# 과제 #1

M1522.006700 확장형 고성능 컴퓨팅 (001)
2022-29677 한주희

## 1. Compilation Process

### 1.1. Preprocessing

(a) `/user/include/math.h`: 1341
`/user/include/stdio.h`: 875

(b)
```
extern int scanf (const char *__restrict __format, ...) ;
extern int printf (const char *__restrict __format, ...);
extern double sqrt (double __x) __attribute__ ((__nothrow__ ,
__leaf__)); extern double __sqrt (double __x) __attribute__
((__nothrow__ , __leaf__));
```

(c) 실제 구현이 들어있지 않다. 전처리 단계에서는 해당 함수들의 선언부만 포함되기 때문이다. 구현부는 컴파일 후 링킹 단계에 포함된다.

### 1.2. Compilation

(a) `$ gcc -c sqrt.c -o sqrt.o`

(b) ELF 포맷
```
$ file sqrt.o
>> sqrt.o: ELF 64-bit LSB relocatable, x86-64, version 1
(SYSV), not stripped
```

### 1.3. Linking

(a) `sqrt.o` 파일이 `sqrt` 함수를 사용하고 있는데, `sqrt` 함수의 위치를 알 수 없기 때문에 에러가 발생한다. `sqrt` 함수가 포함된 라이브러리를 링크해야 한다. 즉, `gcc`가 `sqrt` 함수의 구현을 찾지 못했기 때문에 발생한 것이다.

이 문제를 해결하기 위해서는 수학 라이브러리를 명시적으로 링크해야 한다. 이를 위해 `-lm` 옵션을 사용하여 `libm`을 링크한다.
```
$ gcc sqrt.o -lm -o sqrt
```

(b)
```
shpc152@elogin3:~/hw1/sqrt$ ./sqrt 2500
50.00000000
```

## 2. C Programming

### 2.1. Shift

(a) `1111 1111 1111 1111 1111 1111 1111 0000`

(b) `1111 1111 1111 1111 1111 1111 1111 1100`

(c) `0011 1111 1111 1111 1111 1111 1111 1100`

(d) Arithmetic Shift는 부호 비트를 유지하는 반면, Logical Shift는 부호 비트를 무시하고 단순히 비트를 이동시킨다.

- `a >> 2` (Arithmetic Shift): a = -16 (음수)인 경우, 부호 비트가 1로 보존하면서 값을 오른쪽으로 이동시킴
  `1111 1111 1111 1111 1111 1111 1111 1100`
- `ua >> 2` (Logical Shift): 단순히 비트를 오른쪽으로 이동시키고, 최상위 비트는 항상 0으로 채움
  `0011 1111 1111 1111 1111 1111 1111 1100`

## 3. 클러스터 사용 연습

(a)

---

```
shpc152@elogin3:~/hw1/sqrt$ sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
class1       up       5:00      1    mix a04
class1       up       5:00      8  alloc a[00-03,05-07,10]
class1       up       5:00      3   idle a[08-09,11]
```

---

명령어

- `sinfo`: 노드 현황 확인

출력

- PARTITION: Name of a partition.
- AVAIL: Partition state. Can be either up, down, drain, or inact (for INACTIVE).
- TIMELIMIT: Maximum time limit for any user job in days-hours:minutes:seconds. infinite is used to identify partitions without a job time limit.
- NODES: Number of nodes.
- STATE: State of the nodes. Possible states include: allocated, blocked, completing, down, drained, draining, fail, failing, future, idle, maint, mixed, perfctrs, planned, power_down, power_up, reserved, and unknown. Their abbreviated forms are: alloc, block, comp, down, drain, drng, fail, failg, futr, idle, maint, mix, npc, plnd, pow_dn, pow_up, resv, and unk respectively.
- NODELIST: List of node names.

