PULP tutorial

how to compile and simulate software on platform

What is PULP?

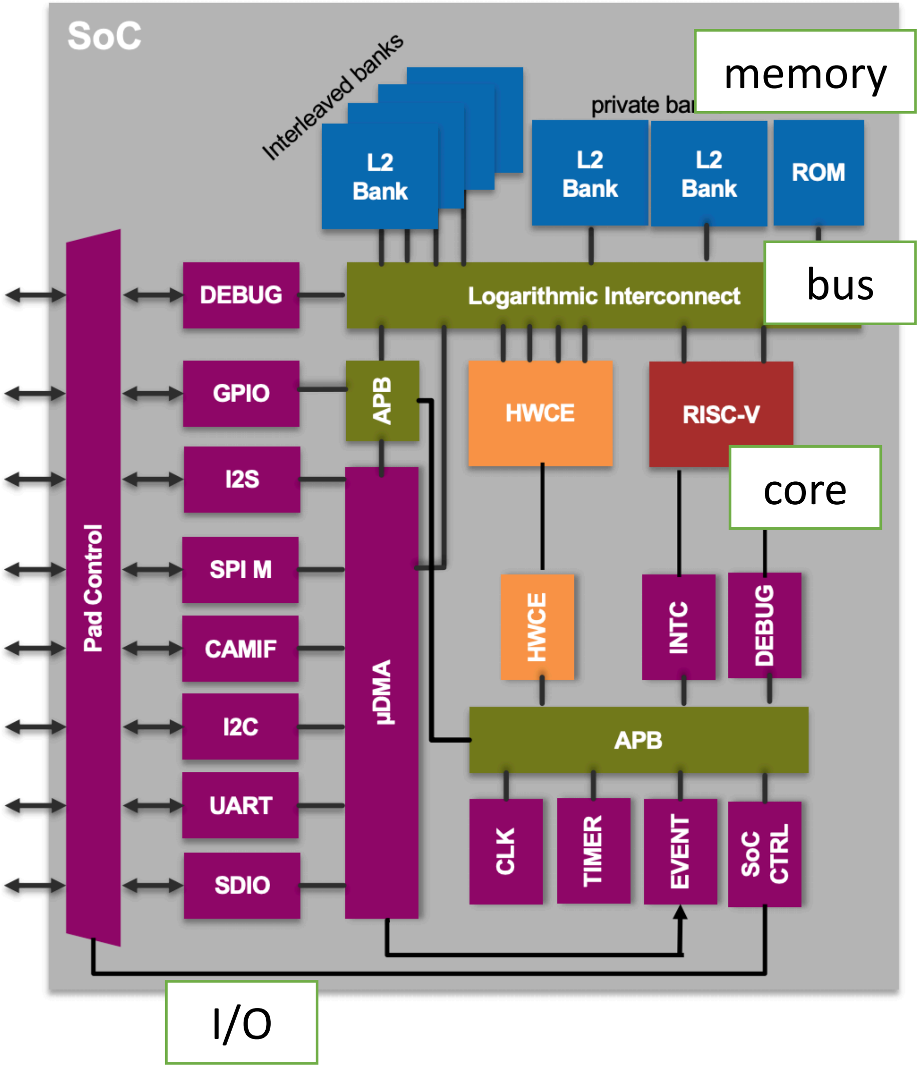
- Parallel Ultra-Low Platform
- Aim to: edge computing devices
  - Signal processing
  - Low energy consumption

1 * board + N * sensors → need to process the signal more efficiently!

