

Problem 1

Model:
$$\frac{\text{average cycle}}{\text{word access}} = f_c \cdot \frac{\text{cache cycle}}{\text{word access}} + (1 - f_c) \frac{\text{main mem. cycle}}{\text{word access}}$$

a) $f_c = 99\% = 0.99$

$$\therefore \frac{\text{avg. cycle}}{\text{word access}} = 0.99 \times \frac{2 \text{ cycles}}{\text{word}} + (1 - 0.99) \frac{100 \text{ cycles}}{\text{word}}$$

$$\therefore \frac{\text{avg. cycle}}{\text{word}} = (1.98 + 1) \frac{\text{cycles}}{\text{word}}$$

$$\therefore \frac{\text{avg cycle}}{\text{word}} = 2.98 \frac{\text{cycles}}{\text{word}}$$

$$S_{\text{WM}} = \frac{\text{floating point ops.}}{\text{memory access}}; \text{ processor} = 2 \text{ GHz} = 2 \times 10^9 \text{ cycles/sec.}$$

Predicted

$$\therefore \text{Peak performance} = \frac{\text{processor speed} \times S_{\text{WM}}}{\text{avg. cycle}}$$
$$= \frac{2 \times 10^9 \times 2}{2.98} = 1.34 \times 10^9 \text{ FLOPS}$$
$$= \underline{1.34 \text{ giga FLOPS}}$$

$$f_c = 1\% = 0.01$$

$$\Rightarrow \frac{\text{avg cycle}}{\text{word}} = 0.01 \times 2 + 0.99 \times 100 = 99.02 \frac{\text{cycles}}{\text{word}}$$

Predicted

$$\therefore \text{Peak performance} = \frac{2 \times 10^9 \times 2}{99.02} = 0.04 \times 10^9 \text{ FLOPS}$$
$$= \underline{40 \text{ mega FLOPS}}$$



Problem 2

Sample Batch script:

```
#!/bin/sh
##SBATCH --partition=general-compute
#SBATCH --time=00:05:00
#SBATCH --nodes=1
#SBATCH --ntasks-per-node=1
#SBATCH --constraint=CPU-L5520
##SBATCH --mem=24000
# Memory per node specification is in MB. It is optional.
# The default limit is 3GB per core.
#SBATCH --job-name="hw1-8node"
#SBATCH --output=hw1-8-ibm.out
#SBATCH --mail-user=npaliwal@buffalo.edu
#SBATCH --mail-type=END
##SBATCH --requeue
#Specifies that the job will be requeued after a node failure.
#The default is that the job will not be requeued.

echo "SLURM_JOBID"=$SLURM_JOBID
echo "SLURM_JOB_NODELIST"=$SLURM_JOB_NODELIST
echo "SLURM_NNODES"=$SLURM_NNODES
echo "SLURMTMPDIR"=$SLURMTMPDIR

cd $SLURM_SUBMIT_DIR
echo "working directory = "$SLURM_SUBMIT_DIR

srun lstopo --whole-system topo-8nodes.pdf

echo "All Done!"
```

Output files:

8 Node

```
SLURM_JOBID=436866
SLURM_JOB_NODELIST=d07n40s01
SLURM_NNODES=1
SLURMTMPDIR=/scratch/436866
working directory = /ifs/user/npaliwal/hw1
All Done!
```

