gem5/SST Integration

First step: Install SST

We're not going to do this today.

What we'll do instead is use a docker container with sst installed.

Run the following to go into the docker container.
Note: You shouldn't use a container interactively like this, but I'm lazy.

```
cd /workspaces/2024
docker run --rm --volume
/workspaces/:/workspaces -w `pwd` ghcr.io/gem5/sst-env
```

gem5 as a Library: Hello, World!

To use gem5 as a "component" in SST, you need to build it as a library.
This is yet another unique build target...
Note: if you're building on a Mac, it's not ".so" it's ".dynlib"

Compiling gem5 as a library

```
cd gem5/
scons defconfig build/for_sst build_opts/RISCV
scons build/for_sst/libgem5_opt.so -j8 --without-tcmalloc --duplicate-sources
```

Building the gem5 component in gem5

Compiling gem5 component

```
cd ext/sst
cp Makefile.linux Makefile
```

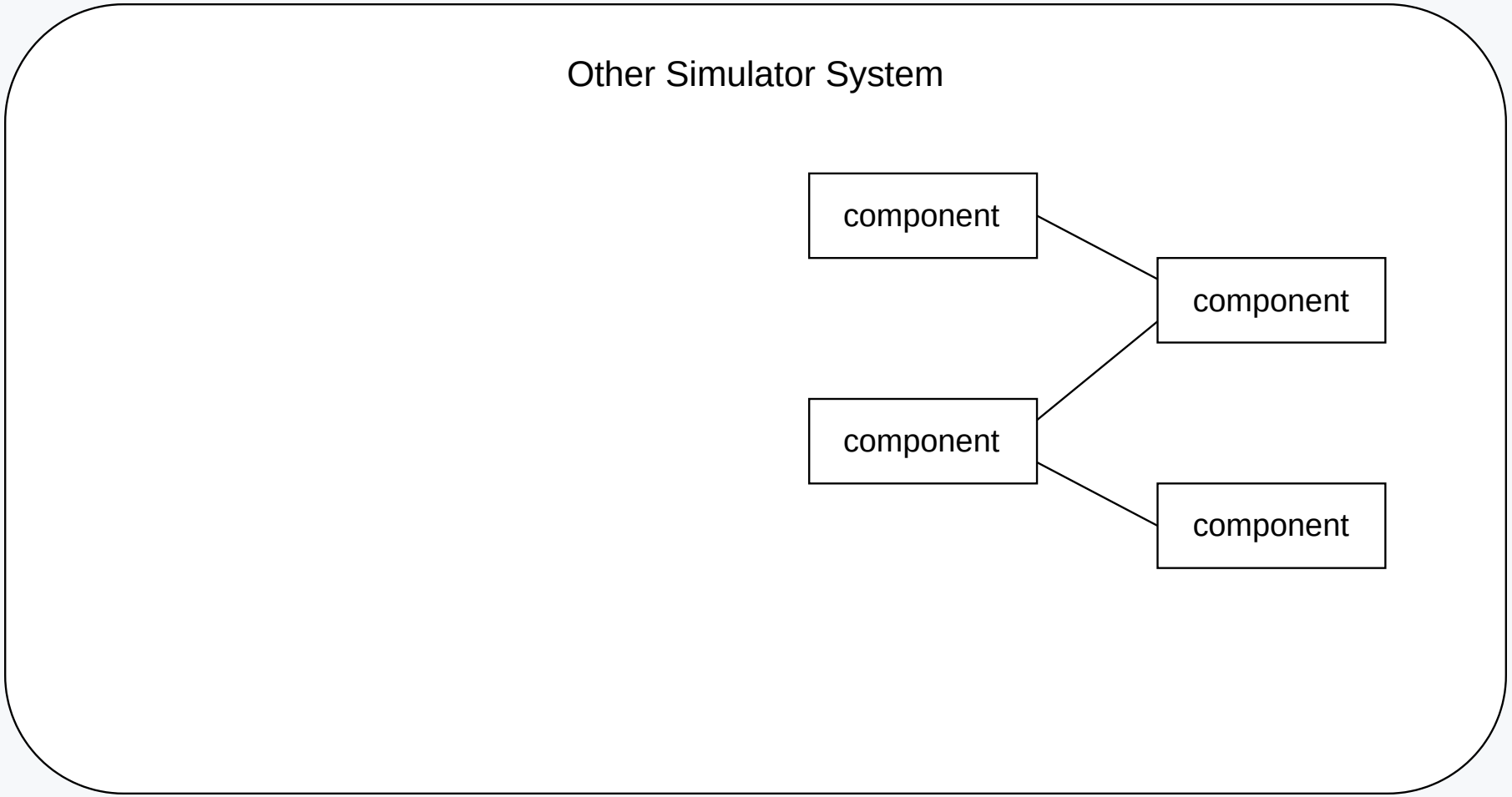
Change the line with `ARCH=RISCV` to `ARCH=for_sst`

```
make -j8
```