ETH zürich
Integrated Systems Laboratory

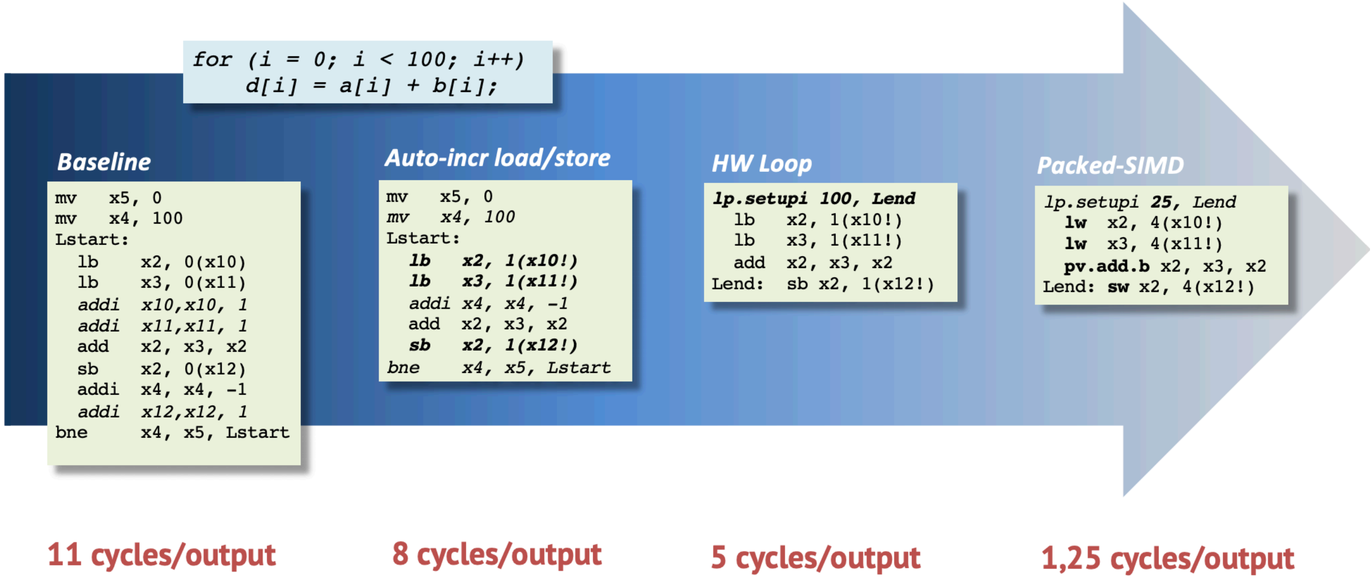
What is PULP?

- Platform
  - RISC-V based core
  - Memory model
  - Interconnect (bus)
  - DMA
  - I/O
  - …



Core – RI5CY

- 4-stage pipeline
- RV32IMFC + **Xpulp extension**
    - Memory Access Extensions
    - Hardware loops extensions
    - DSP extensions



```
for (i = 0; i < 100; i++)
    d[i] = a[i] + b[i];
```

Baseline

```
mv    x5, 0
mv    x4, 100
Lstart:
  lb    x2, 0(x10)
  lb    x3, 0(x11)
  addi  x10,x10, 1
  addi  x11,x11, 1
  add   x2, x3, x2
  sb    x2, 0(x12)
  addi  x4, x4, -1
  addi  x12,x12, 1
bne     x4, x5, Lstart
```

11 cycles/output

Auto-incr load/store

```
mv    x5, 0
mv    x4, 100
Lstart:
  lb    x2, 1(x10!)
  lb    x3, 1(x11!)
  addi  x4, x4, -1
  add   x2, x3, x2
  sb    x2, 1(x12!)
bne     x4, x5, Lstart
```

8 cycles/output

HW Loop

```
lp.setupi 100, Lend
  lb   x2, 1(x10!)
  lb   x3, 1(x11!)
  add  x2, x3, x2
Lend:  sb x2, 1(x12!)
```

5 cycles/output

Packed-SIMD

```
lp.setupi 25, Lend
  lw  x2, 4(x10!)
  lw  x3, 4(x11!)
  pv.add.b x2, x3, x2
Lend: sw x2, 4(x12!)
```

1,25 cycles/output

Get Started

Get PULPissimo platform source code.

Use software tool the simulate the program result.

