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https://github.com/CS211-Fall2023/hw3-hwen020
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Problem 1 (10 points):
Run the parallel Sieve of Eratosthenes program given in the slides (which is also sieve0).
Problem 2 (30 points):
Modify the parallel Sieve of Eratosthenes program in class (sieve0) so that the program does NOT set aside memory for even integers. Put your code in sieve1.
Problem 3 (30 points):
Modify sieve1 so that each process of the program finds its own sieving primes via local computations instead of broadcasts. Put your code in sieve2.
Problem 4 (30 points):
Modify sieve2 so that the program can have effective uses of caches. Put your code in sieve3.
For each version of sieve, record the time and number of primes when n= 10^10 and number of cores = 24, 48, 72, 96, 120 (which means number of nodes = 1, 2, 3, 4, 5). Check whether your execution time is inversely proportional to the number of cores. Compare the execution time of each version of your program to see how different designs affect the execution time.

Answer:

```
[hwen020@cluster-001-login-node hw3-hwen020]$ python3 starter.py
make: 'main' is up to date.
mkdir: cannot create directory 'sh': File exists
Submitted batch job 34037
Submitted batch job 34038
Submitted batch job 34039
Submitted batch job 34040
Submitted batch job 34041
Submitted batch job 34042
Submitted batch job 34043
Submitted batch job 34044
Submitted batch job 34045
Submitted batch job 34046
Submitted batch job 34047
Submitted batch job 34048
Submitted batch job 34049
Submitted batch job 34050
Submitted batch job 34051
Submitted batch job 34052
Submitted batch job 34053
Submitted batch job 34054
Submitted batch job 34055
Submitted batch job 34056
```

```
34050.0        hydra_pmi+        120        120    00:02:00 2023-11-22T02:26:56 2023-11-22T02:26:
[hwen020@cluster-001-login-node hw3-hwen020]$ sacct --format=JobID,JobName,AllocCPUS,Start,End
       JobID      JobName  AllocCPUS                Start                 End
------------ ---------- ---------- ------------------- -------------------
33839          sieve0_1         24 2023-11-22T00:44:02 2023-11-22T00:44:24
33839.batch       batch         24 2023-11-22T00:44:02 2023-11-22T00:44:24
33839.extern     extern         24 2023-11-22T00:44:02 2023-11-22T00:44:24
33839.0      hydra_pmi+         24 2023-11-22T00:44:02 2023-11-22T00:44:24
```

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33915.0      hydra_pmi+        120 2023-11-22T01:19:13 2023-11-22T01:19:15
34037          sieve0_1         24 2023-11-22T02:25:49 2023-11-22T02:26:12    23s
34037.batch       batch         24 2023-11-22T02:25:49 2023-11-22T02:26:12
34037.extern     extern         24 2023-11-22T02:25:49 2023-11-22T02:26:12
34037.0      hydra_pmi+         24 2023-11-22T02:25:49 2023-11-22T02:26:12
34038          sieve1_1         24 2023-11-22T02:25:49 2023-11-22T02:26:00    11s
34038.batch       batch         24 2023-11-22T02:25:49 2023-11-22T02:26:00
34038.extern     extern         24 2023-11-22T02:25:49 2023-11-22T02:26:00
34038.0      hydra_pmi+         24 2023-11-22T02:25:49 2023-11-22T02:26:00
34039          sieve2_1         24 2023-11-22T02:25:49 2023-11-22T02:26:02    13s
