12 HOURS	2 HOURS	21 MINUTES	5 MINUTES	25 SECONDS
	30 SECONDS	4 WEEKS	3 DAYS	12 HOURS	2 HOURS	30 MINUTES	2 MINUTES
	1 MINUTE	8 WEEKS	6 DAYS	1 DAY	4 HOURS	1 HOUR	5 MINUTES
	5 MINUTES	9 MONTHS	4 WEEKS	6 DAYS	21 HOURS	5 HOURS	25 MINUTES
	30 MINUTES		6 MONTHS	5 WEEKS	5 DAYS	1 DAY	2 HOURS
	1 HOUR		10 MONTHS	2 MONTHS	10 DAYS	2 DAYS	5 HOURS
	6 HOURS				2 MONTHS	2 WEEKS	1 DAY
	1 DAY					8 WEEKS	5 DAYS

©xkcd

Identification and Solutions to Technical Debt

Identification:

- Outdated documentation
- Band-aid bugfixes
- Parallel development

Solution:

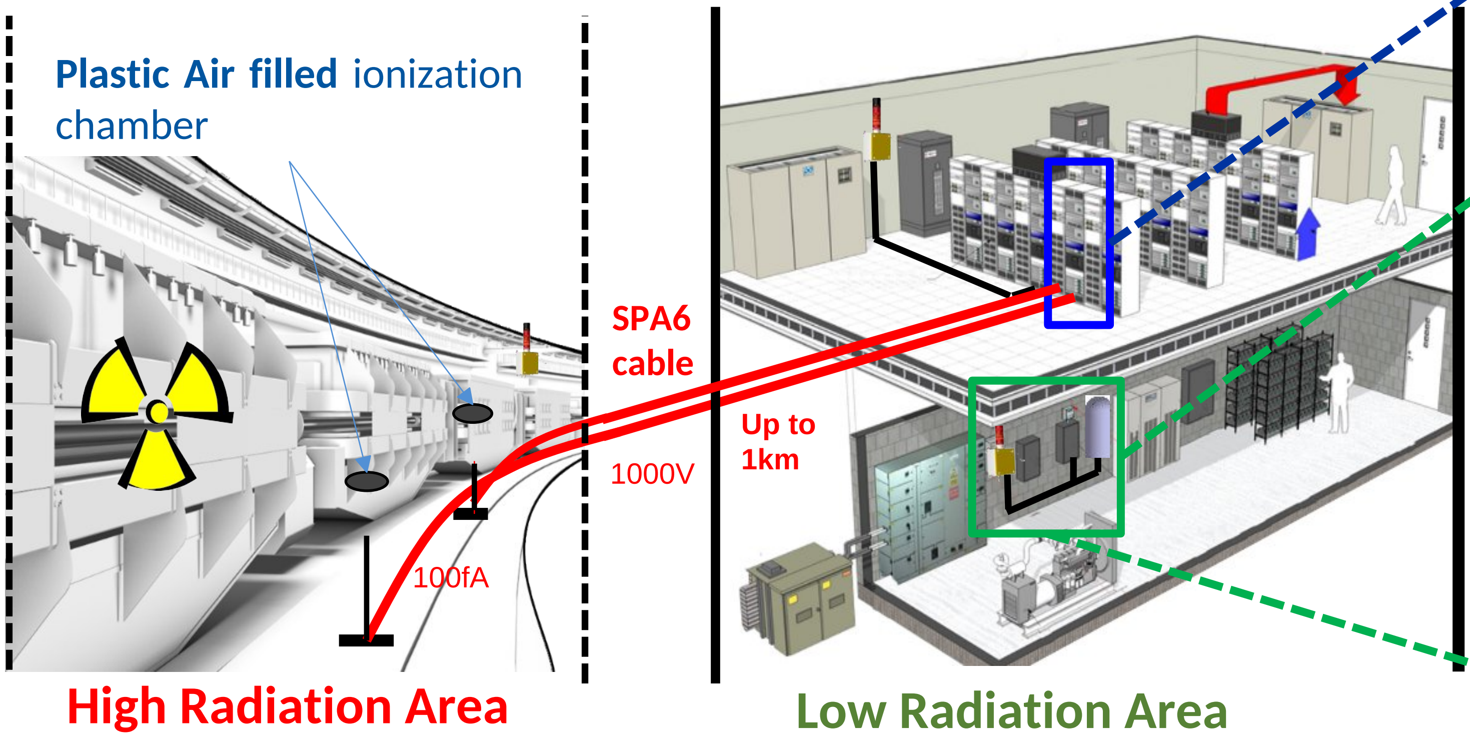
- Re-factoring

CROME Project

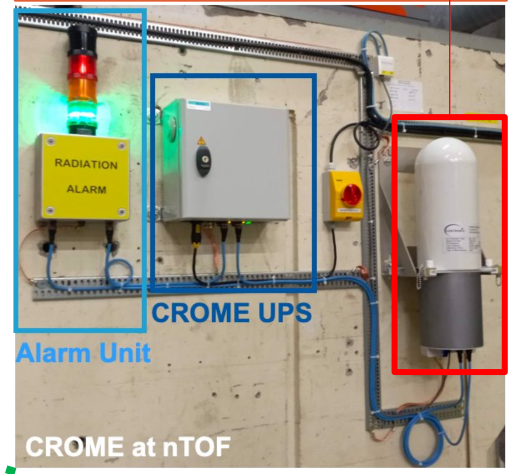
CERN Radiation Monitoring Electronics (CROME)

Two configurations :