Prerequisites

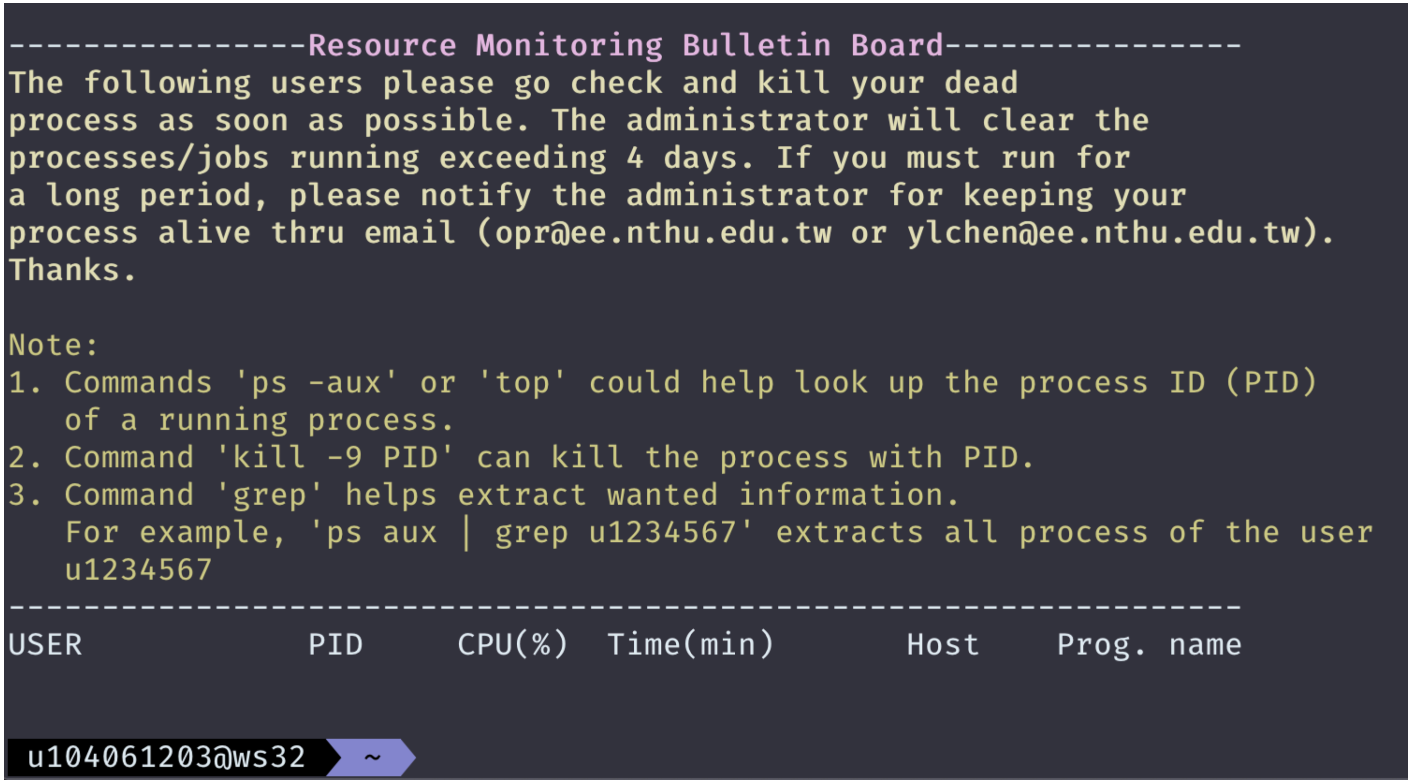
- CAD tool
  - ModelSim or QuestaSim
- Compiler
  - Pulp-riscv-gnu-toolchain
  - https://github.com/pulp-platform/pulp-riscv-gnu-toolchain

3 Steps

1. Install Pulp-riscv-gnu-toolchain **(Compiler)**
   - https://github.com/pulp-platform/pulp-riscv-gnu-toolchain
2. Get PULPissimo RTL source code & PULP SDK
   - https://github.com/pulp-platform/pulpissimo
3. Write your C program and run simulation

