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SODA Synthesizer
Accelerating Data Science Applications with an end-to-end Silicon Compiler

Productive High-Level Synthesis with Bambu

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Hands-on setup

- The hands-on sessions are supported by Jupiter Notebook(s) running on Google Colab
  - Link for this session and the next
  - If you don't have access to a Google account, you can run the notebook locally (provided all dependencies are met)
- The first cell of the notebook downloads Bambu and all required tools, you don't need to install anything else
- If you want to use Bambu later on your own, installation instructions are provided on the website

QR-code

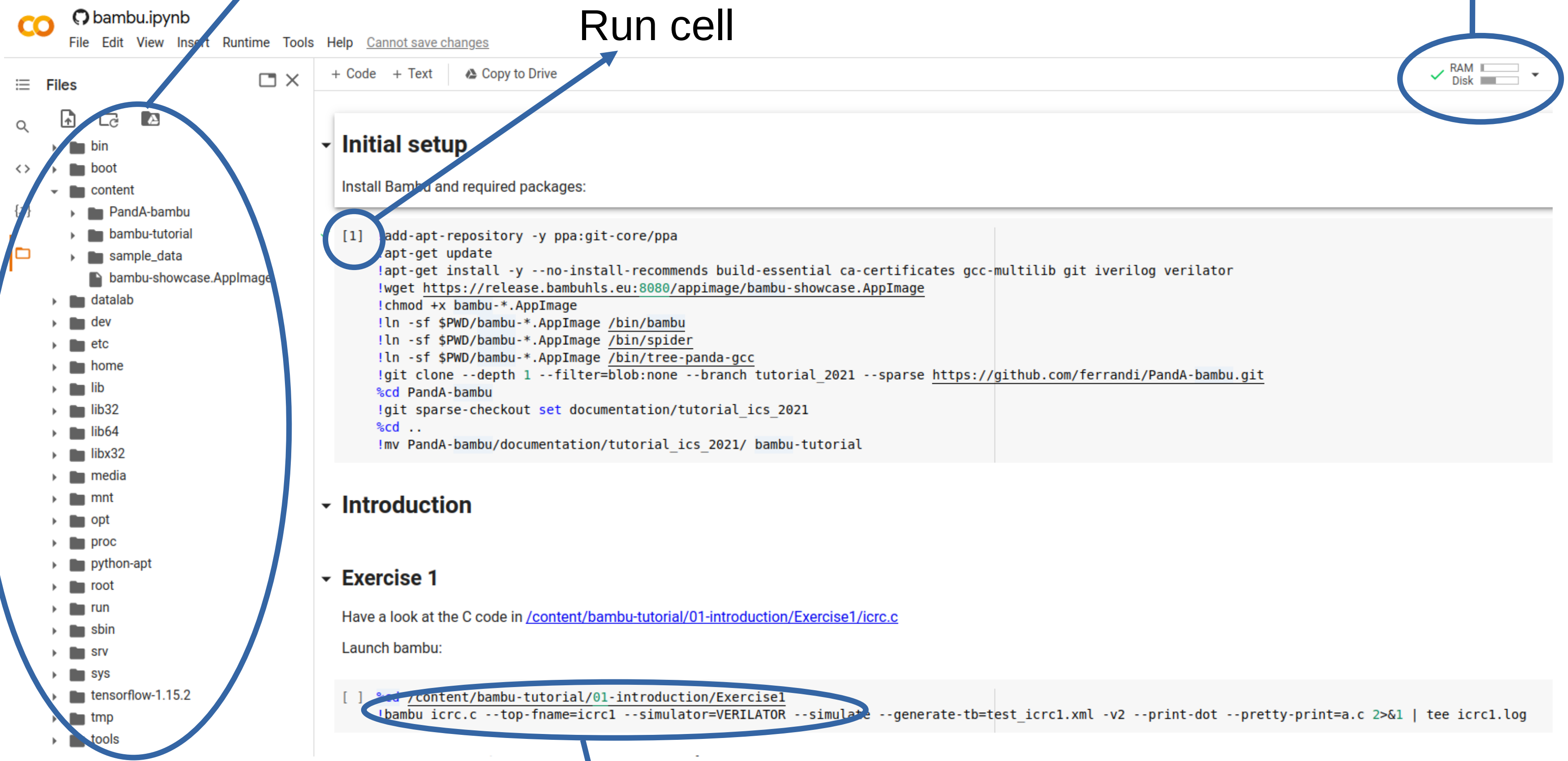
https://github.com/ferrandi/PandA-bambu/tree/feature/tutorial_pact23/documentation/tutorial_pact_2023

Hands-on setup

Explore folders and open files here

Run cell

Runtime information



Initial setup

Install Bambu and required packages:

```
[1]  !add-apt-repository -y ppa:git-core/ppa
     !apt-get update
     !apt-get install -y --no-install-recommends build-essential ca-certificates gcc-multilib git iverilog verilator
     !wget https://release.bambuhls.eu:8080/appimage/bambu-showcase.AppImage
     !chmod +x bambu-*.AppImage
     !ln -sf $PWD/bambu-*.AppImage /bin/bambu
     !ln -sf $PWD/bambu-*.AppImage /bin/spider
     !ln -sf $PWD/bambu-*.AppImage /bin/tree-panda-gcc
     !git clone --depth 1 --filter=blob:none --branch tutorial_2021 --sparse https://github.com/ferrandi/PandA-bambu.git
     %cd PandA-bambu
     !git sparse-checkout set documentation/tutorial_ics_2021
     %cd ..
     !mv PandA-bambu/documentation/tutorial_ics_2021/ bambu-tutorial
```