Conceptual view of CROME at CERN

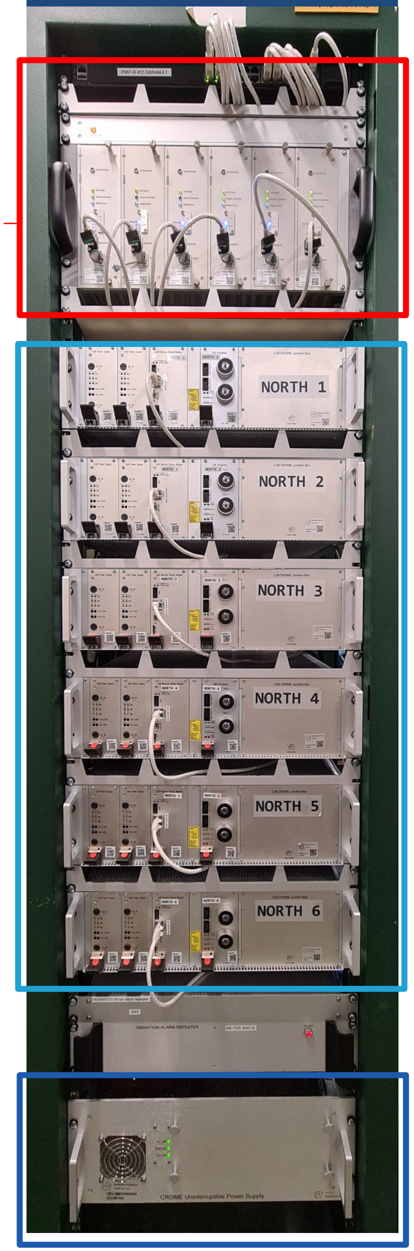


Bulk



Rackable

Radiation Monitoring and processing units

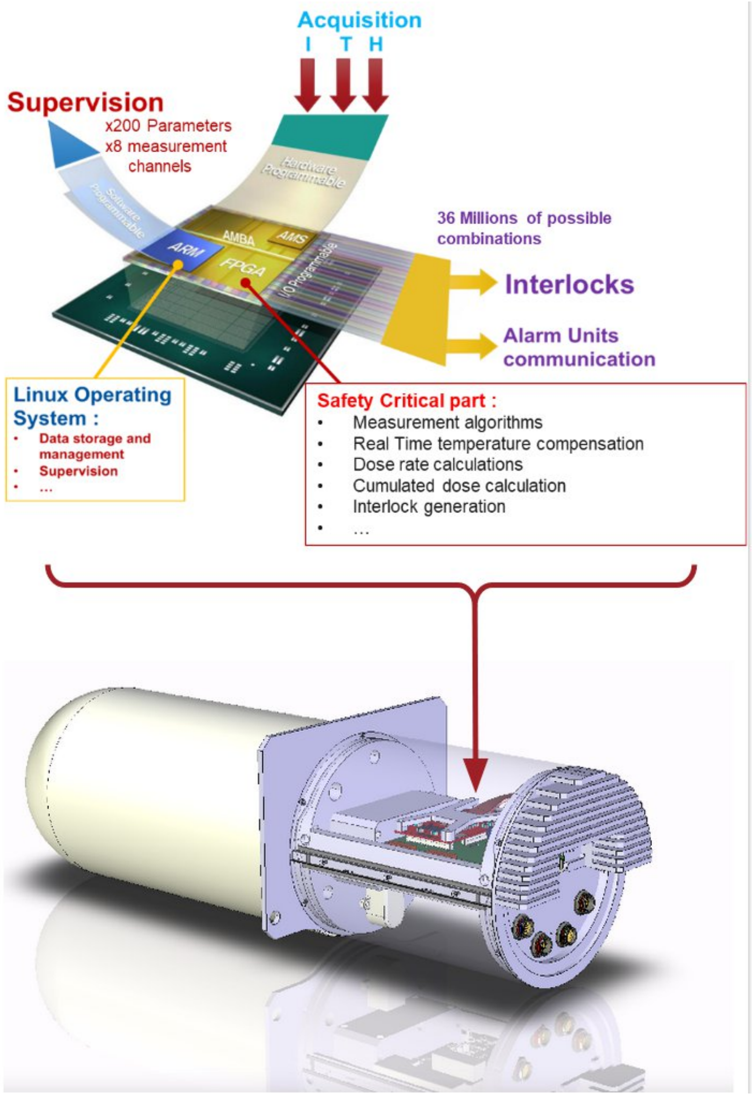


CROME Rack at EHN1 (North Area)