12 Node

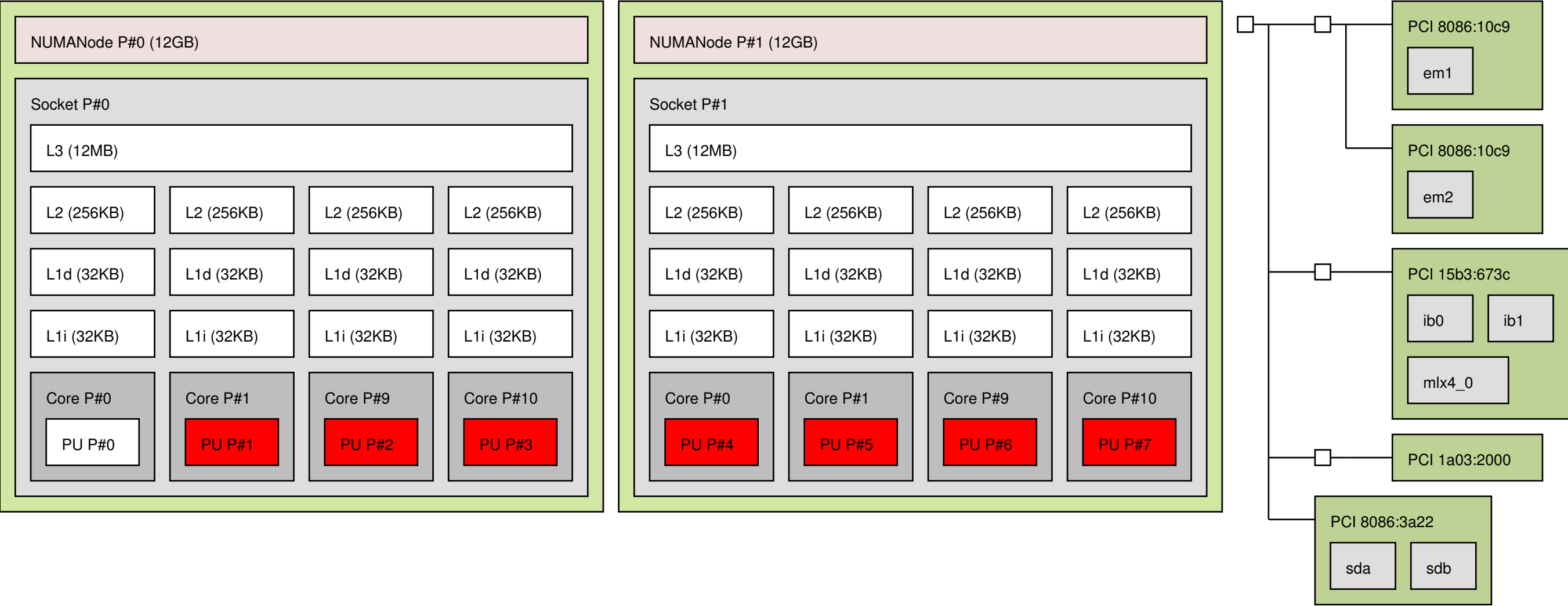
```
SLURM_JOBID=436825
SLURM_JOB_NODELIST=k08n16s02
SLURM_NNODES=1
SLURMTMPDIR=/scratch/436825
working directory = /ifs/user/npaliwal/hw1
All Done!
```

