

Debugging and debug flags



We will cover

- How to enable debug flags (examples of DRAM and Exec) [Not doing this]
- `--debug-help`
- Adding a new debug flag
- Functions other than DPRINTF
- Panic/fatal/assert
- gdb? Mahyar's opinion: does not sound interesting or exclusive to gem5 and hard to teach.

DebugFlags: Debugging and Logging in gem5

IMPORTANT: This slide deck builds on top of what has already been developed in [Introduction to SimObjects](#).



DebugFlags

`DebugFlags` help with debug printing. Debug printing is useful for debugging models in gem5 and logging.

Each `DebugFlag` enables printing certain statements within the gem5 code base. Run the following commands to see all the available `DebugFlags` in gem5.

```
cd gem5
./build/NULL/gem5.opt --debug-help
```

This command will show you a list of all the `DebugFlags`. You can choose to use a specific `DebugFlag`, like `Activity`, or you can choose a class of `DebugFlags`, like `Registers`, which will enable the following `DebugFlags`: `IntRegs`, `FloatRegs`, `VecRegs`, `VecPredRegs`, `MatRegs`, `CCRegs`, `MiscRegs`.

In the following slide, you will see the expected output.



```
gem5 git:(v24.0.0.0-0-g43769abaf0) ./build/NULL/gem5.opt --debug-help
```



DebugFlags: HelloExampleFlag

To define a new `DebugFlag` in gem5, you just have to define it in **any** `SConscript` in the gem5 directory. However, it is convention that `DebugFlags` are defined in the same `SConscript` that registers `SimObjects` that are relevant to the `DebugFlag`.

To define a new `DebugFlag` that we will use to print debug/log statement in `HelloSimObject`, open `src/bootcamp/hello-sim-object/SConscript` in your editor of choice and add the following line.

```
DebugFlag("HelloExampleFlag")
```

Adding this line will create a new **auto-generated** header file (with the same name as the `DebugFlag`) that defines the `DebugFlag` in C++.

DebugFlags: Using HelloExampleFlag in Code

One of the functions in gem5 that allows for debug printing is `DPRINTF`, which will let you print a formatted string if a certain `DebugFlag` is enabled (more on how to enable `DebugFlags` later). `DPRINTF` is defined in `src/base/trace.hh`. Make sure to include it every time you want to use `DPRINTF`.

Now let's get to actually adding `HelloExampleFlag` in C++. As I mentioned, the header files for `DebugFlags` are auto-generated. For now, trust that the header file for `HelloExampleFlag` will be in `build/NULL/debug/HelloExampleFlag.hh` when we recompile gem5.

Let's include the header files in `hello_sim_object.cc` by adding the following lines. Remember to follow the conventional order of includes!

```
#include "base/trace.hh"
#include "debug/HelloExampleFlag.hh"
```

Now let's add a simple `DPRINTF` statement inside the constructor of `HelloSimObject` to print `Hello from ...`. Do it by adding the following line after the `for-loop`. **NOTE:** `__func__` will return the name of the function we're in as a string.



```
DPRINTF(HelloExampleFlag, "%s: Hello from HelloSimObject's constructor!\n", __func__);
```

DebugFlags: How Files Look Like

Below is how `src/bootcamp/hello-sim-object/SConscript` should look like after the changes.

```
Import("*")

SimObject("HelloSimObject.py", sim_objects=["HelloSimObject"])

Source("hello_sim_object.cc")

DebugFlag("HelloExampleFlag")
```

Below is how `src/bootcamp/hello-sim-object/hello_sim_object.cc` looks like with changes

Continued

```
#include "bootcamp/hello-sim-object/hello_sim_object.hh"

#include <iostream>

#include "base/trace.hh"
#include "debug/HelloExampleFlag.hh"

namespace gem5
{
    HelloSimObject::HelloSimObject(const HelloSimObjectParams& params):
        SimObject(params)
    {
        for (int i = 0; i < params.num_hellos; i++) {
            std::cout << "i: " << i << ", Hello from HelloSimObject's constructor!" << std::endl;
        }
        DPRINTF(HelloExampleFlag, "%s: Hello from HelloSimObject's constructor!\n", __func__);
    }

} // namespace gem5
```


Let's Recompile

Now, let's recompile gem5 with the command below. After compilation is done, you should be able to find the header file in `build/NULL/debug/HelloExampleFlag.hh`.

```
scons build/NULL/gem5.opt -j$(nproc)
```

Continued on the next slide.

And here is a snippet of the contents of `build/NULL/debug/HelloExampleFlag.hh`.

```
/**
 * DO NOT EDIT THIS FILE!
 * File automatically generated by
 *   build_tools/debugflaghh.py:139
 */

#ifdef __DEBUG_HelloExampleFlag_HH__
#define __DEBUG_HelloExampleFlag_HH__

#include "base/compiler.hh" // For namespace deprecation
#include "base/debug.hh"
namespace gem5
{
    namespace debug
    {
        namespace unions
        {
            inline union HelloExampleFlag
            {
                ~HelloExampleFlag() {}
                SimpleFlag HelloExampleFlag = {
                    "HelloExampleFlag", "", false
                };
            } HelloExampleFlag;
        } // namespace unions
    }

    inline constexpr const auto& HelloExampleFlag =
        ::gem5::debug::unions::HelloExampleFlag.HelloExampleFlag;
} // namespace debug
} // namespace gem5

#endif // __DEBUG_HelloExampleFlag_HH__
```

DebugFlags: After Adding HelloExampleFlag

Now, our `HelloExampleFlag` should be listed whenever we print debug help from gem5. Let's run the following command in the base gem5 directory to verify that our `DebugFlag` is added.

```
./build/NULL/gem5.opt --debug-help
```