CROME Junction Box

Uninterruptible Power Supply
Includes a battery for continuous operation

CROME Project



Supervision
x200 Parameters
x8 measurement channels

36 Millions of possible combinations

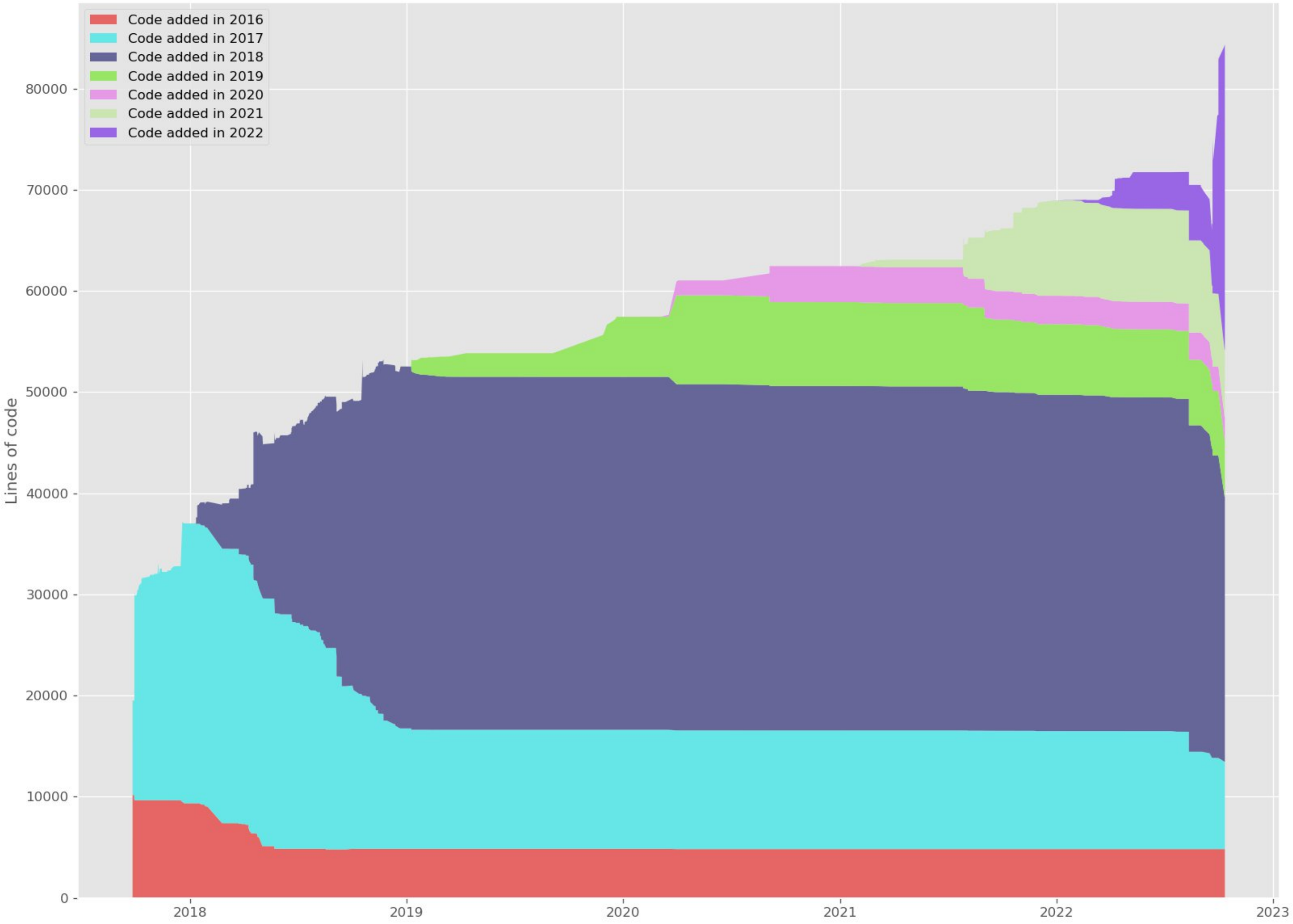
Interlocks

Alarm Units communication

Linux Operating System :
- Data storage and management
- Supervision
- …

Safety Critical part :
- Measurement algorithms
- Real Time temperature compensation
- Dose rate calculations
- Cumulated dose calculation
- Interlock generation
- …

SoC Number of Lines of Code (Without CROMiX)