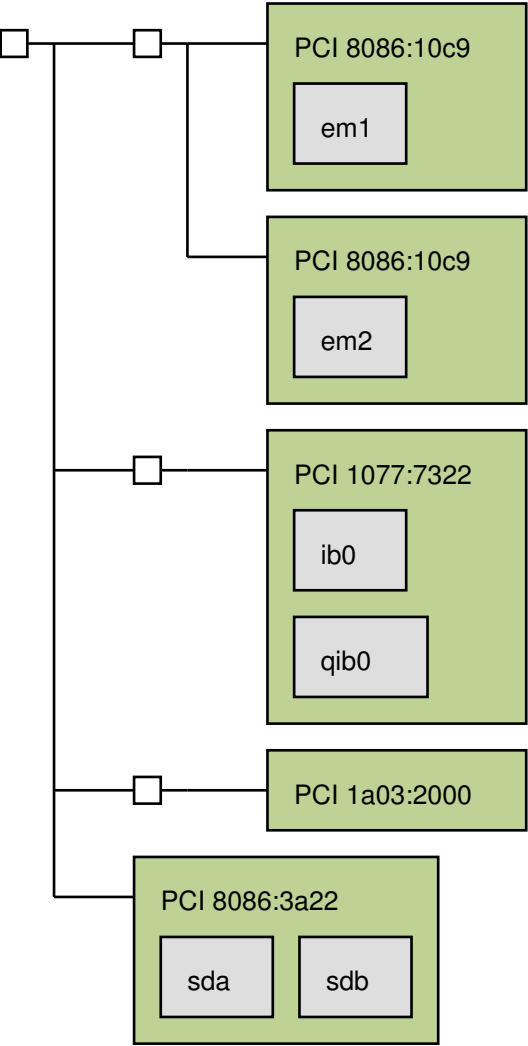
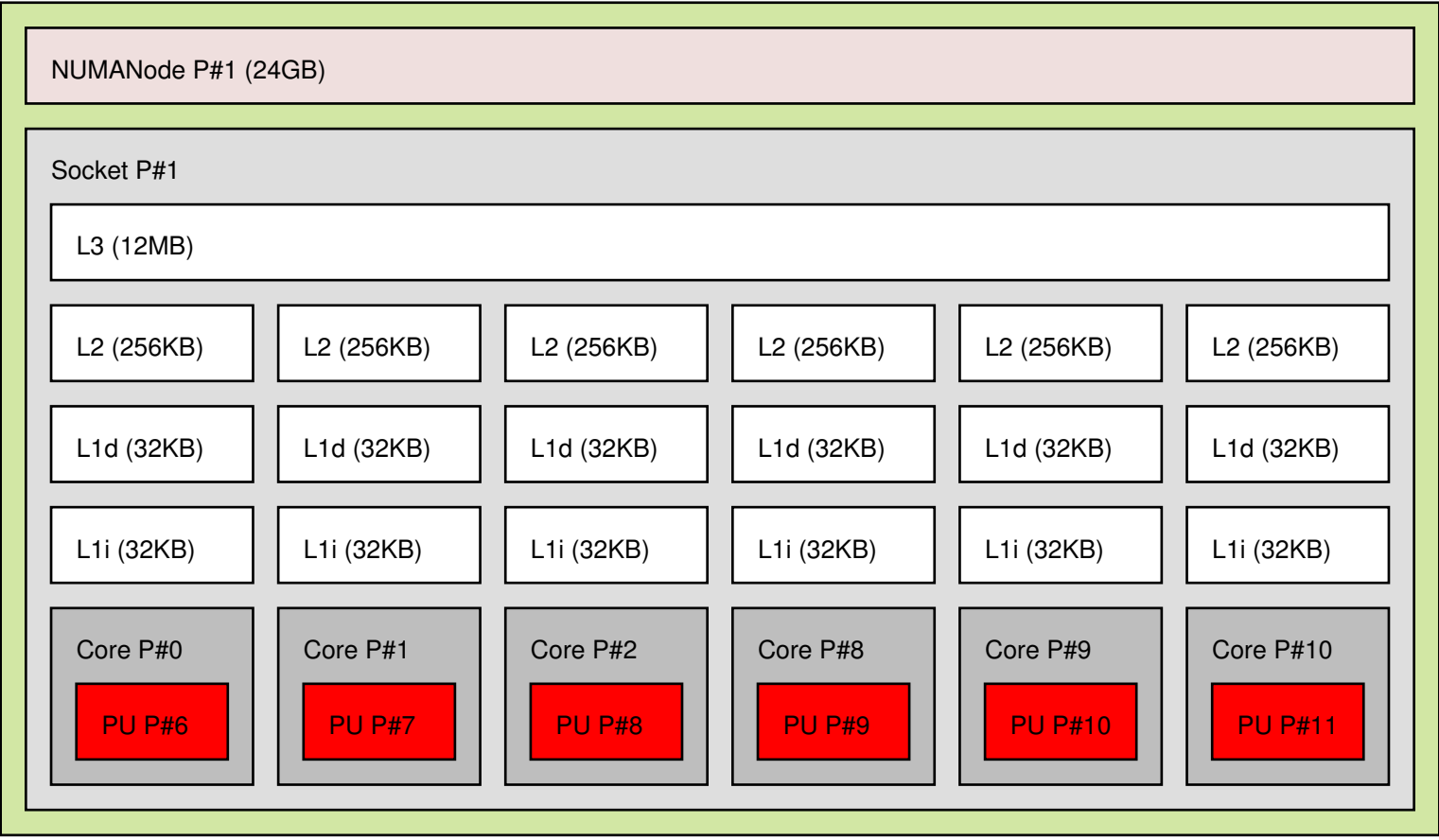