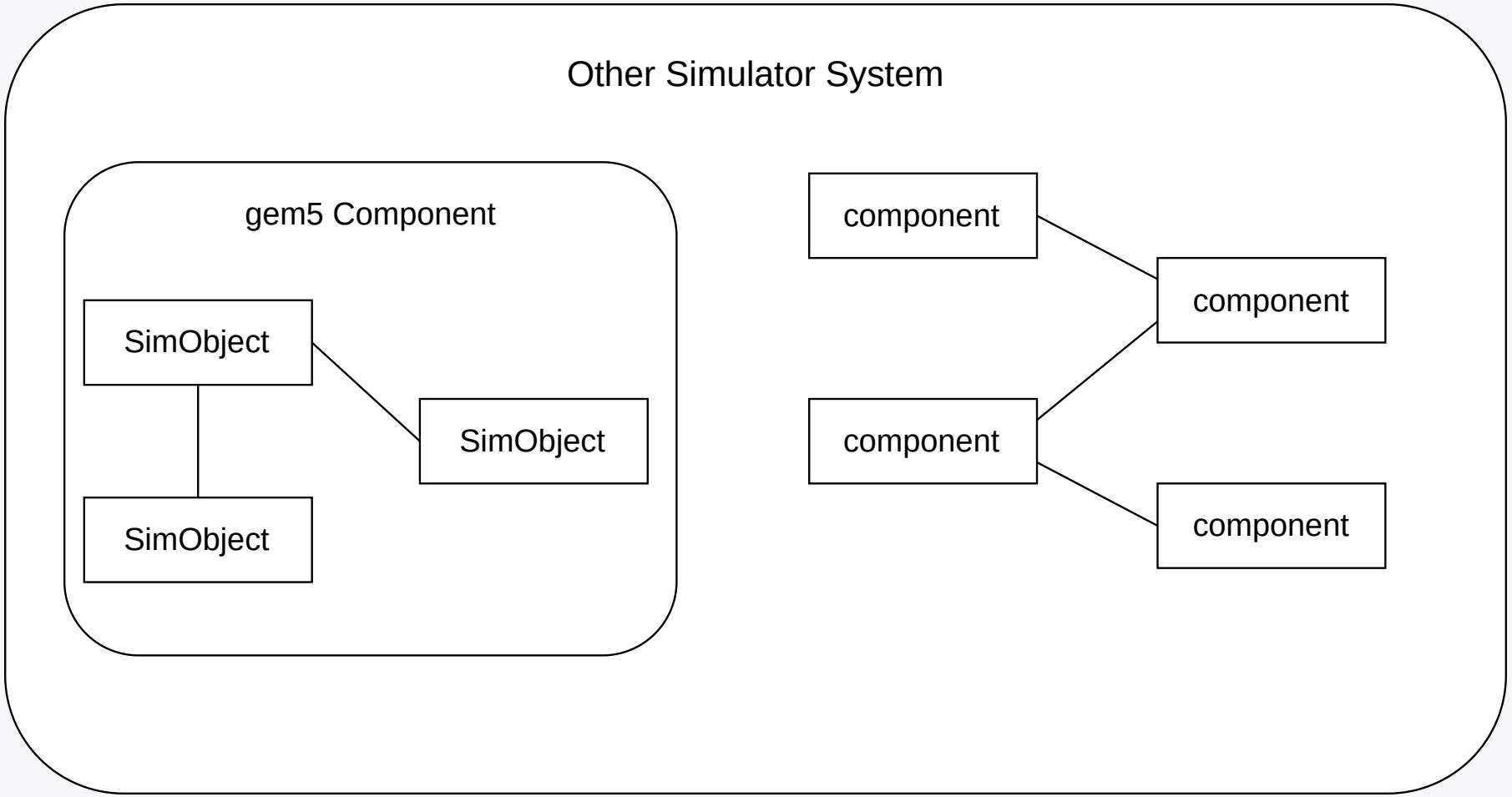
Running the simulation,

```
sst --add-lib-path=. sst/example.py
```