Environment

- Login to EEWS/CSWS
- For EEWS: ws32



```
----------------Resource Monitoring Bulletin Board----------------
The following users please go check and kill your dead
process as soon as possible. The administrator will clear the
processes/jobs running exceeding 4 days. If you must run for
a long period, please notify the administrator for keeping your
process alive thru email (opr@ee.nthu.edu.tw or ylchen@ee.nthu.edu.tw).
Thanks.

Note:
1. Commands 'ps -aux' or 'top' could help look up the process ID (PID)
   of a running process.
2. Command 'kill -9 PID' can kill the process with PID.
3. Command 'grep' helps extract wanted information.
   For example, 'ps aux | grep u1234567' extracts all process of the user
   u1234567
------------------------------------------------------------------
USER            PID     CPU(%)  Time(min)      Host    Prog. name


 u104061203@ws32  ~
```

1. Pulp-riscv-gnu-toolchain

1. Copy prebuilt toolchain zip

```
$ cp ~ee345000/riscv_toolchain_pulpissimo.zip ~/
```

2. Unzip (extract)

```
$ unzip ~/riscv_toolchain_pulpissimo.zip -d ~/
```

3. Set environment variable (set)

```
$ echo "setenv PULP_RISCV_GCC_TOOLCHAIN $HOME/toolchain" >> ~/.cshrc
```

2. RTL source code & SDK

- 1. Clone repo from github
  - https://github.com/pulp-platform/pulpissimo

```
$ git clone https://github.com/pulp-platform/pulpissimo &&
cd pulpissimo
```