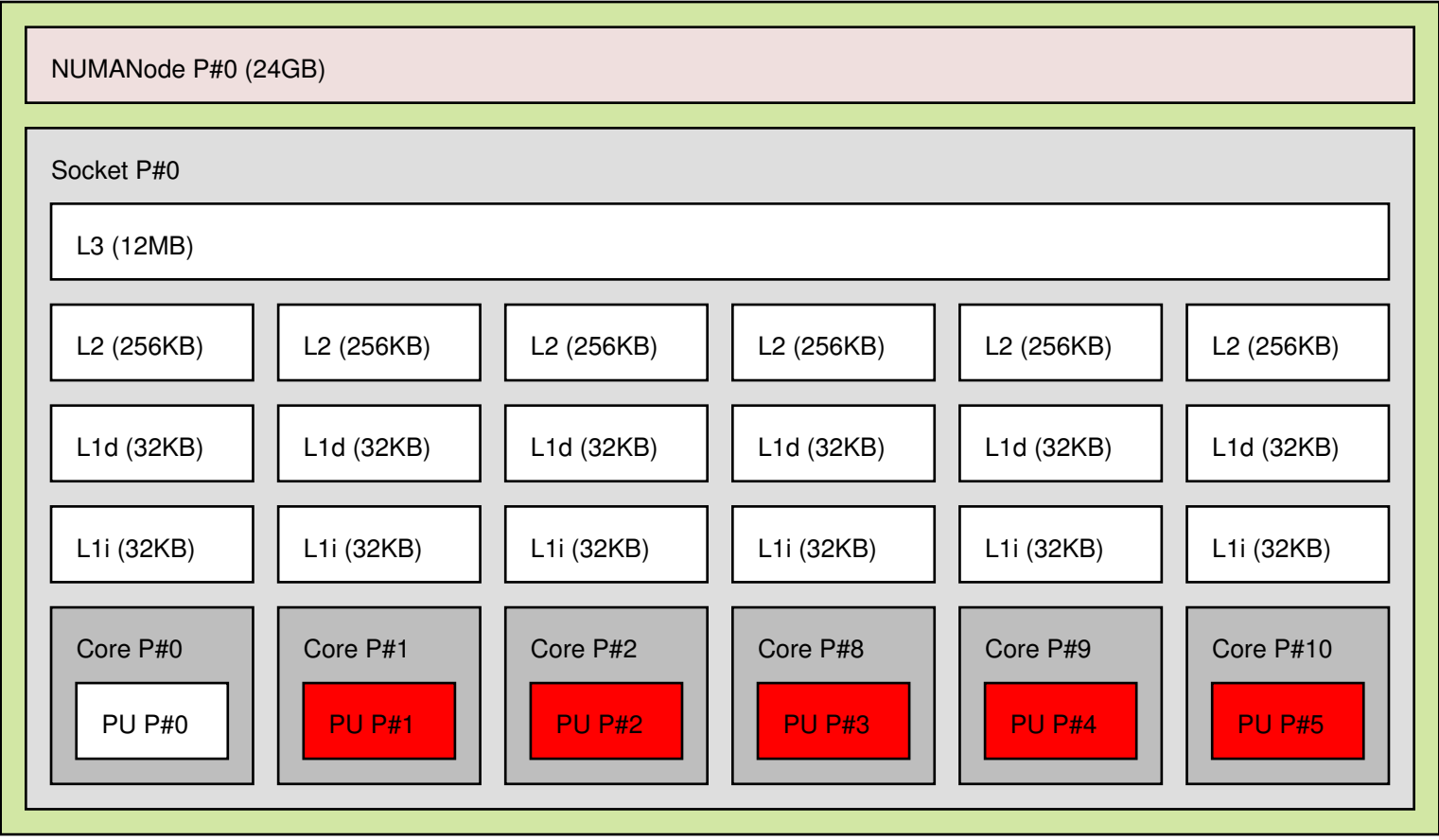
32 Node AMD