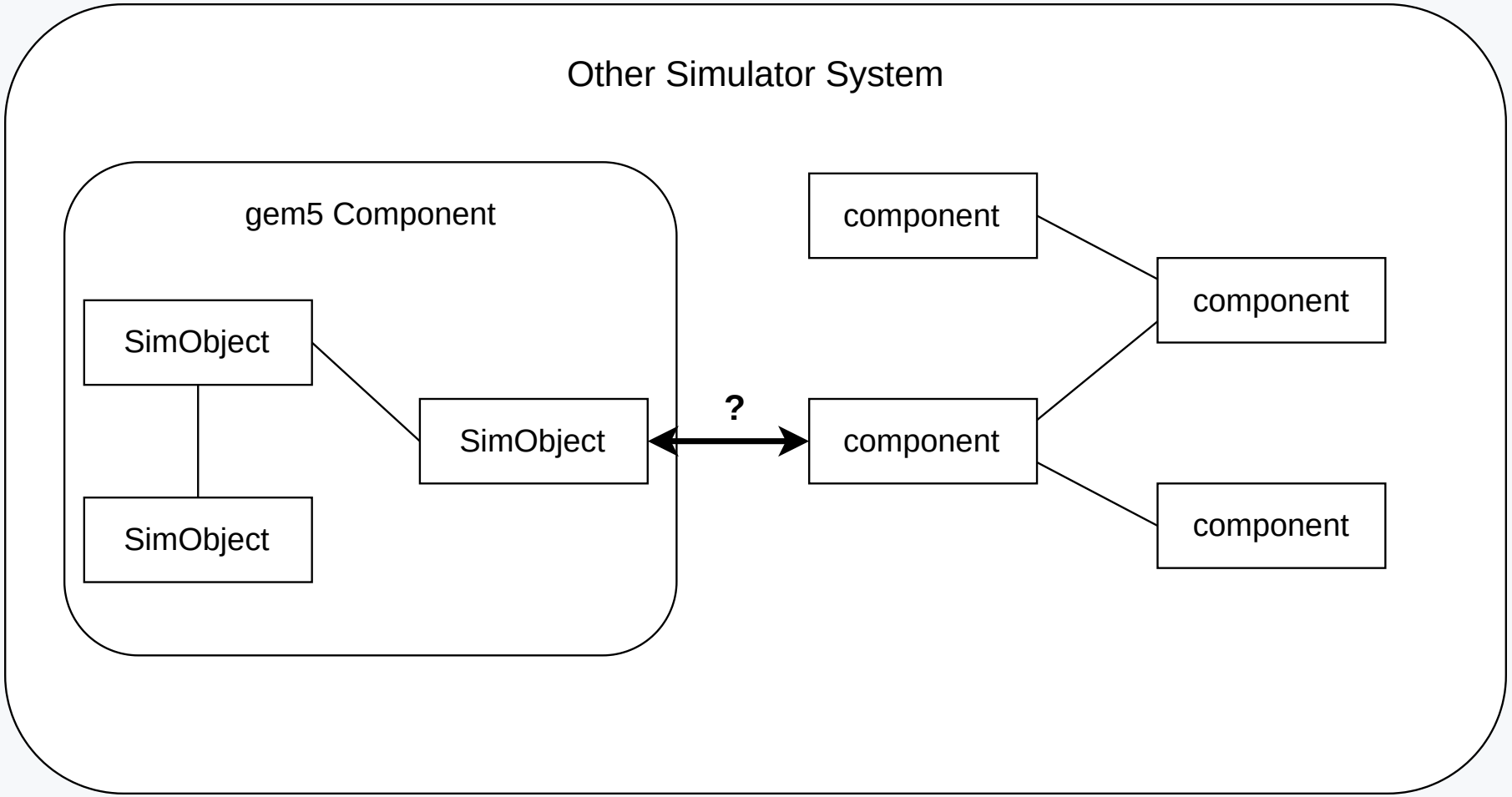
gem5 as a Library: instantiation



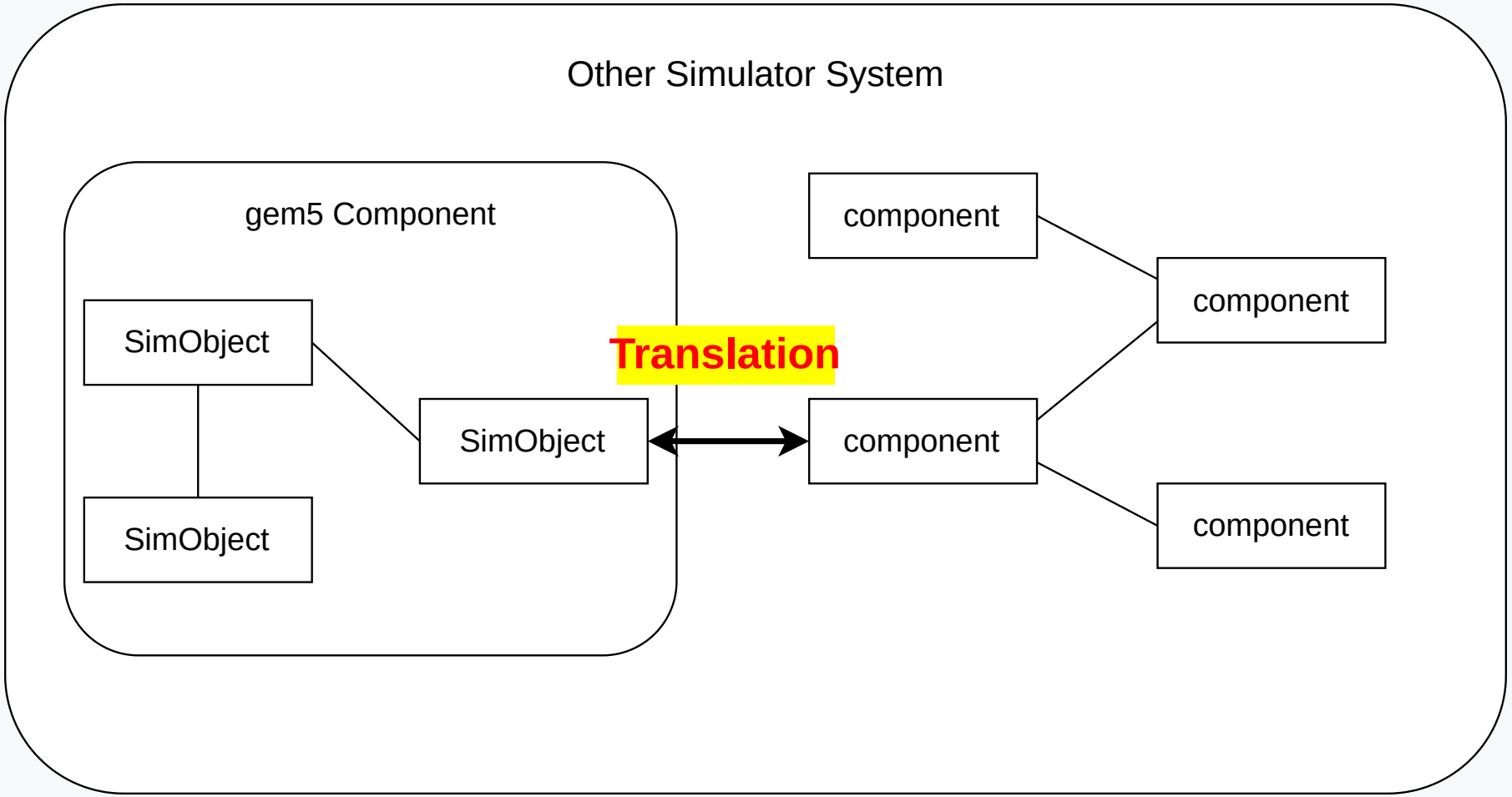
gem5 as a Library: instantiation



gem5 as a Library: instantiation



gem5 as a Library: instantiation

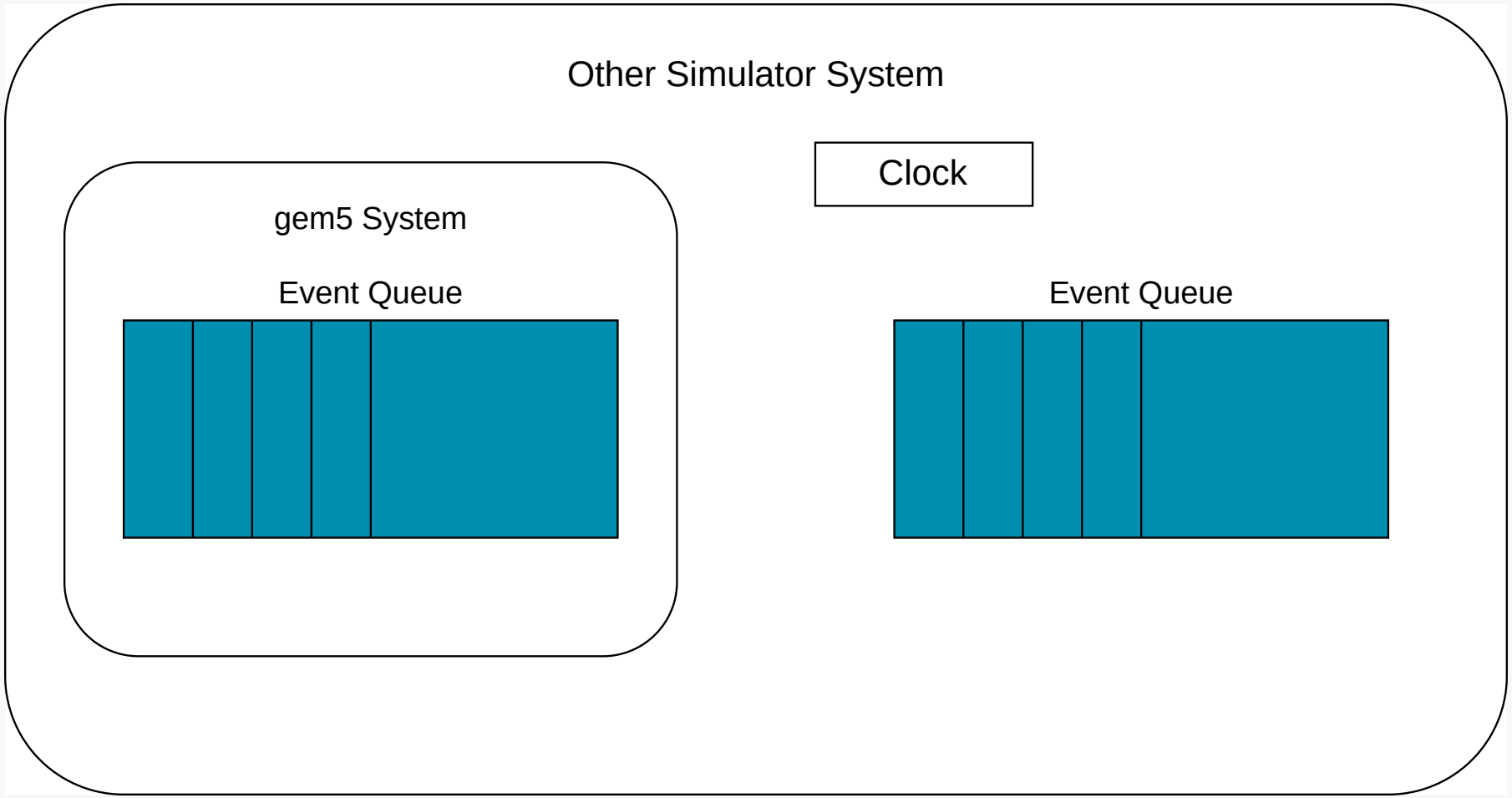


gem5 as a Library

How to set up gem5 in another simulator?

- Step 1: Setting up the gem5 Python environment.
  - Need to manually import the m5 module
- Step 2: Reading the gem5 Python system configuration file.
  - This includes setting up the communication data path for gem5 and the other simulator
- Notes:
  - `m5.instantiate()` must be called before any simulation.
  - `m5.simulate(K)` runs the gem5 simulation for `K` ticks.

gem5 as a Library: simulation



gem5 as a Library: simulation

For every external simulator clock tick:

```
external_simulator.advance_to_next_event()
gem5_system.advance(n_ticks)
```

where `n_ticks` = time difference between this event and previous event of the external simulator

