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Ookami User Group Meeting

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How to tell compilers to optimize for A64FX on Ookami

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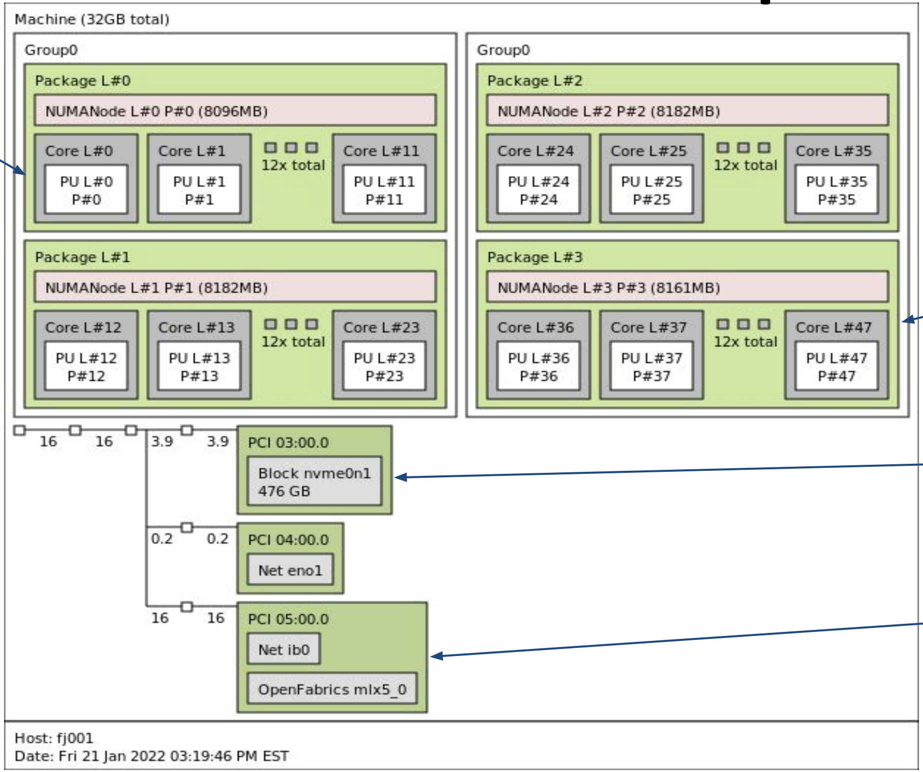
OUGM: Compilers

- A walk-through of the info in the Ookami FAQ
  - https://www.stonybrook.edu/commcms/ookami/support/faq/Vectorization_Flags
- How to tell compilers to generate a64fx code
  - SVE = Scalar Vector Extensions
- For C, C++, and Fortran

OUGM: Compilers

A64FX 700 architecture



CMG #0

CMG #3

Local disk for OS (SBU addition)

Infiniband

OUGM: Compilers

- N.B. login nodes vs. compute nodes
  - Login nodes are ARM, but ThunderX2
    - Many more cores, much more memory
  - You can compile for a64fx on them, but they cannot run that code

```
login1$ ./a.out
Illegal instruction (core dumped)
```

OUGM: Compilers

- GNU Compilers

gcc, g++, gfortran

  - GCC = **G**NU **C**ompiler **C**ollection
    - Originally GCC = only GNU C compiler
    - Now also added C++, Fortran, Go, Ada, D, …
  - A64fx vectorization supported from v 10.x
    - Latest release is 11.2.0

OUGM: Compilers

armclang, armclang++, armflang

- ARM Compilers
  - C, C++, Fortran
  - Fork from LLVM 12 with …
    - … vendor-added vectorization
    - Optimized math library (ARMPL)
  - ARM are now upstreaming their changes to LLVM
    - In github, *guessing* will be in release 14.0.0

OUGM: Compilers

- HPE/Cray Compilers
  - Storied HPC compiler chain
    - 2 available
      - 1 with SVE support
      - 1 without (version of LLVM)
  - SVE version has support for a64fx
  - Optimized math library (scilib)

cc, CC, ftn

OUGM: Compilers

- Fujitsu Compilers
  - Vendor of a64fx chip
  - Compiler has long history (SPARC)
  - Strong optimizations for a64fx
    - Tuning environment variables for data layout
  - Scientific Subroutine Library (SSL) math library
  - Also provides MPI implementation
    - Based on Open-MPI 4.0

fcc, FCC, frt

mpifcc, mpiFCC, mpifrt

OUGM: Compilers

- NVIDIA (formerly PGI) Compilers
  - Generally intended for GPU systems
    - Can be used on both x86_64 and aarch64
  - No SVE vectorization at present

nvc, nvc++, nvfortran

OUGM: Compilers

- Summary
  - Matrix of compilers and important options
    - https://www.stonybrook.edu/commcms/ookami/support/faq/Vectorization_Flags
  - Get the compilers to tell you what they are (or are not) doing
  - Quick examples coming up…