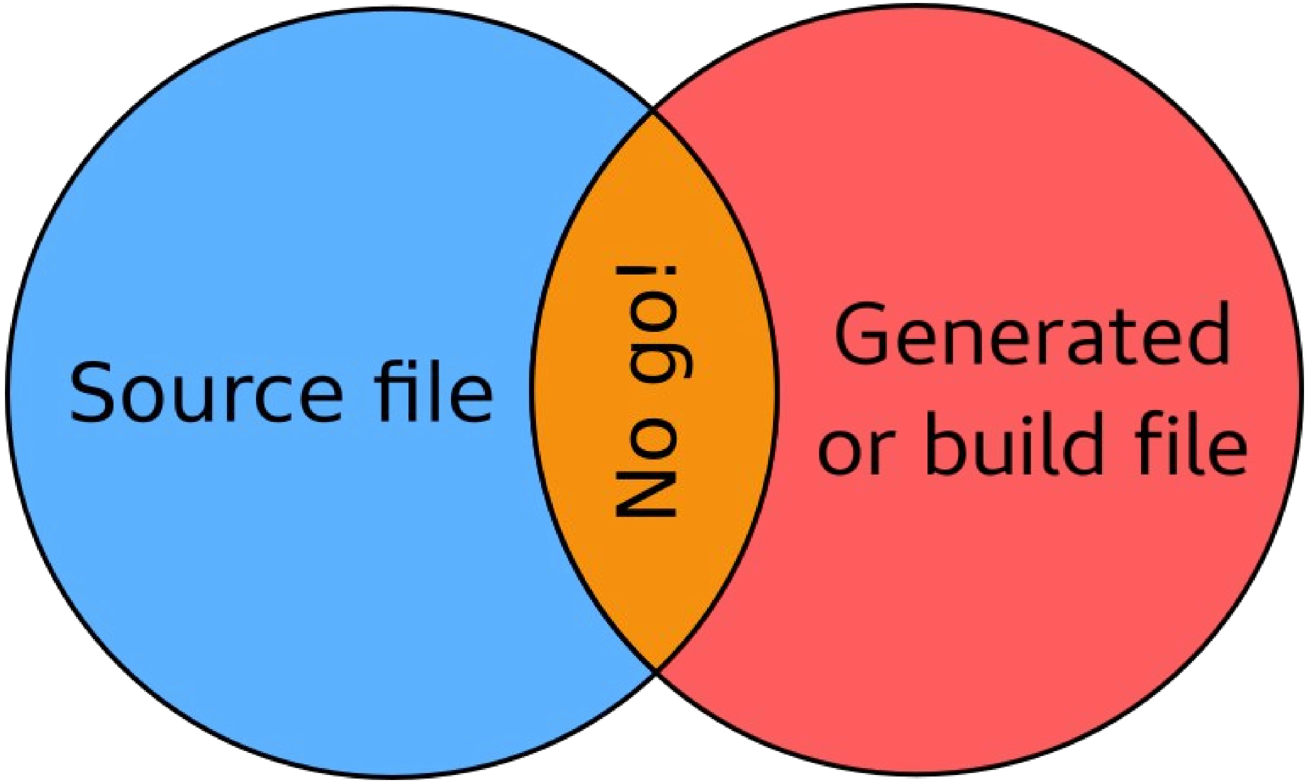
Issues in CROME

A tasteless cocktail

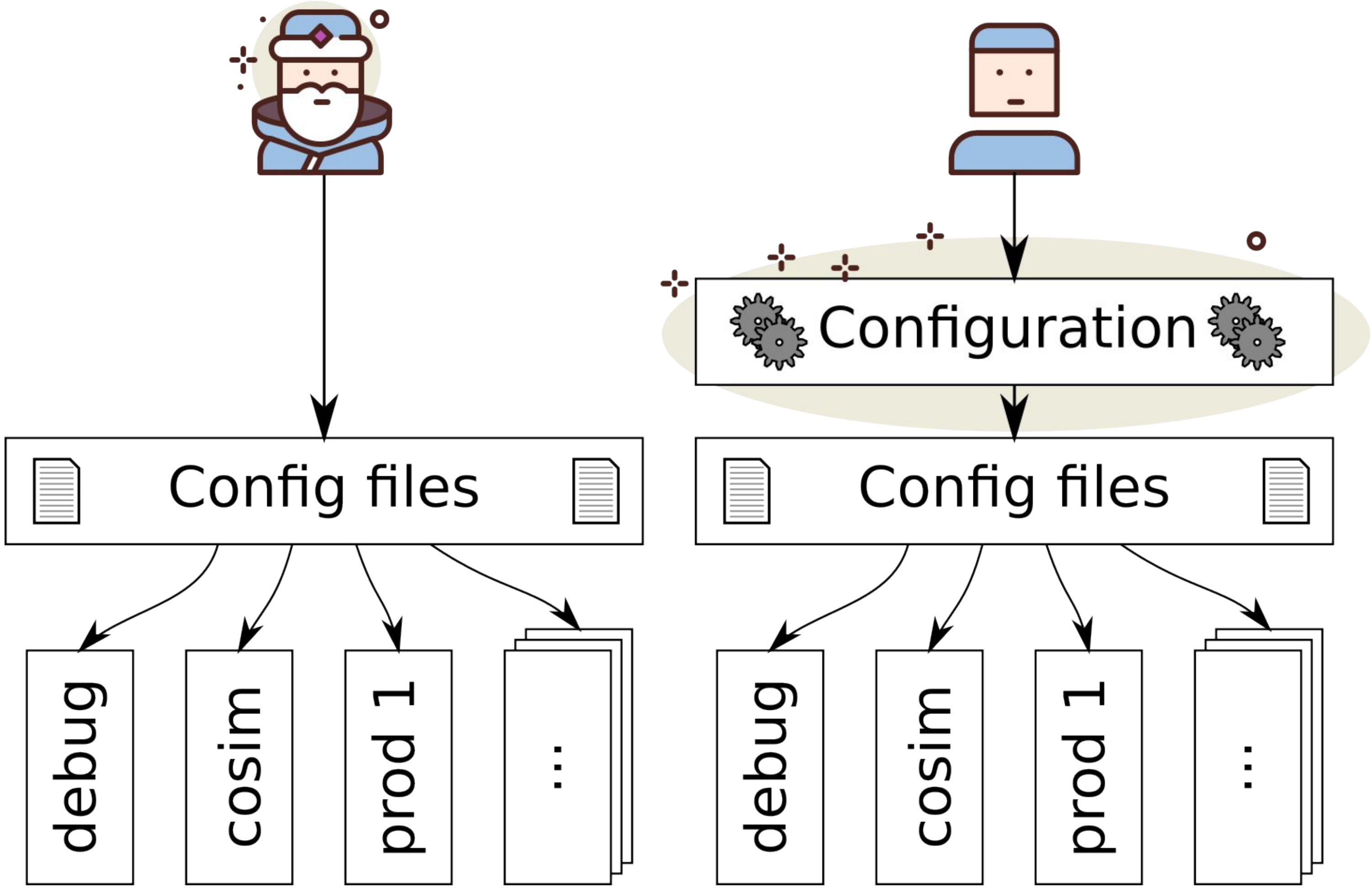
- What can I touch?
- Noisy commits

Going further: separate source and build directories

- Reduces noise
- Build configurations

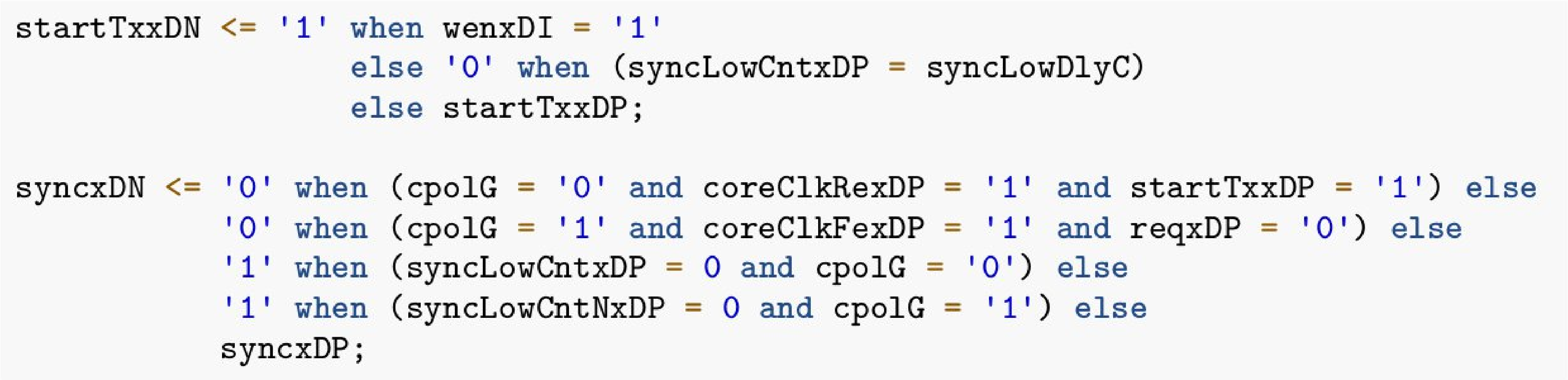


Configuration

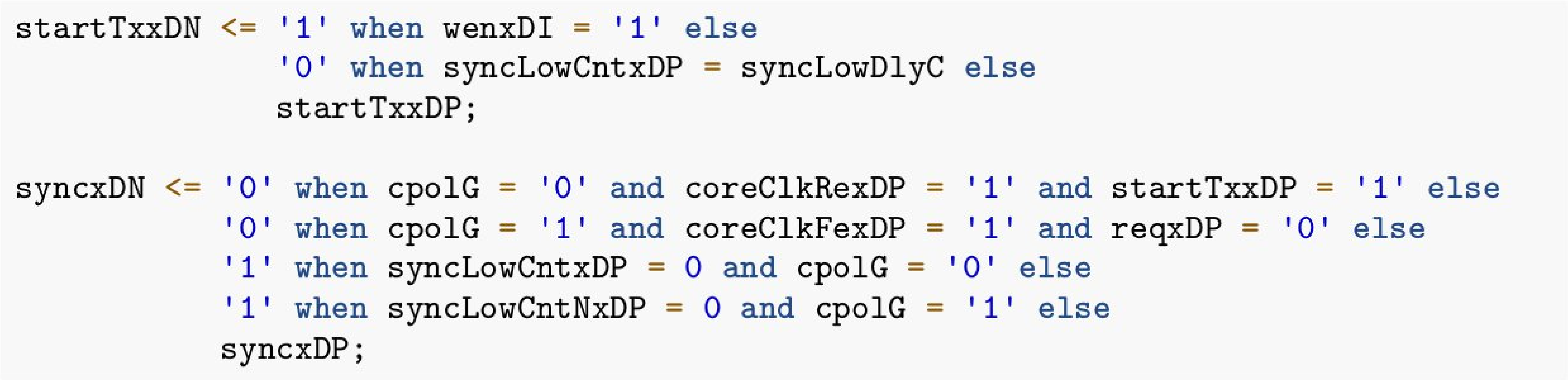


Code Style

- Uniformity = less mental load



```
startTxxDN <= '1' when wenxDI = '1'
                  else '0' when (syncLowCntxDP = syncLowDlyC)
                  else startTxxDP;

syncxDN <= '0' when (cpolG = '0' and coreClkRexDP = '1' and startTxxDP = '1') else
           '0' when (cpolG = '1' and coreClkFexDP = '1' and reqxDP = '0') else
           '1' when (syncLowCntxDP = 0 and cpolG = '0') else
           '1' when (syncLowCntNxDP = 0 and cpolG = '1') else
           syncxDP;
```



```
startTxxDN <= '1' when wenxDI = '1' else
              '0' when syncLowCntxDP = syncLowDlyC else
              startTxxDP;

syncxDN <= '0' when cpolG = '0' and coreClkRexDP = '1' and startTxxDP = '1' else
           '0' when cpolG = '1' and coreClkFexDP = '1' and reqxDP = '0' else
           '1' when syncLowCntxDP = 0 and cpolG = '0' else
           '1' when syncLowCntNxDP = 0 and cpolG = '1' else
           syncxDP;
```