Case study: gem5/SST integration

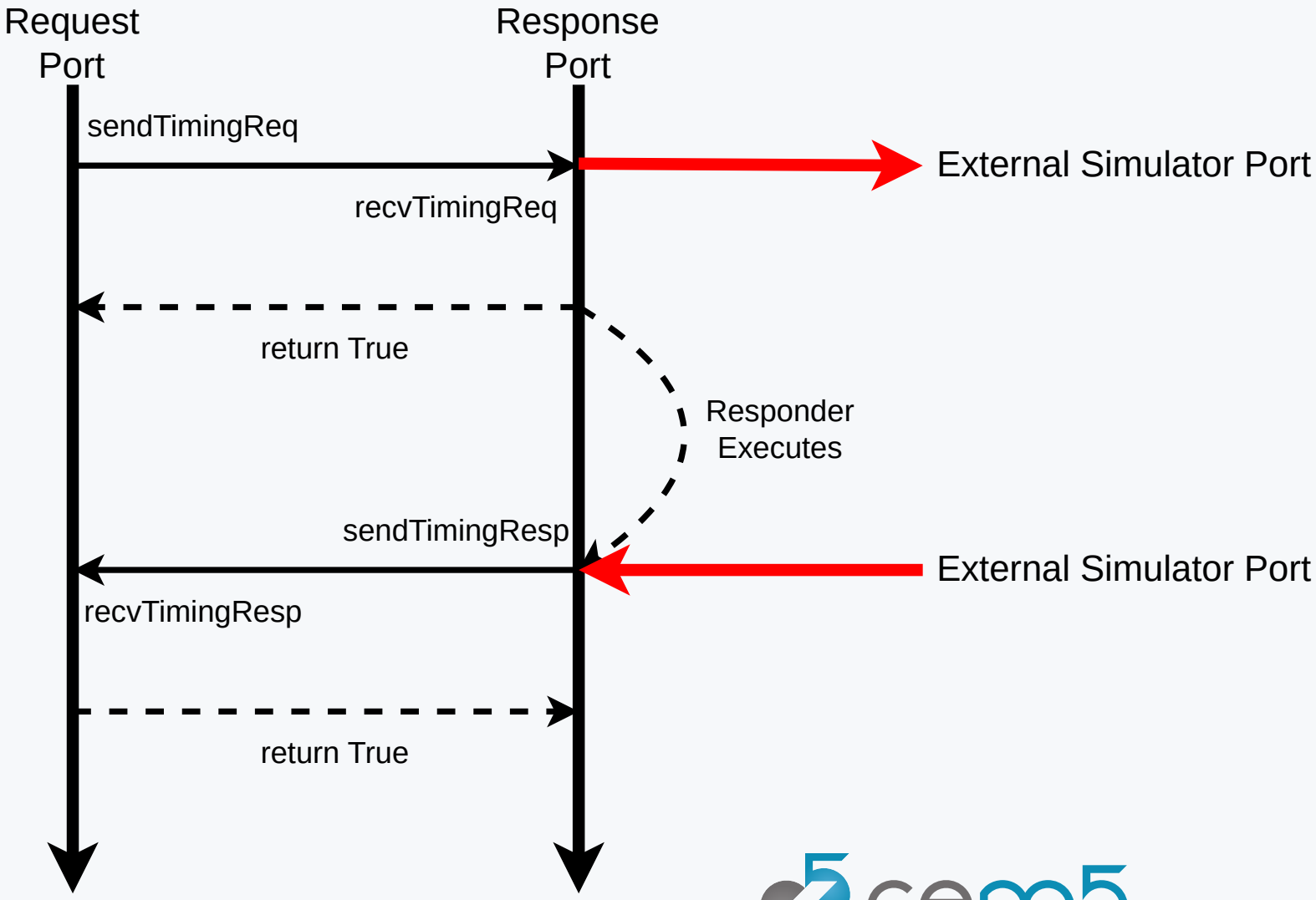
SST: Structural Simulation Toolkit
http://sst-simulator.org/

- A highly parallelized discrete event simulator.
- Consists of:
  - SST-Core (the simulator)
  - SST-Elements (components)
  - SST-Macro