OUGM: Compilers

- Example: GNU

Quick check for SVE instructions!

```
fj-debug1$ module add gcc/11.2.0

fj-debug1$ gcc -fopenmp -O3 -mcpu=a64fx loop.c -lm

fj-debug1$ objdump -d a.out | grep 'z[0-9]'

  400728:   85c0e004   ld1rd {z4.d}, p0/z, [x0]
  400740:   a54046c0   ld1w  {z0.s}, p1/z, [x22, x0, lsl #2]
  400744:   a54046e2   ld1w  {z2.s}, p1/z, [x23, x0, lsl #2]
  400748:   05a06001   zip1  z1.s, z0.s, z0.s
  …
  400774:   65caa000   fcvt  z0.s, p0/m, z0.d
  400778:   05a06820   uzp1  z0.s, z1.s, z0.s
  40077c:   e5404420   st1w  {z0.s}, p1, [x1, x0, lsl #2]
```

OUGM: Compilers

- Example: ARM

```
fj-debug1$ module load arm-modules/21.1

fj-debug1$ armclang -fopenmp -O3 -mcpu=a64fx -armpl loop.c

fj-debug1$ objdump -d a.out | grep 'z[0-9]'

  400918:  05282000   mov  z0.d, d0
  400930:  a54d4921   ld1w {z1.s}, p2/z, [x9, x13, lsl #2]
  400934:  a54d4943   ld1w {z3.s}, p2/z, [x10, x13, lsl #2]
  400938:  05f23822   uunpklo    z2.d, z1.s
  …
  400abc:  65caa042   fcvt z2.s, p0/m, z2.d
  400ac0:  05a16841   uzp1 z1.s, z2.s, z1.s
  400ac4:  e540e5c1   st1w {z1.s}, p1, [x14]
```

OUGM: Compilers

- Example: HPE/Cray

```
fj-debug1$ module load CPE

fj-debug1$ cc -h omp -h msgs -O3 -h vector3 loop.c

…

CC-6005 craycc: SCALAR File = loop.c, Line = 35
  A loop was unrolled 4 times.


CC-6204 craycc: VECTOR File = loop.c, Line = 35
  A loop was vectorized.
```

```
fj-debug1$ objdump -d a.out | grep 'z[0-9]'

  400bfc:       05a08000        mov     z0.s, p0/m, s0
  400c0c:       a540a221        ld1w    {z1.s}, p0/z, [x17]
  …
  400c28:       a54f4210        ld1w    {z16.s}, p0/z, [x16, x15, lsl #2]
  400c2c:       65a10002        fmla    z2.s, p0/m, z0.s, z1.s
  400c30:       65a30004        fmla    z4.s, p0/m, z0.s, z3.s
  …
  400c50:       e54f4210        st1w    {z16.s}, p0, [x16, x15, lsl #2]
```

OUGM: Compilers

- Example: Fujitsu

```
fj-debug1$ module add fujitsu/compiler

fj-debug1$ fcc -Kfast -Kopenmp -KSVE -SSL2BLAMP loop.c

fj-debug1$ objdump -d a.out | grep 'z[0-9]'

  40109c:  04d5a231   uxtw  z17.d, p0/m, z17.d
  …
  4010cc:  c574c041   ld1w  {z1.d}, p0/z, [x2, z20.d, lsl #2]
  …
  4010e8:  c577c07d   ld1w  {z29.d}, p0/z, [x3, z23.d, lsl #2]
  4010ec:  05a0395e   mov   z30.s, w10
  4010f0:  05a038e8   mov   z8.s, w7
```

Important! https://www.stonybrook.edu/commcms/ookami/support/faq/ookami-fujitsu-compilers

OUGM: Compilers

- Wrap-up
  - Which compiler is right for me?
    - Sadly, no magic bullet
      - We're all learning as we go…
    - Fujitsu and HPE/Cray often produce good code
      - But do not play well with cmake/autoconf
    - ARM and GCC can also generate good code
      - But play better with cmake/autoconf

OUGM: Compilers

- Wrap-up
  - Got questions?
    - Come to office hours Zoom, and/or Slack channel, and ask!
      - OpenMP
      - MPI
      - Compilation / Configuration
      - Performance
      - Interconnect
      - … https://www.stonybrook.edu/commcms/ookami/support/index.php