Extras

- Vivado text base build
- Git guidelines

Configuration

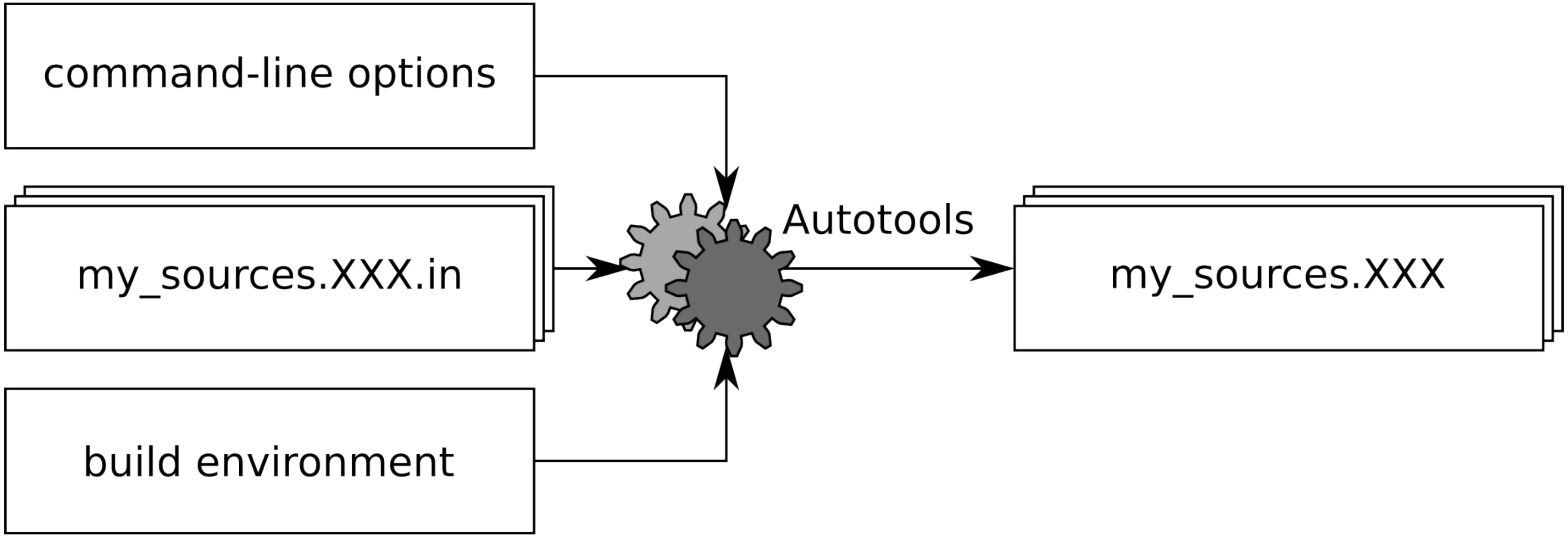
Idea

```
-- configPkg.vhd.in
package configPkg is
    constant triplication : std_logic := @TRIPLICATION@;
    -- [...]
end package configPkg;
```

```
$ ./someScript --enable-debug
```

```
-- configPkg.vhd
package configPkg is
    constant triplication : std_logic := '0';
    -- [...]
end package configPkg;
```