(b)

---

```
shpc152@elogin3:~/hw1/sqrt$ squeue
             JOBID PARTITION     NAME     USER ST       TIME
NODES NODELIST(REASON)
```

---

명령어

- `squeue`: 제출된 작업 목록 확인

출력

- JOBID: This will have a unique value for each element of job arrays and each component of heterogeneous jobs. (Valid for jobs only)
- PARTITION: Partition of the job or job step. (Valid for jobs and job steps)
- NAME: Job or job step name. (Valid for jobs and job steps)
- USER:The name of the user who submitted the job.
- ST:The state of the job.
  - **PD**: Pending (waiting for resources or other conditions).
  - **R**: Running.
  - **CG**: Completing (job is finishing up).
  - **CD**: Completed.
  - **F**: Failed.
  - **CA**: Cancelled.
  - **TO**: Timeout (job ran longer than its time limit).
- TIME: The time the job has been running.
- NODES: The number of nodes allocated to the job.
- NODELIST:  The list of nodes the job is running on, or, if the job is pending, the reason for why it is pending (e.g., Resources, Dependency, Priority, etc.).

(c)

---

```
$ shpc152@elogin3:~/hw1/sqrt$ srun -N 2 hostname
srun: job 822264 queued and waiting for resources
srun: job 822264 has been allocated resources
a09
a08
```

---

명령어

- `srun`: 작업 요청 및 대기
- `srun -N 2 hostname`: 2개의 노드를 할당받아 각각의 노드에서 hostname 명령어를 실행

출력

- srun: job 822264 queued and waiting for resources: 작업(job) 번호 822264가 제출되었으며, 자원이 할당되기를 기다리고 있음
- srun: job 822264 has been allocated resources: 작업에 필요한 자원이 할당
- a09, a08: 할당된 두 노드에서 실행된 hostname 명령어의 출력
    - 각 노드의 호스트 이름을 나타내며, a09와 a08은 작업이 실행된 두 노드의 이름

(d)

---

```
$ shpc152@elogin3:~/hw1/sqrt$ lscpu
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   46 bits physical, 48 bits
virtual
CPU(s):                          32
On-line CPU(s) list:             0-31
Thread(s) per core:              2
Core(s) per socket:              8
Socket(s):                       2
NUMA node(s):                    2
Vendor ID:                       GenuineIntel
CPU family:                      6
Model:                           79
Model name:                      Intel(R) Xeon(R) CPU E5-2620
v4 @ 2.10GHz
Stepping:                        1
CPU MHz:                         1203.265
CPU max MHz:                     3000.0000
CPU min MHz:                     1200.0000
BogoMIPS:                        4199.96
Virtualization:                  VT-x
L1d cache:                       512 KiB
L1i cache:                       512 KiB
L2 cache:                        4 MiB
L3 cache:                        40 MiB
NUMA node0 CPU(s):               0-7,16-23
NUMA node1 CPU(s):               8-15,24-31
Vulnerability Itlb multihit:     KVM: Mitigation: Split huge
pages
Vulnerability L1tf:              Mitigation; PTE Inversion;
VMX conditional cache flushes, SMT vulner
                                 able
Vulnerability Mds:               Mitigation; Clear CPU
buffers; SMT vulnerable
```

```
Vulnerability Meltdown:          Mitigation; PTI
Vulnerability Spec store bypass: Mitigation; Speculative Store
Bypass disabled via prctl and seccomp
Vulnerability Spectre v1:        Mitigation; usercopy/swapgs
barriers and __user pointer sanitization
Vulnerability Spectre v2:        Mitigation; Full generic
retpoline, IBPB conditional, IBRS_FW, STIBP
                                  conditional, RSB filling
Vulnerability Srbds:             Not affected
Vulnerability Tsx async abort:   Mitigation; Clear CPU
buffers; SMT vulnerable
Flags:                           fpu vme de pse tsc msr pae
mce cx8 apic sep mtrr pge mca cmov pat ps e36 clflush dts acpi
mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm
constant_tsc arch_perfmon pebs bts rep_good nopl xtopology
nonstop_tsc cpuid aperfmperf pni pclmulqdq dtes64 monitor
ds_cpl vmx smx est tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid dca
sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes xsave
avx f16c rdrand lahf_lm abm 3dnowprefetch cpuid_fault epb
cat_l3 cdp_l3 invpcid_single pti intel_ppin ssbd ibrs ibpb
stibp tpr_shadow vnmi flexpriority ept vpid ept_ad fsgsbase
tsc_adjust bmi1 hle avx2 smep bmi2 erms invpcid rtm cqm rdt_a
rdseed adx smap intel_pt xsaveopt cqm_llc cqm_occup_llc
cqm_mbm_total cqm_mbm_local dtherm ida arat pln pts md_clear
flush_l1d
```