34039.batch       batch         24 2023-11-22T02:25:49 2023-11-22T02:26:02
34039.extern     extern         24 2023-11-22T02:25:49 2023-11-22T02:26:02
34039.0      hydra_pmi+         24 2023-11-22T02:25:49 2023-11-22T02:26:02
34040          sieve3_1         24 2023-11-22T02:25:49 2023-11-22T02:25:57    8s
34040.batch       batch         24 2023-11-22T02:25:49 2023-11-22T02:25:57
34040.extern     extern         24 2023-11-22T02:25:49 2023-11-22T02:25:57
34040.0      hydra_pmi+         24 2023-11-22T02:25:49 2023-11-22T02:25:57
34041          sieve0_2         48 2023-11-22T02:25:57 2023-11-22T02:26:09    12s
34041.batch       batch         24 2023-11-22T02:25:57 2023-11-22T02:26:09
34041.extern     extern         48 2023-11-22T02:25:57 2023-11-22T02:26:09
34041.0      hydra_pmi+         48 2023-11-22T02:25:57 2023-11-22T02:26:09
34042          sieve1_2         48 2023-11-22T02:26:03 2023-11-22T02:26:08    11s
34042.batch       batch         24 2023-11-22T02:26:03 2023-11-22T02:26:08
34042.extern     extern         48 2023-11-22T02:26:03 2023-11-22T02:26:08
34042.0      hydra_pmi+         48 2023-11-22T02:26:03 2023-11-22T02:26:08
34043          sieve2_2         48 2023-11-22T02:26:08 2023-11-22T02:26:15    6s
34043.batch       batch         24 2023-11-22T02:26:08 2023-11-22T02:26:15
34043.extern     extern         48 2023-11-22T02:26:08 2023-11-22T02:26:15
34043.0      hydra_pmi+         48 2023-11-22T02:26:09 2023-11-22T02:26:15
34044          sieve3_2         48 2023-11-22T02:26:09 2023-11-22T02:26:13    4s
34044.batch       batch         24 2023-11-22T02:26:09 2023-11-22T02:26:13
34044.extern     extern         48 2023-11-22T02:26:09 2023-11-22T02:26:13
34044.0      hydra_pmi+         48 2023-11-22T02:26:09 2023-11-22T02:26:13
34045          sieve0_3         72 2023-11-22T02:26:13 2023-11-22T02:26:21    8s
34045.batch       batch         24 2023-11-22T02:26:13 2023-11-22T02:26:21
34045.extern     extern         72 2023-11-22T02:26:13 2023-11-22T02:26:21
34045.0      hydra_pmi+         72 2023-11-22T02:26:13 2023-11-22T02:26:21
34046          sieve1_3         72 2023-11-22T02:26:21 2023-11-22T02:26:25    4s
34046.batch       batch         24 2023-11-22T02:26:21 2023-11-22T02:26:25
34046.extern     extern         72 2023-11-22T02:26:21 2023-11-22T02:26:25
34046.0      hydra_pmi+         72 2023-11-22T02:26:21 2023-11-22T02:26:25
34047          sieve2_3         72 2023-11-22T02:26:25 2023-11-22T02:26:29    4s
34047.batch       batch         24 2023-11-22T02:26:25 2023-11-22T02:26:29
34047.extern     extern         72 2023-11-22T02:26:25 2023-11-22T02:26:29
34047.0      hydra_pmi+         72 2023-11-22T02:26:25 2023-11-22T02:26:29
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34046.0      hydra_pmi+         72 2023-11-22T02:26:21 2023-11-22T02:26:25
34047          sieve2_3         72 2023-11-22T02:26:25 2023-11-22T02:26:29
34047.batch       batch         24 2023-11-22T02:26:25 2023-11-22T02:26:29
34047.extern     extern         72 2023-11-22T02:26:25 2023-11-22T02:26:29
34047.0      hydra_pmi+         72 2023-11-22T02:26:25 2023-11-22T02:26:29
34048          sieve3_3         72 2023-11-22T02:26:29 2023-11-22T02:26:31    2s
34048.batch       batch         24 2023-11-22T02:26:29 2023-11-22T02:26:31