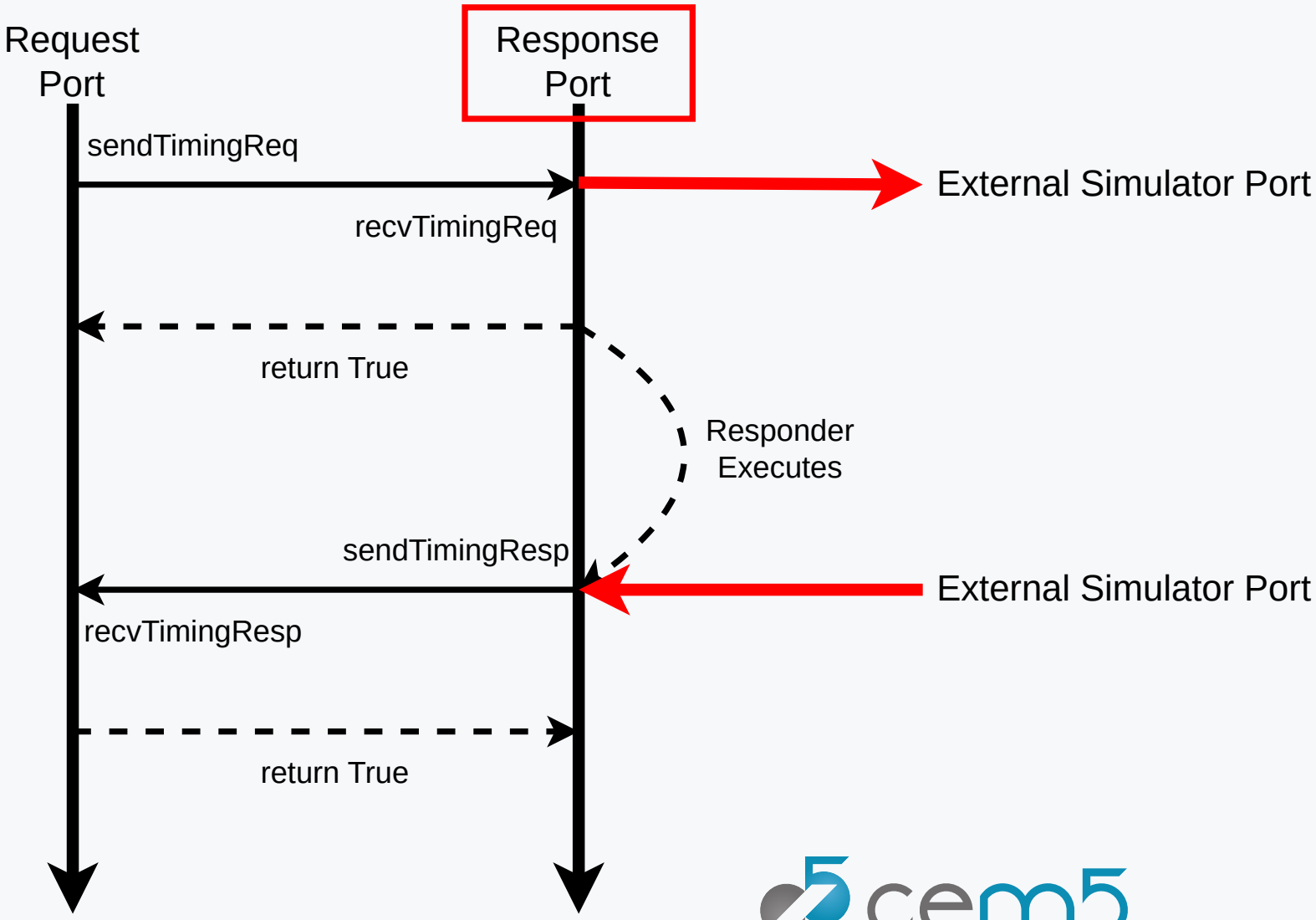
SST: Brief Overview

- Simulation objects:
  - SST::Component (similar to gem5::SimObject)
  - SST::Link (allows two components to send SST::Event to each other)
    - Bidirectional
  - SST::Event (similar to gem5::Event)
    - Sent via SST::Link
- Parallelization,
  - SST partitions components to multiple partitions.
  - Communication between partitions are done via MPI.
  - The partitioning process can be done automatically or manually