- 2. Read README.md carefully!
- 3. Download IPs / SDK

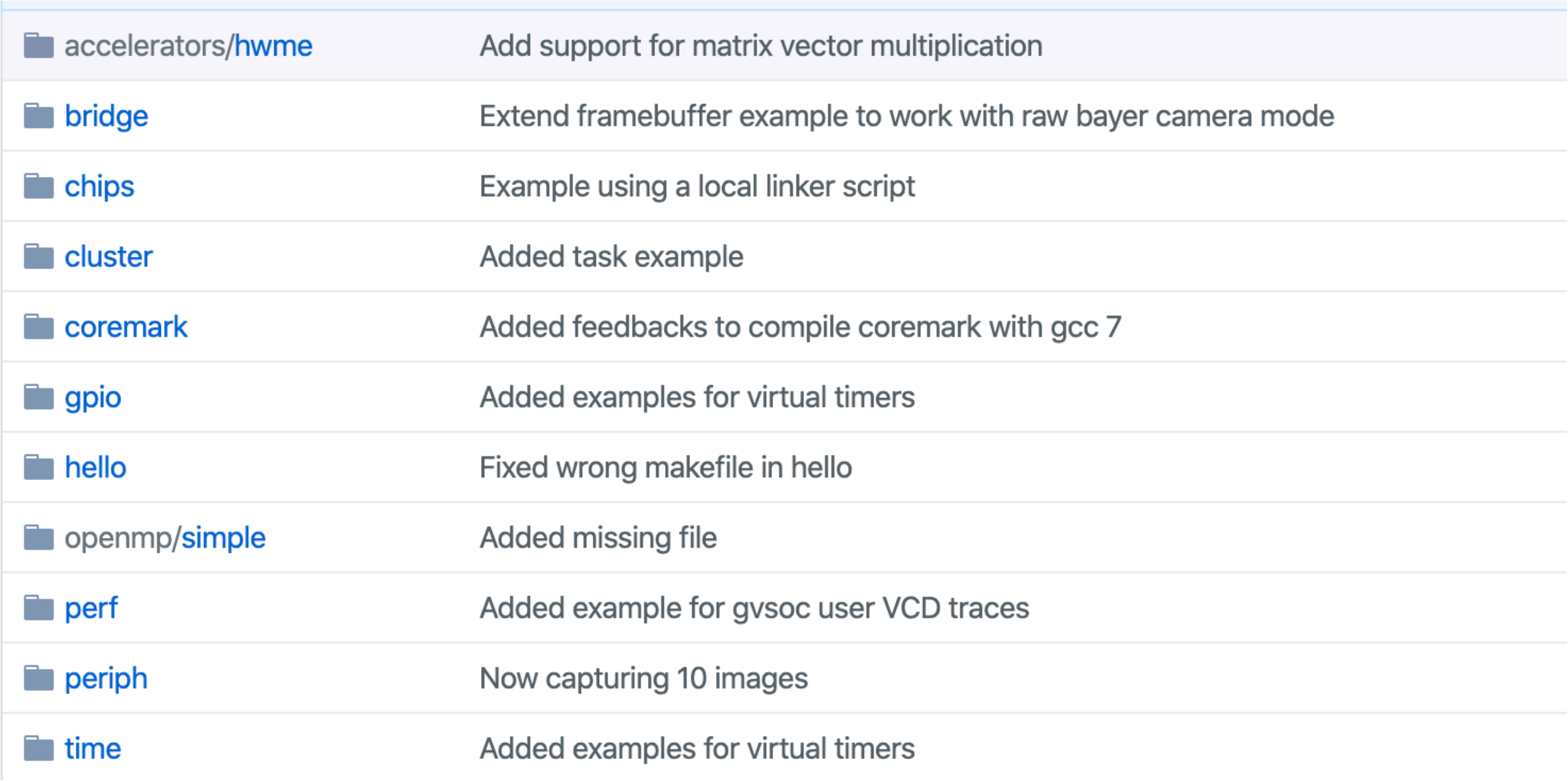
```
$ make checkout sdk
```

- 4. Synthesis RTL

```
$ cd sim && make lib build opt
```

3. Write C program

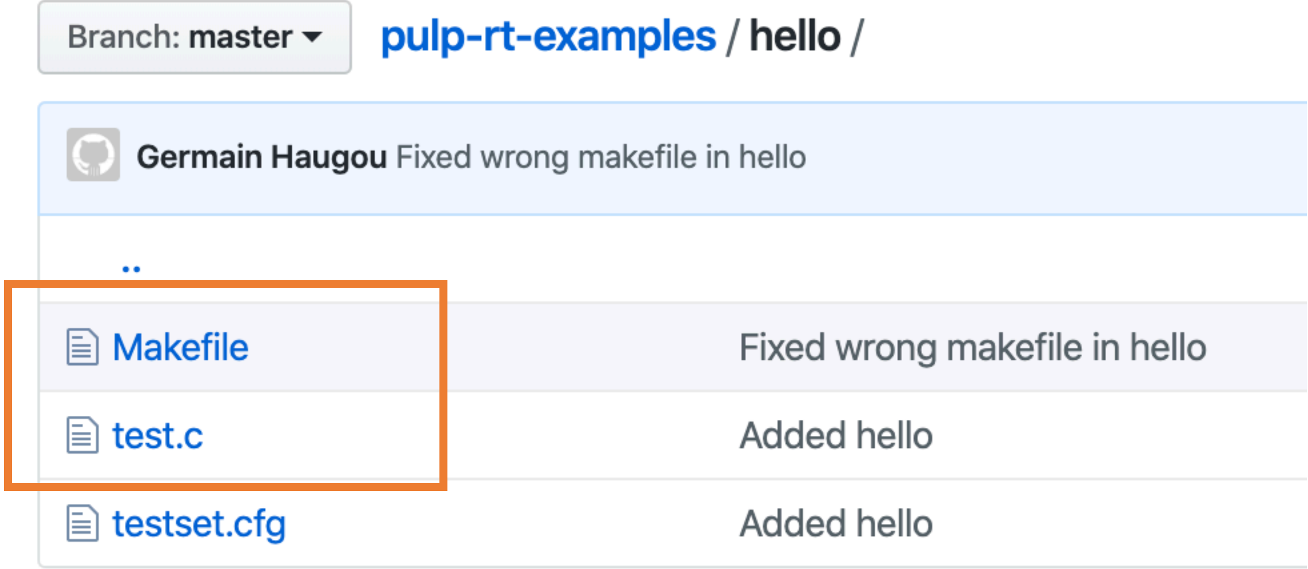
- Run C example program provided by official
  - https://github.com/pulp-platform/pulp-rt-examples



accelerators/hwme	Add support for matrix vector multiplication
bridge	Extend framebuffer example to work with raw bayer camera mode
chips	Example using a local linker script
cluster	Added task example
coremark	Added feedbacks to compile coremark with gcc 7
gpio	Added examples for virtual timers
hello	Fixed wrong makefile in hello
openmp/simple	Added missing file
perf	Added example for gvsoc user VCD traces
periph	Now capturing 10 images
time	Added examples for virtual timers