34048.extern     extern         72 2023-11-22T02:26:29 2023-11-22T02:26:31
34048.0      hydra_pmi+         72 2023-11-22T02:26:29 2023-11-22T02:26:31
34049          sieve0_4         96 2023-11-22T02:26:31 2023-11-22T02:26:37    6s
34049.batch       batch         24 2023-11-22T02:26:31 2023-11-22T02:26:37
34049.extern     extern         96 2023-11-22T02:26:31 2023-11-22T02:26:37
34049.0      hydra_pmi+         96 2023-11-22T02:26:31 2023-11-22T02:26:37
34050          sieve1_4         96 2023-11-22T02:26:37 2023-11-22T02:26:40    3s
34050.batch       batch         24 2023-11-22T02:26:37 2023-11-22T02:26:40
34050.extern     extern         96 2023-11-22T02:26:37 2023-11-22T02:26:40
34050.0      hydra_pmi+         96 2023-11-22T02:26:37 2023-11-22T02:26:40
34051          sieve2_4         96 2023-11-22T02:26:40 2023-11-22T02:26:43    3s
34051.batch       batch         24 2023-11-22T02:26:40 2023-11-22T02:26:43
34051.extern     extern         96 2023-11-22T02:26:40 2023-11-22T02:26:43
34051.0      hydra_pmi+         96 2023-11-22T02:26:40 2023-11-22T02:26:43
34052          sieve3_4         96 2023-11-22T02:26:43 2023-11-22T02:26:45    2s
34052.batch       batch         24 2023-11-22T02:26:43 2023-11-22T02:26:45
34052.extern     extern         96 2023-11-22T02:26:43 2023-11-22T02:26:45
34052.0      hydra_pmi+         96 2023-11-22T02:26:43 2023-11-22T02:26:45
34053          sieve0_5        120 2023-11-22T02:26:45 2023-11-22T02:26:50    5s
34053.batch       batch         24 2023-11-22T02:26:45 2023-11-22T02:26:50
34053.extern     extern        120 2023-11-22T02:26:45 2023-11-22T02:26:50
34053.0      hydra_pmi+        120 2023-11-22T02:26:45 2023-11-22T02:26:50
34054          sieve1_5        120 2023-11-22T02:26:50 2023-11-22T02:26:52    2s
34054.batch       batch         24 2023-11-22T02:26:50 2023-11-22T02:26:52
34054.extern     extern        120 2023-11-22T02:26:50 2023-11-22T02:26:52
34054.0      hydra_pmi+        120 2023-11-22T02:26:50 2023-11-22T02:26:52
34055          sieve2_5        120 2023-11-22T02:26:52 2023-11-22T02:26:55    2s
34055.batch       batch         24 2023-11-22T02:26:52 2023-11-22T02:26:55
34055.extern     extern        120 2023-11-22T02:26:52 2023-11-22T02:26:55
34055.0      hydra_pmi+        120 2023-11-22T02:26:53 2023-11-22T02:26:55
34056          sieve3_5        120 2023-11-22T02:26:55 2023-11-22T02:26:57    1s
34056.batch       batch         24 2023-11-22T02:26:55 2023-11-22T02:26:57
34056.extern     extern        120 2023-11-22T02:26:55 2023-11-22T02:26:57
34056.0      hydra_pmi+        120 2023-11-22T02:26:56 2023-11-22T02:26:57
[hwen020@cluster-001-login-node hw3-hwen020]$
```

number of nodes	1	2	3	4	5
sieve0	23	12	8	6	5
sieve1	11	11	4	3	2
sieve2	13	6	4	3	2
sieve3	8	4	2	2	1

Table. Execution Time(seconds) of each version

From the above outcome we can see that execution time is inversely proportional to the number of cores.

Execution time gets lower and lower(which means efficiency getting higher and higher) from sieve0 to 3: the program that can have effective uses of caches (3)
>(is better than / has lower execution time / is more efficient than)the program that finds its own sieving primes via local computations instead of broadcasts (2)
>the program that does NOT set aside memory for even integers (1)
>the origin version (0)