GNU Autotools

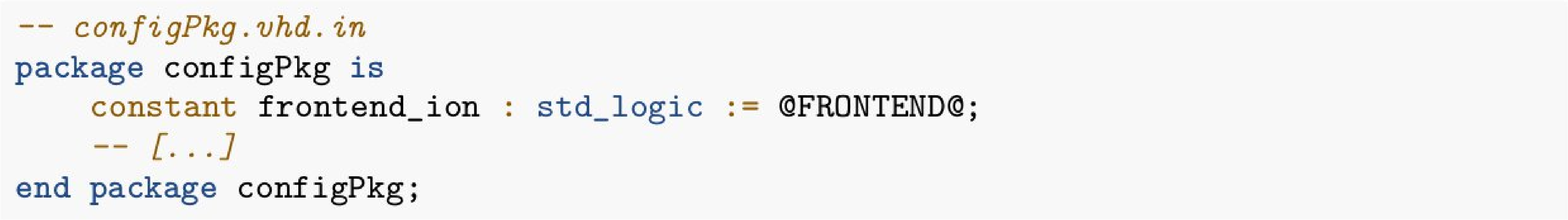


- Good support
- Very powerful
- Support for software dependency checking

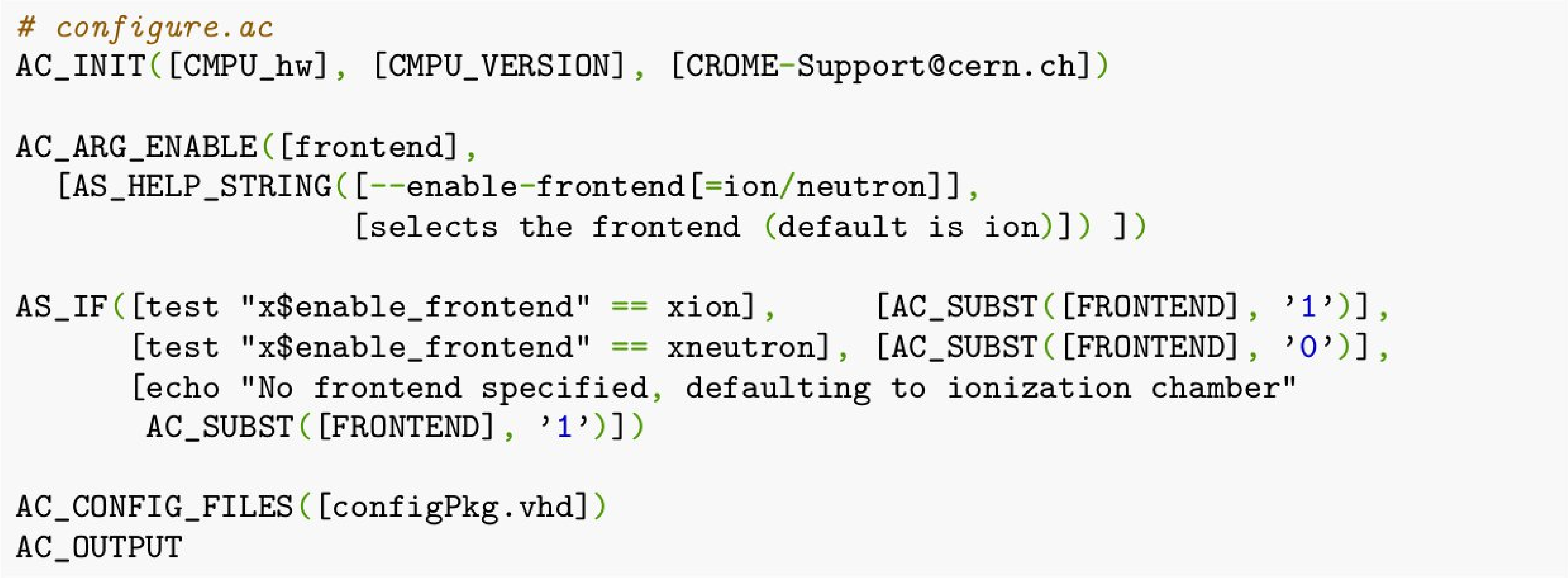
GNU Autotools: Steps

1. Replace configuration dependent values by `@MY_VARIABLE@`
2. Rename and add `.in` suffix at the end of the filename
3. Write `configure.ac` file
4. Enjoy

GNU Autotools: Example

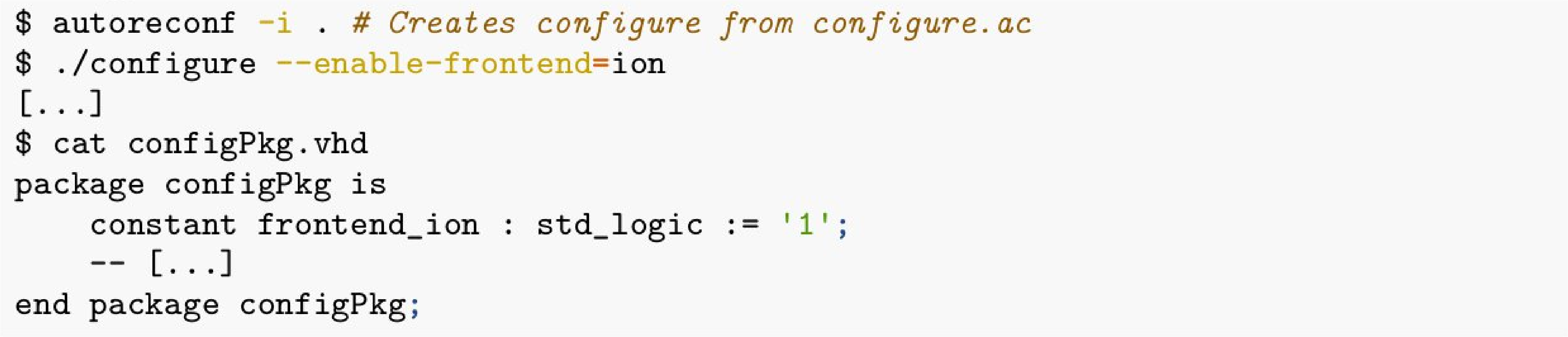


```
-- configPkg.vhd.in
package configPkg is
    constant frontend_ion : std_logic := @FRONTEND@;
    -- [...]
end package configPkg;
```

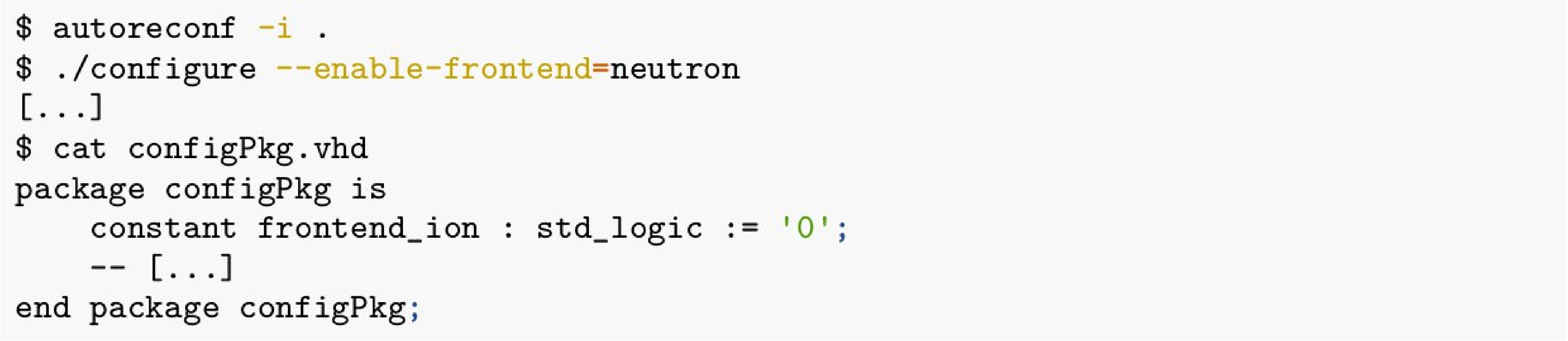


```
# configure.ac
AC_INIT([CMPU_hw], [CMPU_VERSION], [CROME-Support@cern.ch])

AC_ARG_ENABLE([frontend],
  [AS_HELP_STRING([--enable-frontend[=ion/neutron]],
                  [selects the frontend (default is ion)]) ])

AS_IF([test "x$enable_frontend" == xion],     [AC_SUBST([FRONTEND], ’1’)],
      [test "x$enable_frontend" == xneutron], [AC_SUBST([FRONTEND], ’0’)],
      [echo "No frontend specified, defaulting to ionization chamber"
       AC_SUBST([FRONTEND], ’1’)])

AC_CONFIG_FILES([configPkg.vhd])
AC_OUTPUT
```

GNU Autotools: Example – User interface



```
$ autoreconf -i . # Creates configure from configure.ac
$ ./configure --enable-frontend=ion
[...]
$ cat configPkg.vhd
package configPkg is
    constant frontend_ion : std_logic := '1';
    -- [...]
end package configPkg;
```



```
$ autoreconf -i .
$ ./configure --enable-frontend=neutron
[...]
$ cat configPkg.vhd
package configPkg is
    constant frontend_ion : std_logic := '0';
    -- [...]
end package configPkg;
```

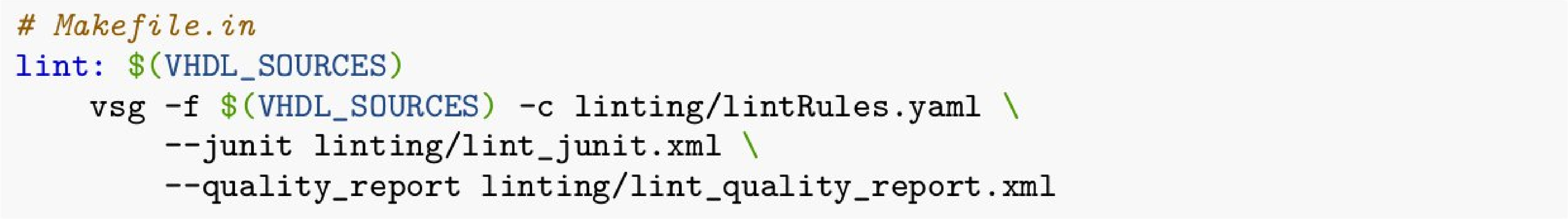
Live Demo!