---

```
$ shpc152@elogin3:~/hw1/sqrt$ srun -N 1 lscpu
srun: job 822265 queued and waiting for resources
srun: job 822265 has been allocated resources
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   46 bits physical, 48 bits
virtual
CPU(s):                          64
On-line CPU(s) list:             0-63
Thread(s) per core:              2
Core(s) per socket:              16
Socket(s):                       2
NUMA node(s):                    2
Vendor ID:                       GenuineIntel
CPU family:                      6
Model:                           85
Model name:                      Intel(R) Xeon(R) Silver 4216
CPU @ 2.10GHz
```

```
Stepping:                        7
CPU MHz:                         866.616
CPU max MHz:                     3200.0000
CPU min MHz:                     800.0000
BogoMIPS:                        4200.00
Virtualization:                  VT-x
L1d cache:                       1 MiB
L1i cache:                       1 MiB
L2 cache:                        32 MiB
L3 cache:                        44 MiB
NUMA node0 CPU(s):               0-15,32-47
NUMA node1 CPU(s):               16-31,48-63
Vulnerability Itlb multihit:     KVM: Mitigation: Split huge
pages
Vulnerability L1tf:              Not affected
Vulnerability Mds:               Not affected
Vulnerability Meltdown:          Not affected
Vulnerability Spec store bypass: Mitigation; Speculative Store
Bypass disabled via prctl and seccomp
Vulnerability Spectre v1:        Mitigation; usercopy/swapgs
barriers and __user pointer sanitization
Vulnerability Spectre v2:        Mitigation; Enhanced IBRS,
IBPB conditional, RSB filling
Vulnerability Srbds:             Not affected
Vulnerability Tsx async abort:   Mitigation; TSX disabled
Flags:                           fpu vme de pse tsc msr pae
mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts acpi
mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm
constant_tsc art arch_perfmon pebs bts rep_good nopl xtopology
nonstop_tsc cpuid aperfmperf pni pclmulqdq dtes64 monitor
ds_cpl vmx smx est tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid dca
sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes xsave
avx f16c rdrand lahf_lm abm 3dnowprefetch cpuid_fault epb
cat_l3 cdp_l3 invpcid_single intel_ppin ssbd mba ibrs ibpb
stibp ibrs_enhanced tpr_shadow vnmi flexpriority ept vpid
ept_ad fsgsbase tsc_adjust bmi1 avx2 smep bmi2 erms invpcid
cqm mpx rdt_a avx512f avx512dq rdseed adx smap clflushopt clwb
intel_pt avx512cd avx512bw avx512vl xsaveopt xsavec xgetbv1
xsaves cqm_llc cqm_occup_llc cqm_mbm_total cqm_mbm_local
dtherm ida arat pln pts pku ospke avx512_vnni md_clear
flush_l1d arch_capabilities
```

---

명령어 출력

- `lscpu`:

lscpu 명령어는 현재 시스템의 CPU 정보를 출력하는 유틸리티다. 이 경우, 로그인 노드에서 명령을 실행한 결과로, CPU가 32개임을 보여준다.CPU 모델은 Intel Xeon E5-2620 v4로, 2.10GHz의 최대 속도를 가진다.

- `srun -N 1 lscpu`:
  srun -N 1 lscpu 명령어는 SLURM 스케줄러를 사용해 계산 노드 중 하나를 할당받아 그 노드에서 lscpu 명령을 실행한 것이다. 결과는 계산 노드에서 실행된 것으로, 이 노드는 64개의 CPU를 가지고 있으며, Intel Xeon Silver 4216 CPU를 사용하고 있음을 보여준다.

두 명령의 출력이 다른 이유

- 두 명령의 출력이 다른 이유는 로그인 노드와 계산 노드의 하드웨어 구성 차이 때문이다.