

Week5 Lab2 Report

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Q1

```
1 $ spack load samtools@1.19.2
2 $ which samtools
```

The output will show the path to the Samtools executable.

```
1 /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/samtools-1.19.2-
  lyfbbdw5hdad4e7pao3waqhawxb5a7gb/bin/samtools
```

Q2

```
1 $ patchelf --print-rpath $(which samtools)
```

```
● scteam01@scteam01a:~$ patchelf --print-rpath $(which samtools)
/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/gcc-runtime-13.3.0-vsx73lx6sjrwmymss5zvpdonyix2trnl5/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2
/gcc-13.3.0/zlib-ng-2.2.3-e4onlbjasu2mm6ipke7lc4g6bsac27ov/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/xz-5.6.3-pizoj2acctlk2yvcuyopy75j7pd
lablu/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/libdeflate-1.18-5iopjd7htixvrr6zupqnof5dlmxmcsx/lib:/opt/spack/opt/spack/linux-ubuntu24.
04-zen2/gcc-13.3.0/bzip2-1.0.8-myxthco2gszsb7b5rajnsgm6m3gjdbld/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/ncurses-6.5-jw2zqmxvqc67ef3cqk
7zruieatsenj7/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/htslib-1.19.1-g3d26wiviyakh4xztqj2ggwjpysh7acqa/lib
```

The output shows the RPATH of the Samtools executable.

```
1 /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/gcc-runtime-13.3.0-
  vsx73lx6sjrwmymss5zvpdonyix2trnl5/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2
  /gcc-13.3.0/zlib-ng-2.2.3-e4onlbjasu2mm6ipke7lc4g6bsac27ov/lib:/opt/spack/opt/
  spack/linux-ubuntu24.04-zen2/gcc-13.3.0/xz-5.6.3-
  pizoj2acctlk2yvcuyopy75j7pdlablu/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2
  /gcc-13.3.0/libdeflate-1.18-5iopjd7htixvrr6zupqnof5dlmxmcsx/lib:/opt/spack/opt/
  spack/linux-ubuntu24.04-zen2/gcc-13.3.0/bzip2-1.0.8-
  myxthco2gszsb7b5rajnsgm6m3gjdbld/lib:/opt/spack/opt/spack/linux-ubuntu24.04-zen2
  /gcc-13.3.0/ncurses-6.5-jw2zqmxvqc67ef3cqk7zruieatsenj7/lib:/opt/spack/opt/
  spack/linux-ubuntu24.04-zen2/gcc-13.3.0/htslib-1.19.1-
  g3d26wiviyakh4xztqj2ggwjpysh7acqa/lib
```

Q3

```
1 $ LD_DEBUG=libs samtools 2>&1 | grep curl
```

```

scteam01@scteam01a:~$ LD_DEBUG=libs samtools 2>&1 | grep curl
709340: find library=libcurl.so.4 [0]; searching
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/htslib-1.19.1-g3d26wivvyakh4xztqj2ggwjpysh7acqa/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/gcc-runtime-13.3.0-vsx73lx6sjrmymss5zvpdonyix2trn15/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/zlib-ng-2.3-e4onlbjasu2mm6ipke7lc4g6bsac27ov/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/xz-5.6.3-pizoj2acctlk2yvcuyopy75j7pdlablu/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/libdeflate-1.18-5iopjd7htixvvr6zupqnof5dlmxcxs/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/bzip2-1.0.8-myxthco2gszsb7b5rajnsgm6m3gjdld/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/gcc-runtime-13.3.0-vsx73lx6sjrmymss5zvpdonyix2trn15/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/zlib-ng-2.3-e4onlbjasu2mm6ipke7lc4g6bsac27ov/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/xz-5.6.3-pizoj2acctlk2yvcuyopy75j7pdlablu/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/libdeflate-1.18-5iopjd7htixvvr6zupqnof5dlmxcxs/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/bzip2-1.0.8-myxthco2gszsb7b5rajnsgm6m3gjdld/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/ncurses-6.5-jw22qmxvqc67ef3cqk7zruieatsenjt7/lib/libcurl.so.4
709340:   trying file=/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/htslib-1.19.1-g3d26wivvyakh4xztqj2ggwjpysh7acqa/lib/libcurl.so.4
709340:   trying file=/opt/openmpi-5.0.7/lib/libcurl.so.4
709340:   trying file=glibc-hwcap/x86-64-v3/libcurl.so.4
709340:   trying file=glibc-hwcap/x86-64-v2/libcurl.so.4
709340:   trying file=libcurl.so.4
709340:   trying file=/lib/x86_64-linux-gnu/libcurl.so.4
709340: calling init: /lib/x86_64-linux-gnu/libcurl.so.4
709340: calling fini: /lib/x86_64-linux-gnu/libcurl.so.4 [0]

```

From the output, we found that the actual loaded path is:

```
1 /lib/x86_64-linux-gnu/libcurl.so.4
```