Code style

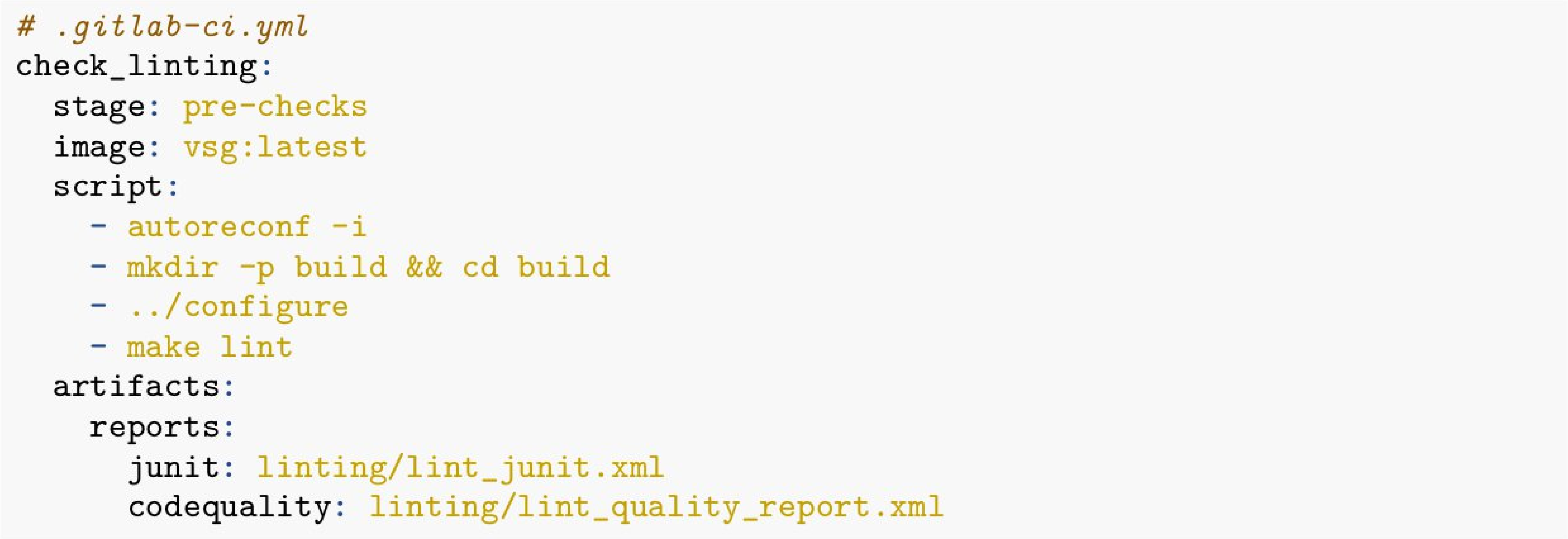
vhdl-style-guide

- Open source
- Can fix code automatically
- Many options with good documentation
- Supports CI-friendly formats

CI implementation



```
# Makefile.in
lint: $(VHDL_SOURCES)
    vsg -f $(VHDL_SOURCES) -c linting/lintRules.yaml \
        --junit linting/lint_junit.xml \
        --quality_report linting/lint_quality_report.xml
```



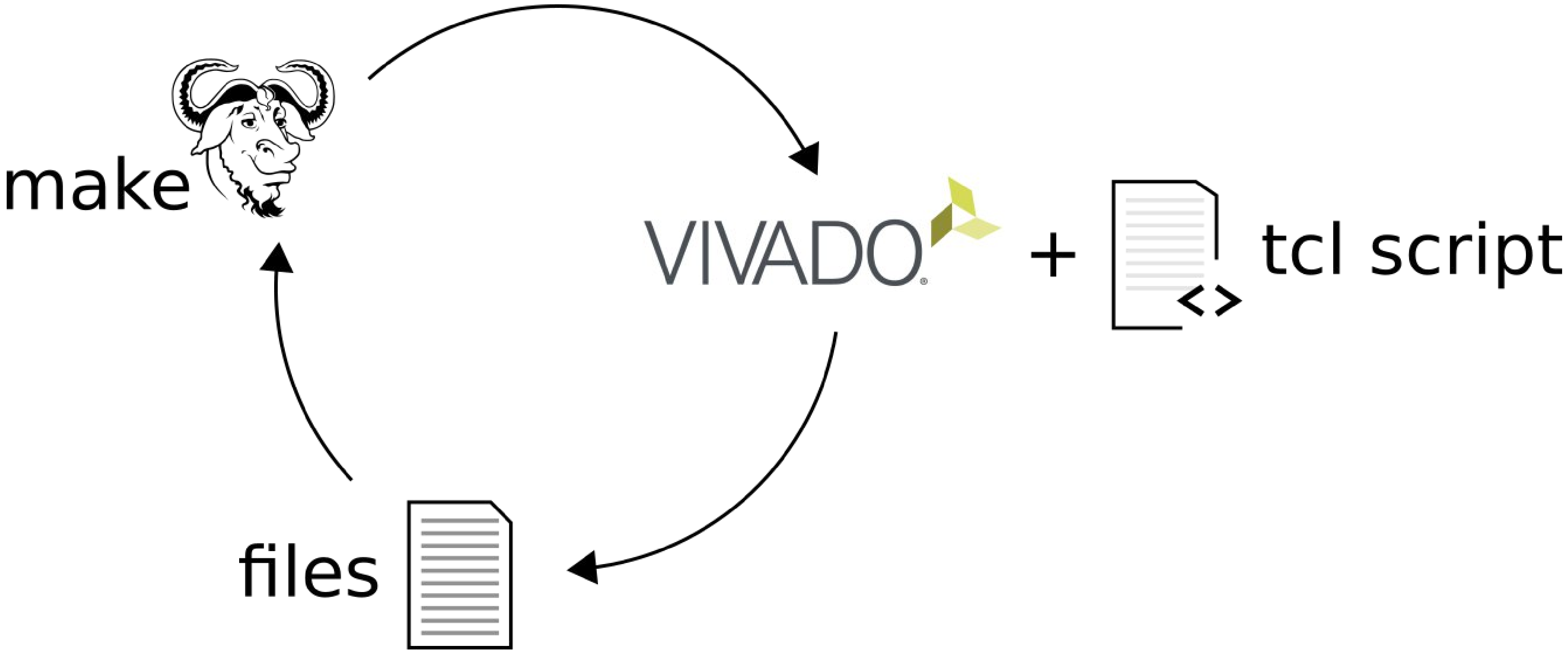
```
# .gitlab-ci.yml
check_linting:
  stage: pre-checks
  image: vsg:latest
  script:
    - autoreconf -i
    - mkdir -p build && cd build
    - ../configure
    - make lint
  artifacts:
    reports:
      junit: linting/lint_junit.xml
      codequality: linting/lint_quality_report.xml
```