gem5/SST Integration



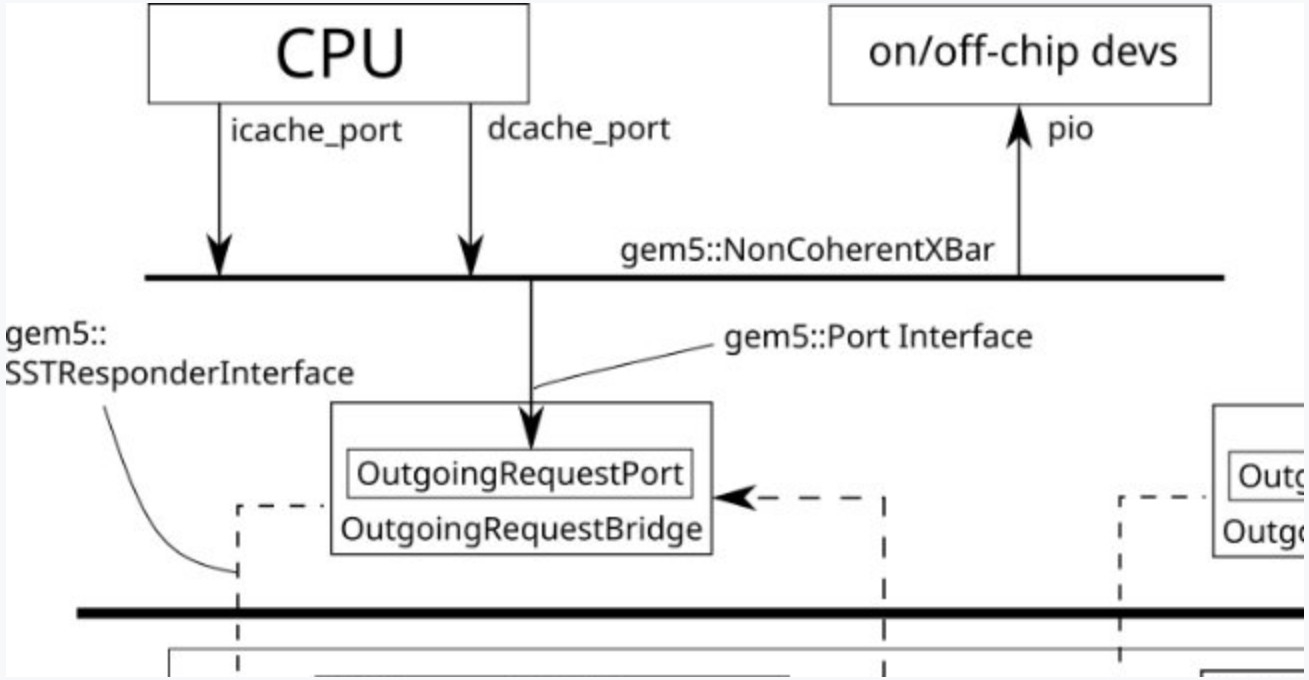
gem5/SST Integration



gem5/SST Integration

- gem5 provides:
  - OutgoingRequestBridge: a Request port sending requests to external components.
  - SSTResponderInterface: an interface for a Response port for an external component.
- gem5 Component is an SST::Component, which has multiple SSTResponder's implementing the SSTReponderInterface.
- The packet translation happens within the gem5 Component.

gem5/SST Integration



gem5/SST Integration

- Example (arm and RISC-V):
  - gem5 as an SST component: gem5/ext/sst/
  - SST system configuration: gem5/ext/sst/sst/example.py
  - gem5 system configuration: gem5/configs/example/sst/riscv_fs.py
- System setup:
  - SST drives the simulation.
  - One gem5 component, which consists of 4 detailed cores.
  - Cache and memory are SST::Components from SST-Elements.

gem5/SST Integration

- System setup:
  - SST drives the full-system simulation.
  - One gem5 component, which consists of 4 detailed cores.
  - Cache and memory are SST::Components from SST-Elements.
- Limitations:
  - gem5 cores wake up frequently per CPU clock tick.
  - The cores are frequently synchronized due to cache coherency protocol.
  - Needs work for block devices to work.

gem5/SST Integration

- However, we can set up multiple-node simulation.
- How?
  - Having multiple gem5 components, each represents a node.
  - Each gem5 component is in a different partition.
  - Communication between gem5 instances can be done via gem5 PIO devices.
- Why?
  - There are more parallelism at the node granularity.

Other Notes

- SST has its own Python environment, so gem5 within SST should not initialize the Python environment again.
- However, the m5 and gem5 libraries should be manually imported.
- m5 library has a function to find SimObject given a SimObject name.
  - Useful for finding the owner for a port in an external simulator.

Documentation

- Setup
  - gem5/ext/sst/README.md
- gem5 interfaces for communication with an external simulator,
  - gem5/src/sst
- gem5 as a component in an external library,
  - gem5/ext/sst
- Compiling the bootloader + kernel + custom workload in a binary,
  - https://gem5.googlesource.com/public/gem5-resources/+/refs/heads/stable/src/riscv-boot-exit-nodisk/README.md