3. Write C program

- HelloWorld program



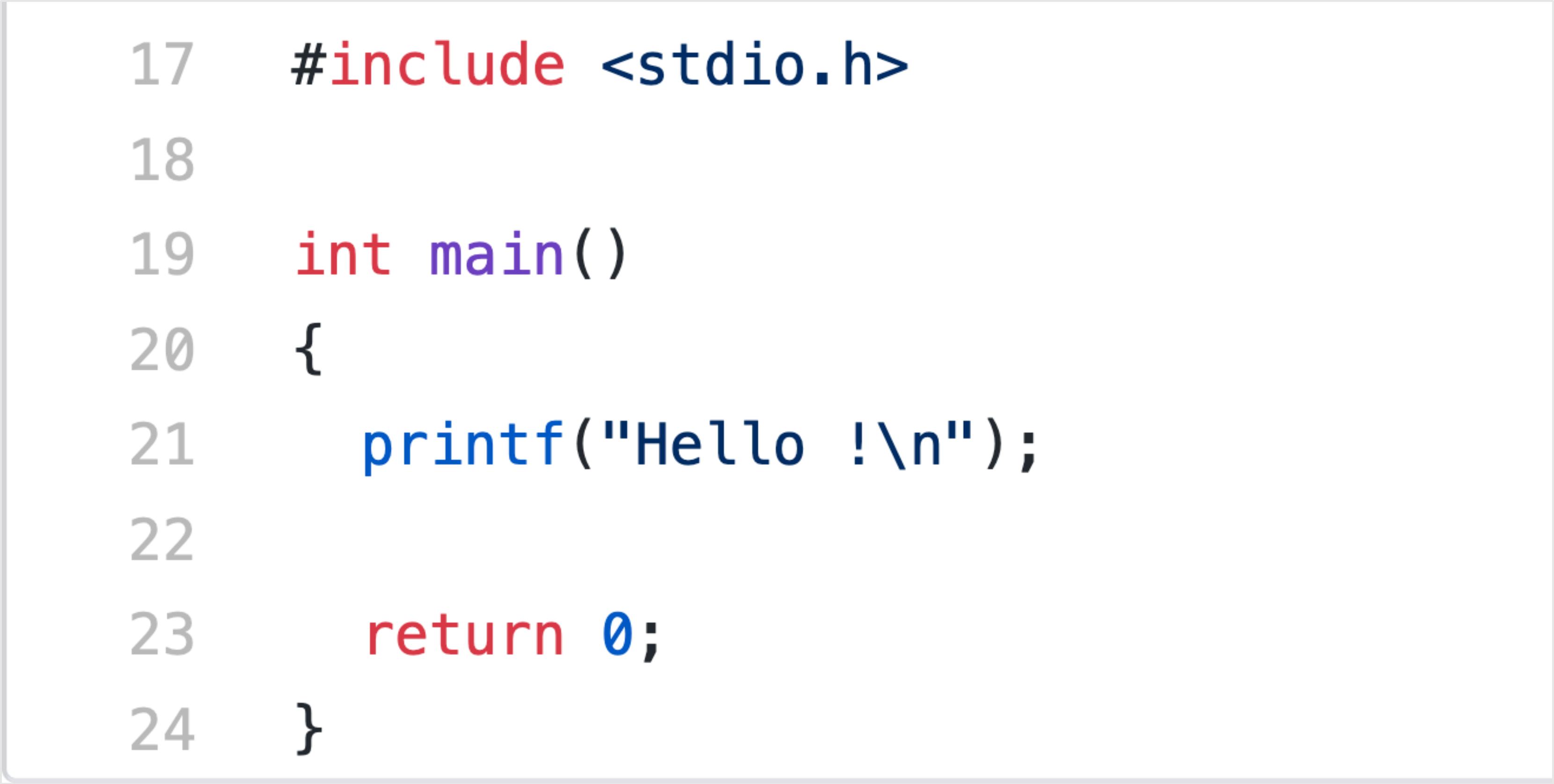
Branch: master ▾ pulp-rt-examples / hello /

Germain Haugou Fixed wrong makefile in hello

..