Vivado text-base build

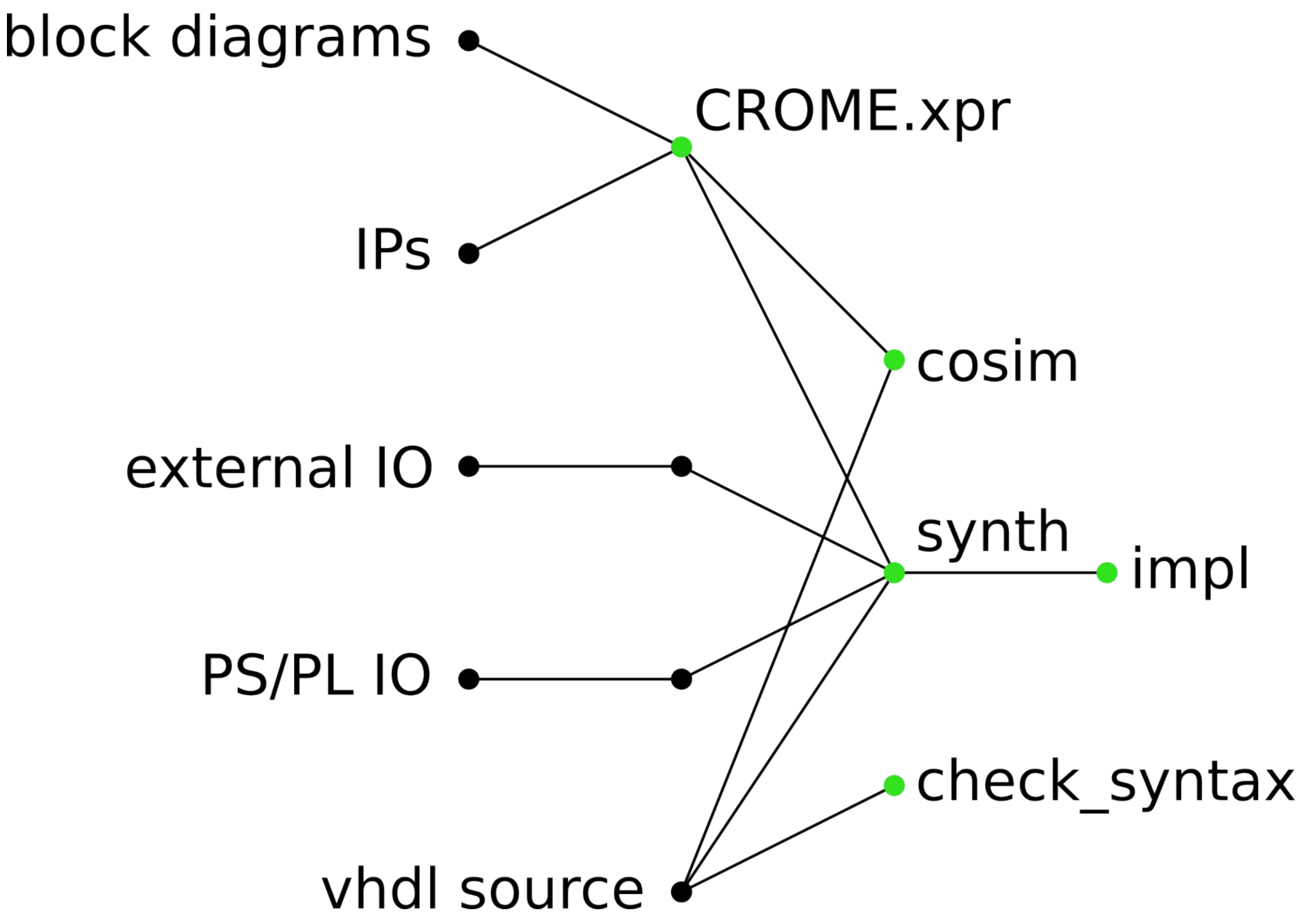
Vivado Build

- **`make` centered workflow**
  - CI integration
  - Reduce number of entry points
- **Dynamic generation of project**
  - Straightforward to version control
  - Reproducible
- **Compatibility with GUI**
  - Usage of project mode
  - Work taken by the tool

Vivado build: Structure



Vivado build: Dependencies



Vivado build: gotchas

- **Source files cannot be added blindly to the project: collision if generated files are present in the source directory**
  - List all source files explicitly
- **Vivado's synthesis can fail without resulting in a non-zero error code**
  - Use if clause with `` `get_property PROGRESS [get_runs synth_1]] != "100%"` ``
- **Each vivado run produces many files which are usually not wanted.**
  - Disable them by using `` `vivado -nolog -nojournal -notrace [...]` ``.
- **Vivado takes time to launch**
  - Reduce the number of steps

Conclusion

- A good technical debt is a managed technical debt
- No easy solution to paying it off

- GNU Autotools: Configuration/Software dependency checking
- vhdl-style-guide: style checking
- Make+tcl+vivado: text-based build

Bonus Round

Git

- Develop in a separate branch
- Do not consider work done as long it is not merged back to main
- Commits should be focused on a single purpose and include the minimum amount of modifications
- Use many small commits during development
- Clean up commit history using “`git rebase -i`” at the end of feature development
- Write meaningful commit messages: one-line summary followed by sh

Pitchfork project

- Ideas and advice on directory structure of code base
- Written for C++, but valuable in any case

Building

- **My one hour build failed at the end due to a typo**
  - Use vivado’s “`check_syntax`” before building
  - Command is not well-behaved, so post processing may be necessary
- **Track files and not stages in make files**
- **Use “`git status –ignored`” to see if “`make clean`” does its job correctly**

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