Q4

```

scteam01@scteam01a:~$ spack location -i curl@8.7.1
/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743t4j4lv5jq4chhdoiiaexzyvy5aubr
scteam01@scteam01a:~$ sudo vim /opt/modules/curl/8.7.1.lua
[sudo] password for scteam01:
scteam01@scteam01a:~$ sudo vim /opt/modules/curl/8.7.1.lua
scteam01@scteam01a:~$ module unload curl/8.7.1
scteam01@scteam01a:~$ module load curl/8.7.1
scteam01@scteam01a:~$ echo $PATH
/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743t4j4lv5jq4chhdoiiaexzyvy5aubr/bin:/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/samtools-1.19.2-lyfbbdw5hdad4e7pao3waqhawxb5a7gb/bin:/opt/spack/bin:/opt/openmpi-5.0.7/bin:/usr/bin:/bin:/home/scteam01/.vscode-server/cli/servers/State-ble-ddc367ed5c8936efe395cfec279b04ffd7db78/server/bin:/remote-cti:/usr/local/sbin:/usr/local/bin:/usr/sbin:/sbin:/usr/games:/usr/local/games:/snap/bin:/home/scteam01/.vscode-server/data/User/globalStorage/github.copilot-chat/debugCommand
scteam01@scteam01a:~$ which curl
/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743t4j4lv5jq4chhdoiiaexzyvy5aubr/bin/curl

```

First, create a Lua-based Lmod modulefile for curl@8.7.1. When loaded, the module performs the following:

- Adds the bin directory of curl@8.7.1 to the PATH, allowing the curl command to be used directly from the terminal.
- Appends the include path to CPATH and the lib path to LIBRARY_PATH, enabling static linking with libcurl.a and access to header files during compilation.
- Prepends the lib path to LD_LIBRARY_PATH, ensuring this version of libcurl.so has priority during dynamic linking.

Below are the commands used to install curl and create the module:

```

1 $ spack install --deprecated curl@8.7.1
2 $ spack location -i curl@8.7.1 # to find the installation path
3 $ sudo vim /opt/modules/curl/8.7.1.lua # to edit the module file
4 $ module use /opt/modules
5 $ module load curl/8.7.1
6 $ echo $PATH # to check if the module is loaded
7 $ which curl

```

The output conforms that the correct version of curl is loaded:

```
1 /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743
  t4j4lv5jq4chhdoiiaexzyvy5aubr/bin/curl
```

Below is the complete content of the /opt/modules/curl/8.7.1.lua modulefile:

```

help([[
This module sets up curl@8.7.1 for CLI usage,
enables static linking, and prioritizes dynamic linking.
]])

whatis("Name: curl")
whatis("Version: 8.7.1")
whatis("Description: curl@8.7.1 with support for static and dynamic linking")

local root = "/opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-
743t4j4lv5jq4chhdoijsaexzyvy5aubr"

-- Allow usage from the command line
prepend_path("PATH", pathJoin(root, "bin"))

-- Static linking
prepend_path("CPATH", pathJoin(root, "include"))           -- for header files
prepend_path("C_INCLUDE_PATH", pathJoin(root, "include"))  -- for C header files
prepend_path("CPLUS_INCLUDE_PATH", pathJoin(root, "include")) -- for C++ header files
prepend_path("LIBRARY_PATH", pathJoin(root, "lib"))         -- for static linking

-- Dynamic linking
prepend_path("LD_LIBRARY_PATH", pathJoin(root, "lib"))      -- for dynamic linking

prepend_path("LDFLAGS", "-L .. pathJoin(root, "lib"))
prepend_path("CPPFLAGS", "-I .. pathJoin(root, "include"))

```

Q5

To remove the embedded RPATH from the Samtools binary, we can use the `patchelf` command.

```
1 $ patchelf --remove-rpath $(which samtools)
```

This command removes the RPATH from the Samtools executable. After executing this command, the RPATH will be empty.

```
1 $ patchelf --print-rpath $(which samtools)
2 (empty output)
```

Q6

```
1 $ module load curl/8.7.1
2 $ LD_DEBUG=libs samtools 2>&1 | grep curl
```

The output showed:

```

1 ...
2 calling init: /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743
  t4j4lv5jq4chhdoijsaexzyvy5aubr/lib/libcurl.so.4
3 calling fini: /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743
  t4j4lv5jq4chhdoijsaexzyvy5aubr/lib/libcurl.so.4 [0]

```

```

821695: calling init: /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743t4j4lv5jq4chhdoijsaexzyvy5aubr/lib/libcurl.so.4
821695: calling fini: /opt/spack/opt/spack/linux-ubuntu24.04-zen2/gcc-13.3.0/curl-8.7.1-743t4j4lv5jq4chhdoijsaexzyvy5aubr/lib/libcurl.so.4 [0]

```

After loading our curl/8.7.1 module, Samtools is now using the Spack-installed curl library instead of the system one we saw in Q3. This happens because our module prepends the Spack curl library path to the `LD_LIBRARY_PATH` environment variable. The dynamic linker now searches directories in the `LD_LIBRARY_PATH` before looking in system directories, leading it to find and load our specified curl library first.