Below shows the expected output.

```
GDBExtra: Dump extra information on reads and writes
GDBMisc: Breakpoints, traps, watchpoints, etc.
GDBRead: Reads to the remote address space
GDBRecv: Messages received from the remote application
GDBSend: Messages sent to the remote application
GDBWrite: Writes to the remote address space
GUPSGen:
GarnetSyntheticTraffic:
HMCController:
HWPrefetch:
HWPrefetchQueue:
HelloExample: For Learning gem5 Part 2. Simple example debug flag
HelloExampleFlag:
```

Enabling DebugFlags: Using Configuration Script

To enable a `DebugFlag` you can import `flags` from `m5.debug` and access the flag by indexing `flags`. You can enable and disable flags by calling `enable` and `disable` methods. Below is an example of what your `second-hello-example.py` would look like if you wanted to enable `HelloExampleFlag`. **CAUTION:** Do **not** make this change in your configuration script for now.

```
import m5
from m5.debug import flags
from m5.objects.Root import Root
from m5.objects.HelloSimObject import HelloSimObject

root = Root(full_system=False)
root.hello = HelloSimObject(num_hellos=5)

m5.instantiate()

flags["HelloExampleFlag"].enable()

exit_event = m5.simulate()

print(f"Exited simulation because: {exit_event.getCause()}."
```

Enabling DebugFlags: Using Command Line

Alternatively you can pass `--debug-flags=[comma-separated list of DebugFlags]` to your gem5 binary when running your configuration script. As an example, below is a shell command that you can use to enable `HelloExampleFlag` (like always, run it in the base gem5 directory).

```
./build/NULL/gem5.opt --debug-flags=HelloExampleFlag configs/bootcamp/hello-sim-object/second-hello-example.py
```



Simulate: Without HelloExampleFlag

Now let's simulate `second-hello-example.py` with and without `DebugFlags` and compare the output.

Run the following command to simulate `second-hello-example.py` without `DebugFlags`.

```
./build/NULL/gem5.opt configs/bootcamp/hello-sim-object/second-hello-example.py
```

Below is a recording of my terminal when doing this.

A terminal window with a dark background. The prompt is 'gem5 git:(v24.0.0.0-g43769abaf0)'. The command entered is './build/NULL/gem5.opt configs/bootcamp/hello-sim-object/second-hello-example.py'. The terminal is mostly empty below the command line.

```
gem5 git:(v24.0.0.0-g43769abaf0) ./build/NULL/gem5.opt configs/bootcamp/hello-sim-object/second-hello-example.py
```



Simulate: With HelloExampleFlag

Run the following command to simulate `second-hello-example.py` with `HelloExampleFlag`.

```
./build/NULL/gem5.opt --debug-flags=HelloExampleFlag configs/bootcamp/hello-sim-object/second-hello-example.py
```

Below is a recording of my terminal when doing this.

A terminal window with a dark background. The prompt is 'gem5 git:(v24.0.0.0-0-g43769abaf0)'. The command entered is './build/NULL/gem5.opt --debug-flags=HelloExampleFlag configs/bootcamp/hello-sim-object/second-hello-example.py'. A large white play button icon is centered in the terminal window.

```
gem5 git:(v24.0.0.0-0-g43769abaf0) ./build/NULL/gem5.opt --debug-flags=HelloExampleFlag configs/bootcamp/hello-sim-object/second-hello-example.py
```

Assertions in gem5

I strongly recommend using `assert` and `static_assert` when developing for gem5. They will help you find untrue assumptions you've made, and they will help you find any development mistakes early. `assert` and `static_assert` are standard C++ functions that you can (and are strongly encouraged to) use while developing in gem5.

`fatal`, `fatal_if`, `panic`, and `panic_if` are gem5's specific assert-like functions that allow you to print error messages. gem5 convention is to use `fatal` and `fatal_if` to assert assumptions on user inputs (similar to `ValueError`). As an example, if a user tries to configure your `SimObject` with negative capacity you can use `fatal` or `fatal_if` in your `SimObject` to let the user (most probably yourself) know their mistake. Below shows an example of doing this with `fatal` and `fatal_if`.

```
if (capacity < 0) { fatal("capacity can not be negative.\n"); }  
\\ OR  
fatal_if(capacity < 0, "capacity can not be negative.\n");
```

You should use `panic`, and `panic_if` to catch developer mistakes. We will see some examples in [Ports](#).



Other Debugging Facilities in gem5

- Most `DebugFlags` require that there is a `name()` function in the current scope (called from a `SimObject` member function).
- Only use the `DebugFlags` if you are using `gem5.opt` or `gem5.debug`.

```
DPRINTF(Flag, __VA_ARGS__)
```

- Takes a flag, and a format string + format parameters.
- Prints the formatted string only when the `Flag` is enabled.

```
DPRINTFR(Flag, __VA_ARGS__)
```

- Outputs debug statements without printing a name
- Useful for using debug statements in object that are not `SimObjects` that do not have a `name()` function.

Other Debugging Facilities in gem5

```
DPRINTF5(Flag, SimObject, __VA_ARGS__)
```

- Useful for debugging from private subclass of a `SimObject` that has a pointer to its owner.

```
DPRINTFN(__VA_ARGS__)
```

```
DPRINTFNR(__VA_ARGS__)
```

- These don't take a flag as a parameter, will always print whenever debugging is enabled.

```
DDUMP(Flag, data, count)
```

- Prints binary `data` of length `count` bytes.
- Formatted in user-readable hex.

Learn more at: https://www.gem5.org/documentation/learning_gem5/part2/debugging/