Introduction

Exercise 1

Have a look at the C code in /content/bambu-tutorial/01-introduction/Exercise1/icrc.c

Launch bambu:

```
[ ]  %cd /content/bambu-tutorial/01-introduction/Exercise1
     !bambu icrc.c --top-fname=icrc1 --simulator=VERILATOR --simulate --generate-tb=test_icrc1.xml -v2 --print-dot --pretty-print=a.c 2>&1 | tee icrc1.log
```

Edit cell (use ! for bash commands)

Getting to know Bambu

- Basic command:

```
bambu filename.c  --top-fname=name
```

- Input: C (or C++, or LLVM IR) file
- Output: Verilog (or VHDL) file
- Compiler-like command-line interface
  - Other options are passed as compiler flags, e.g.:

`-v0|-v1|-v2|-v3|-v4`	Verbosity level
`-O0|-O1|-O2|...`	Optimization level (next session)
`-I<file_name>`	Additional inputs
`-lm`	Functions from `math.h`

Finding help

- Print all available options:

```
bambu --help
```

- For example, you can find how to select VHDL output instead of Verilog

```
--writer,-w<language>
       Output RTL language:
            V - Verilog (default)
            H - VHDL
```

- Other resources:
  - Website/GitHub issues/panda-info@polimi.it
  - Examples folder

Co-simulation

- To verify that the generated HDL design produces correct results, Bambu interfaces with simulation tools

```
--simulate --simulator=SIMULATOR_NAME
```

- Supported simulators are Verilator, Icarus, ModelSim (Mentor), Xsim (Xilinx), Isim (Xilinx)

Co-simulation

- Bambu automatically produces an HDL testbench with input values
  - Random values (no option specified)
  - User provided values `--generate-tb="a=1,b=2"`
  - User provided values `--generate-tb=test.xml`
- Matching between input values and accelerator ports is *name based*
  - Exception: when the input is a `.ll` file, inputs must be named `P0`, `P1`, `P2`…
- Reference outputs can be inferred from the execution of the input code, or provided by the user

Co-simulation

- The testbench communicates with the top-level module to control the computation and collect the computed results
- The inputs are fed to both the sw input and the generated hw module
  - If the module outputs do not match with the return values of the input code, Bambu raises an error
  - If they do, Bambu reports the number of clock cycles
- *The whole process is automated*

Additional input information

- Basic command:

```
bambu filename.c --top-fname=name
```

- Selecting the frontend compiler:

```
--compiler=I386_GCC8|I386_CLANG7|...
```

- Selecting the hardware target:

```
--device-name=5SGXEA7N2F45C1 --clock-period=5
```

Currently supported devices

- Intel
  - Cyclone II: EP2C70F896C6, EP2C70F896C6-R
  - Cyclone V: 5CSEMA5F31C6
  - Stratix IV: EP4SGX530KH40C2
  - Stratix V: 5SGXEA7N2F45C1
- Lattice
  - ECP3: LFE335EA8FN484C
- AMD/Xilinx
  - Virtex 4: xc4vlx100-10ff1513
  - Virtex 5: xc5vlx110t-1ff1136 xc5vlx330t-2ff1738 xc5vlx50-3ff1153
  - Virtex 6: xc6vlx240t-1ff1156
  - Artix 7: xc7a100t-1csg324-VVD
  - Virtex 7: xc7vx330t-1ffg1157 xc7vx485t-2ffg1761-VVD xc7vx690t-3ffg1930-VVD
  - Zynq: xc7z020-1clg484-VVD (default), xc7z020-1clg484, xc7z020-1clg484-YOSYS-VVD
- NanoXplore
  - Brave NG-Medium
  - Brave NG-Large
- ASIC Nangate 45nm and ASAP7 (through OpenROAD)

Target Selection

- ❑ Different targets (FPGA device and clock period) imply:
  - Different delays (e.g., delay of a DSP)
  - Different sizes (e.g., number of LUTs)
  - Different HDL descriptions
- ❑ Target information is embedded in XML files
  - Supported devices ♋❒♏ included in Bambu executable
  - Characterization carried out through eucalyptus (distributed in PandA)
  - New devices can be passed to the tool as XML files (see example)

Interfacing Synthesis Tools

- Bambu can directly interface logic synthesis tools:
  - Quartus / Quartus Prime
  - ISE / Vivado
  - OpenROAD
  - Diamond
  - NxMap
- By default, Bambu generates synthesis scripts for the appropriate tool depending on the target board
- With `--evaluation` Bambu *automatically launches the synthesis script and collects information* about generated solutions

Interfacing Synthesis Tools

- `--no-iob`
- is usually required to avoid consuming all available I/O pins on an FPGA
- Users can provide additional
  - Constraint files `--backend-sdc-extensions`
  - TCL scripts `--backend-script-extensions`

Additional output files

- Bambu can also produce
  - Graphical representations of the Finite State Machine and other relevant graphs

    ```
    --print-dot
    ```
  - A C version of the internal Bambu IR

    ```
    --pretty-print=a.c
    ```
  - VCD for waveform visualization

    ```
    --generate-vcd
    ```
  - All temporary files

    ```
    --no-clean
    ```

Hands-on time

- Switch to Colab Notebook

Question time

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