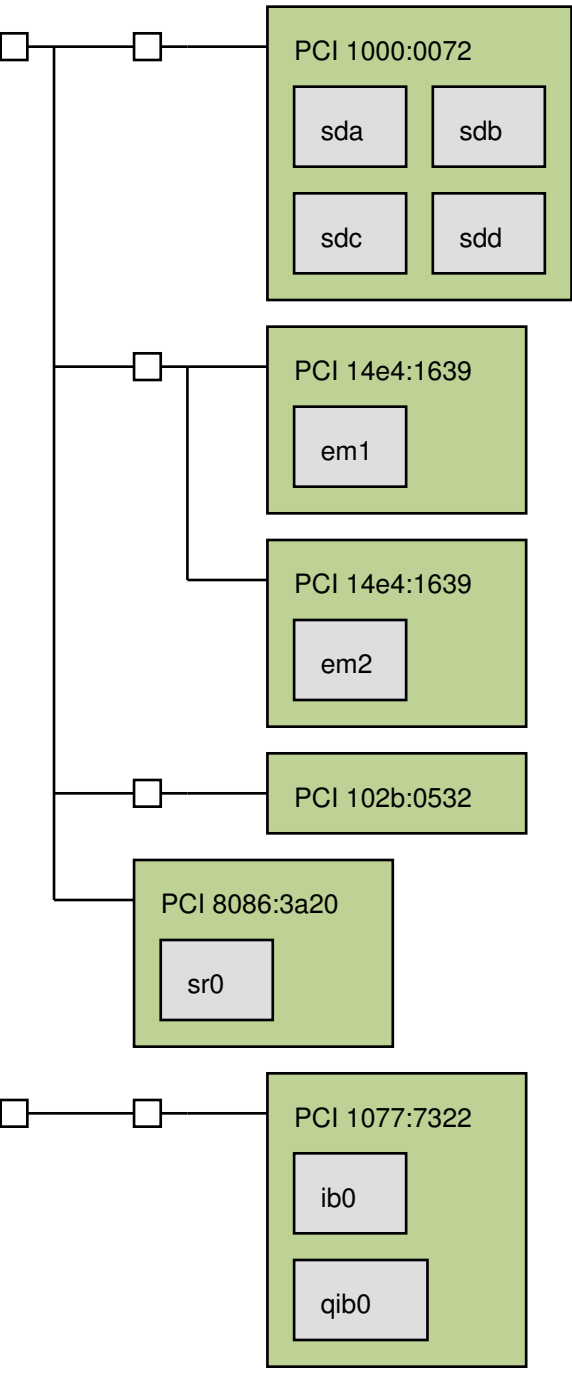
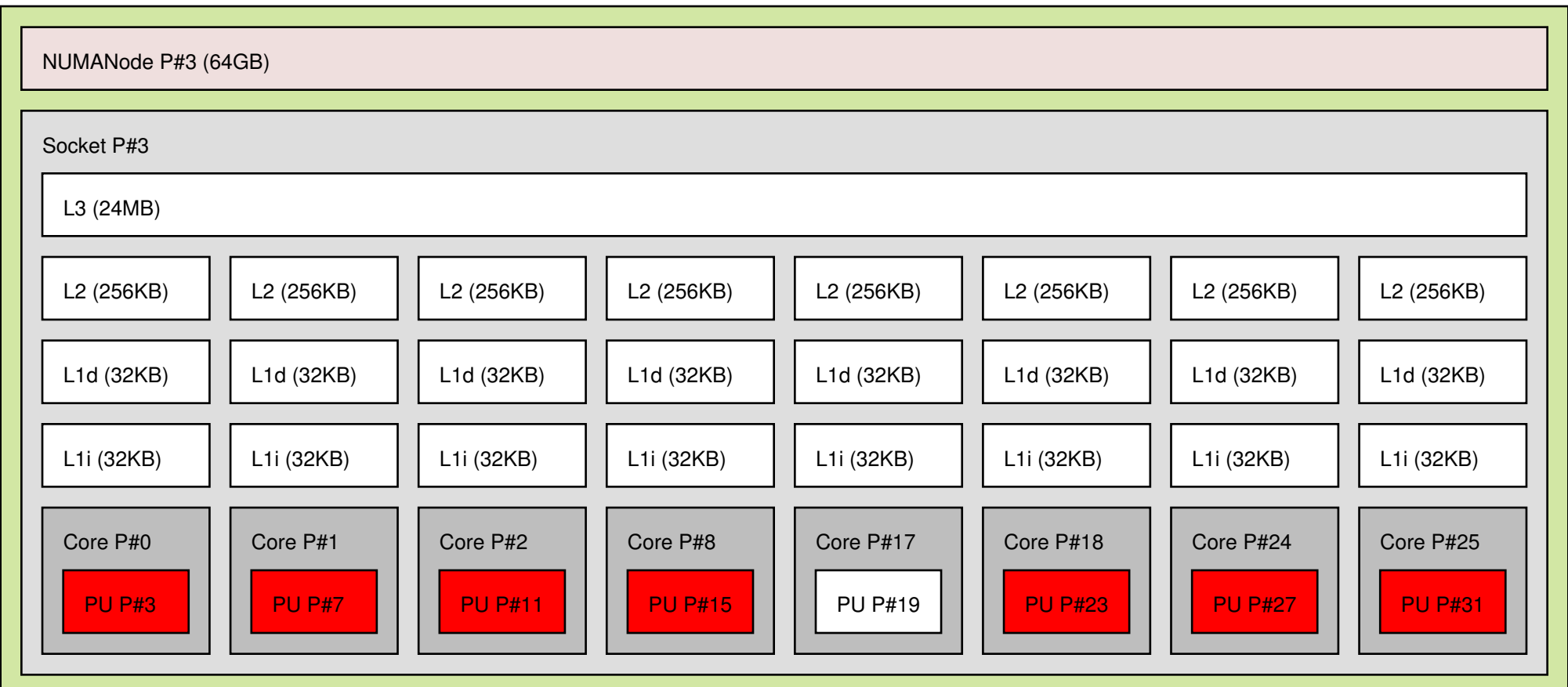
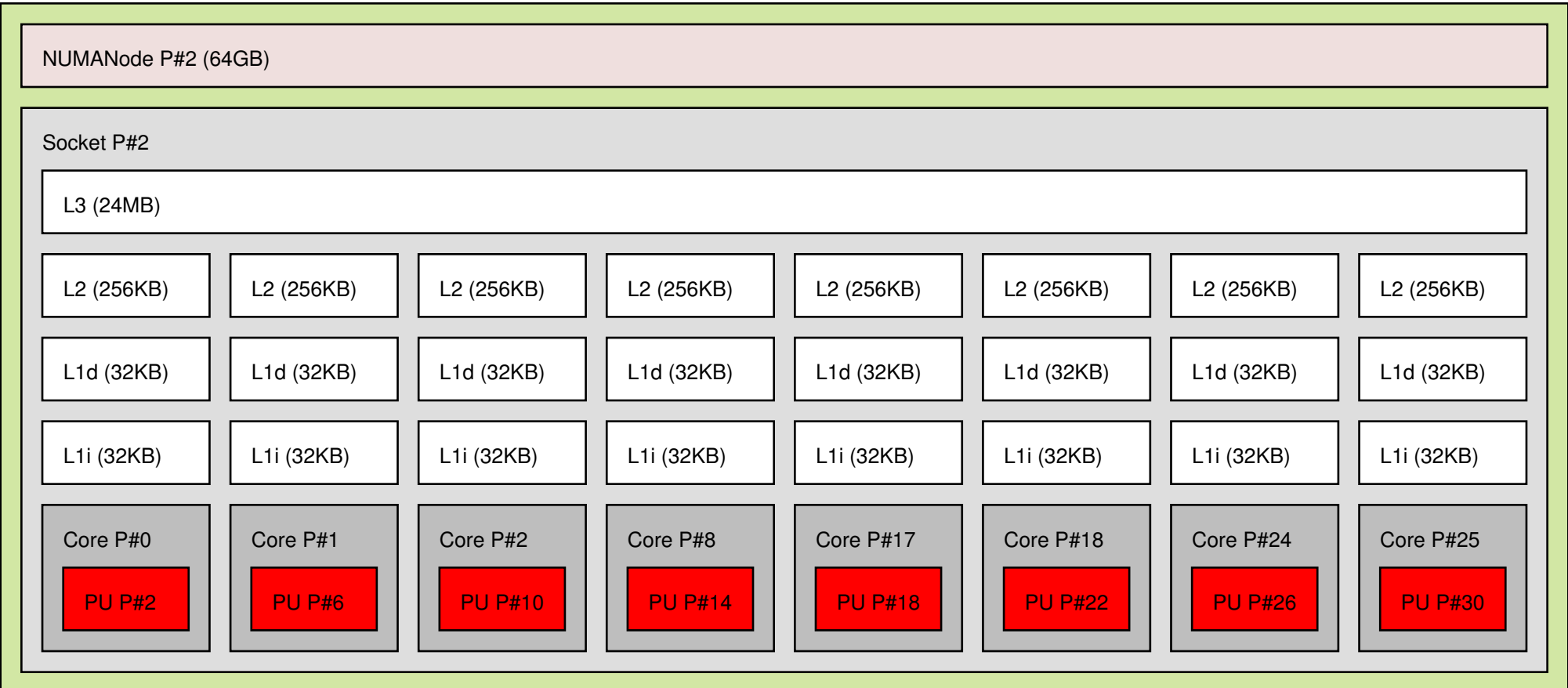
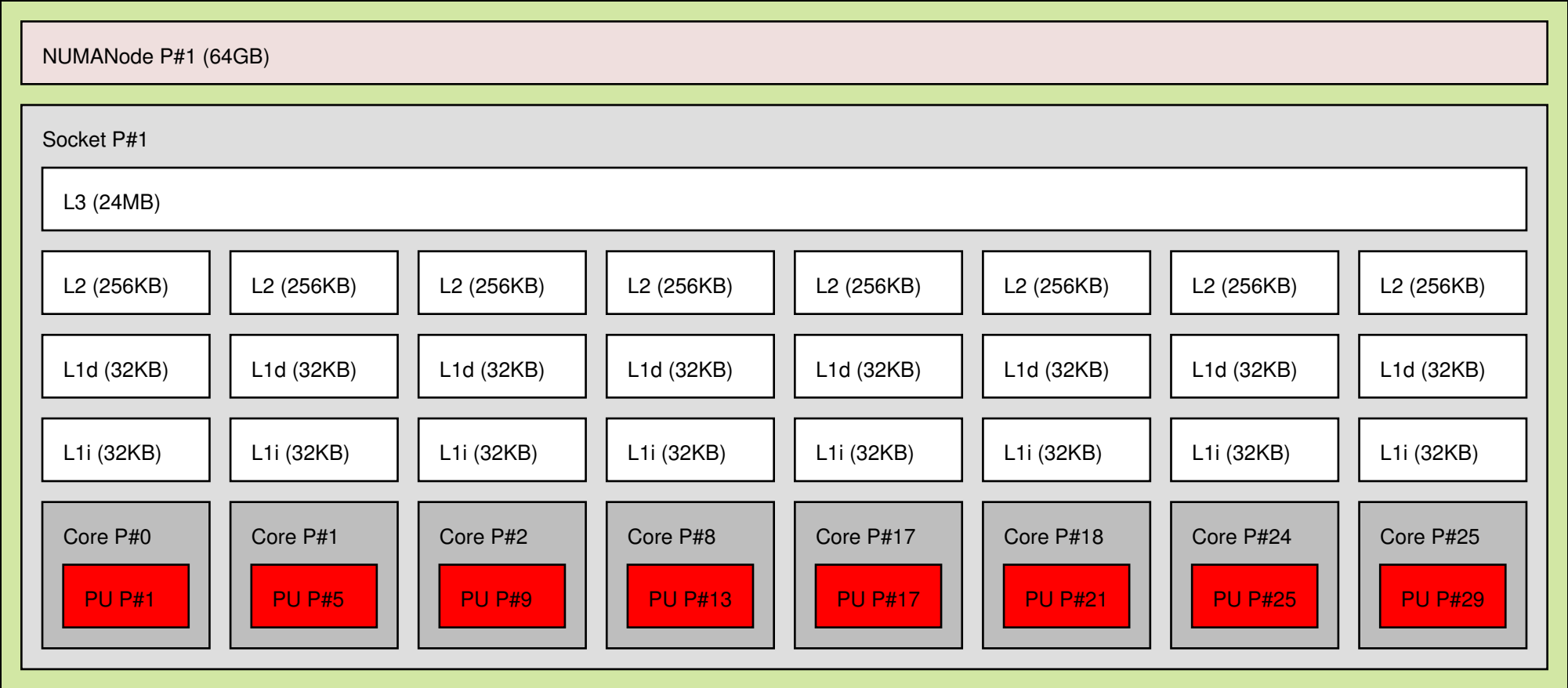
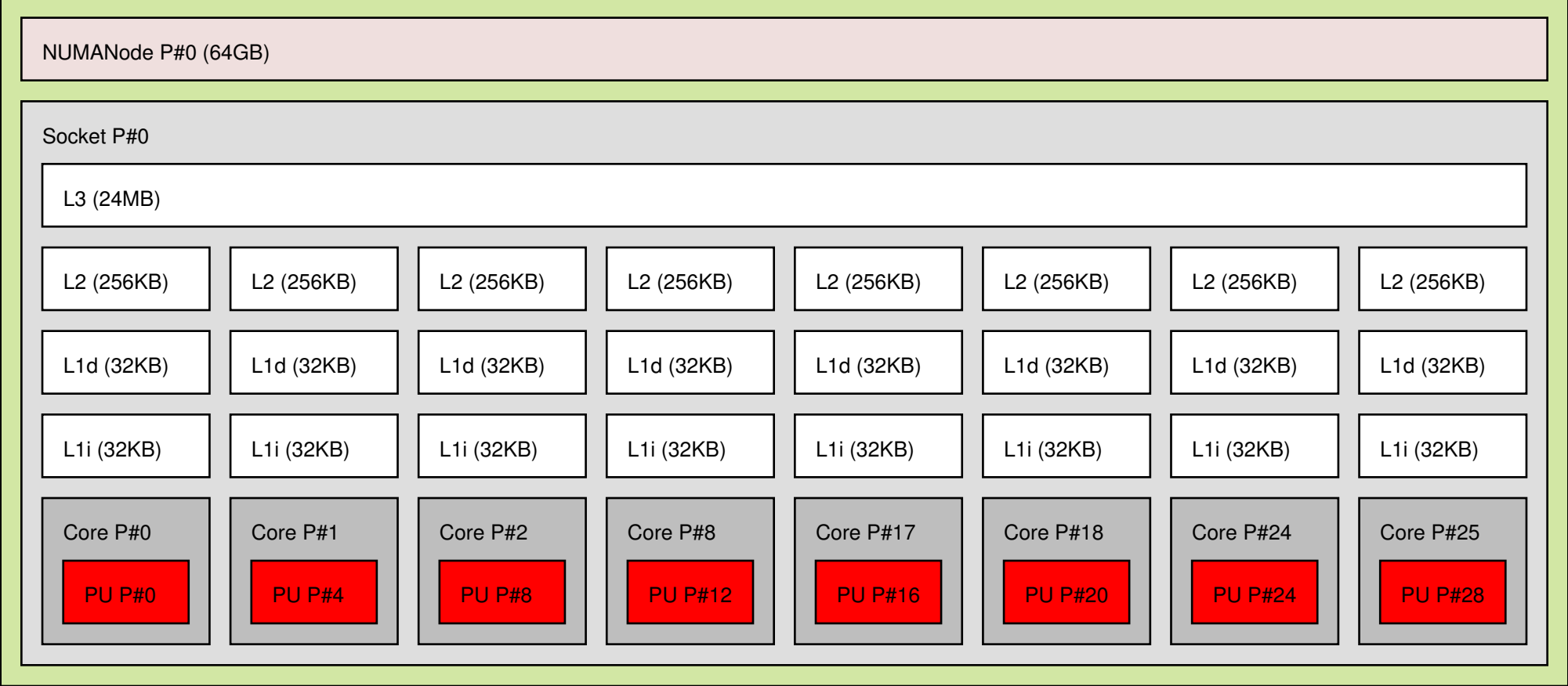
```
SLURM_JOBID=436823
SLURM_JOB_NODELIST=k07n28
SLURM_NNODES=1
SLURMTMPDIR=/scratch/436823
working directory = /ifs/user/npaliwal/hw1
All Done!
```

32 Node Intel

```
SLURM_JOBID=436824
SLURM_JOB_NODELIST=f07n13
SLURM_NNODES=1
SLURMTMPDIR=/scratch/436824
working directory = /ifs/user/npaliwal/hw1
All Done!
```









2. (b)

Since all the nodes are represented as NUMA (non-uniform memory access) nodes, all the nodes have non-uniform shared memory

2. (c)

All the nodes have 2 L1 (L1i and L1d) cache partitions, which might be the most likely source for accessing memory