Makefile	Fixed wrong makefile in hello
test.c	Added hello
testset.cfg	Added hello

Test.c



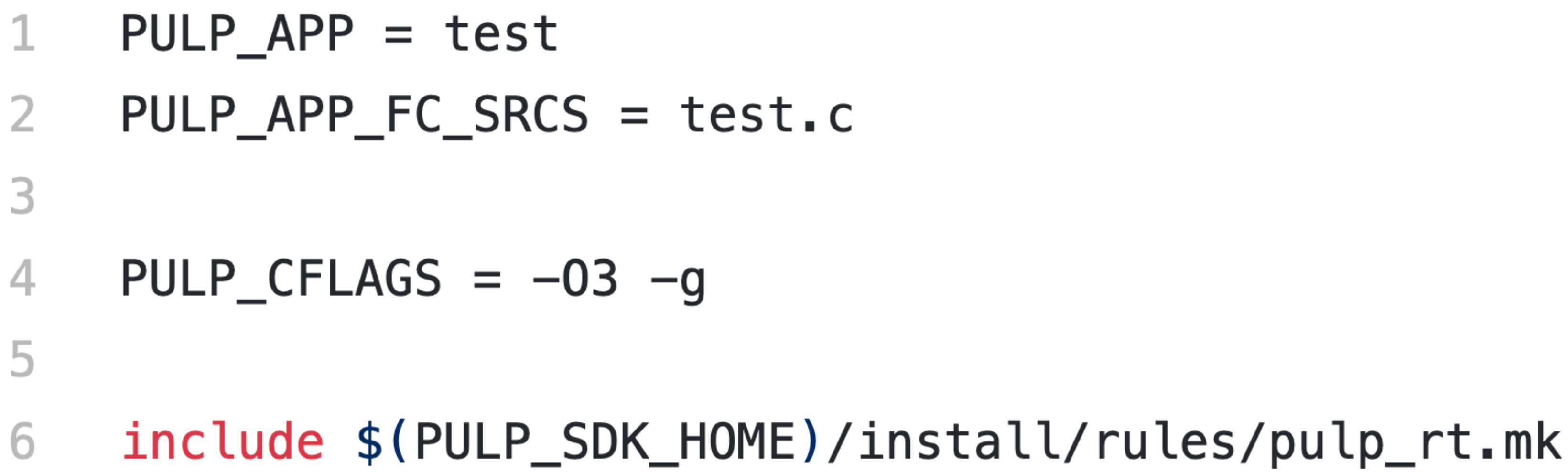
```c
#include <stdio.h>

int main()
{
   printf("Hello !\n");

   return 0;
}
```

Makefile

- Recommend: copy one as template



```
PULP_APP = test
PULP_APP_FC_SRCS = test.c

PULP_CFLAGS = -O3 -g

include $(PULP_SDK_HOME)/install/rules/pulp_rt.mk
```

Compile C code

- Run command:

```
$ make clean all
```

- Start simulation (no GUI):

```
$ make run
```

- Start simulation (GUI, to see waveform)

```
$ make run gui=1
```

Directory Structure

```
pulpissimo
├── ips          --> Most of the actual logic of the platform
├── pulp-builder --> PULP SDK
├── rtl          --> top-level RTL codes (testbench, I/O IPs)
└── sim          --> ModelSim, QuestaSim simulation files
```

Reference

- https://pulp-platform.org/

- https://github.com/pulp-platform/pulpissimo

- https://pulp-platform.org/docs/riscv_workshop_zurich/schiavone_wosh2019_tutorial.pdf