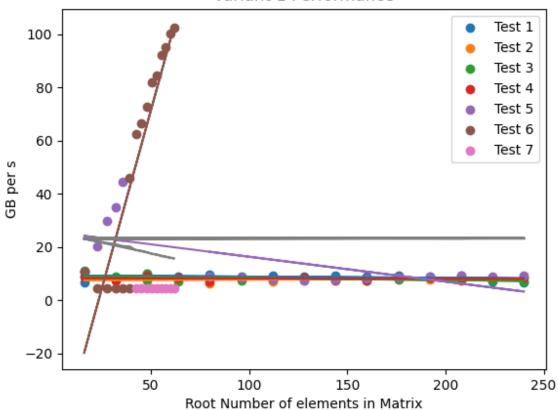
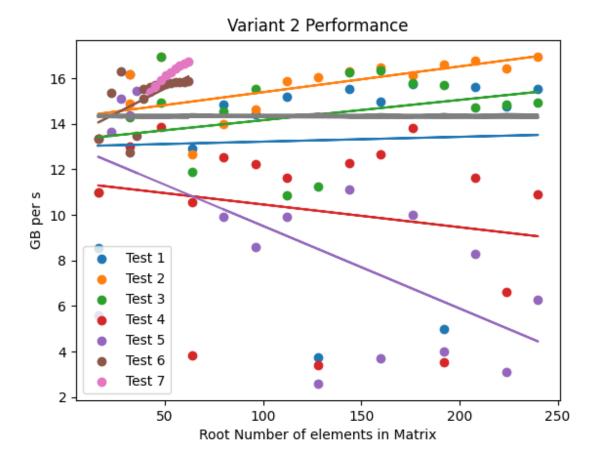
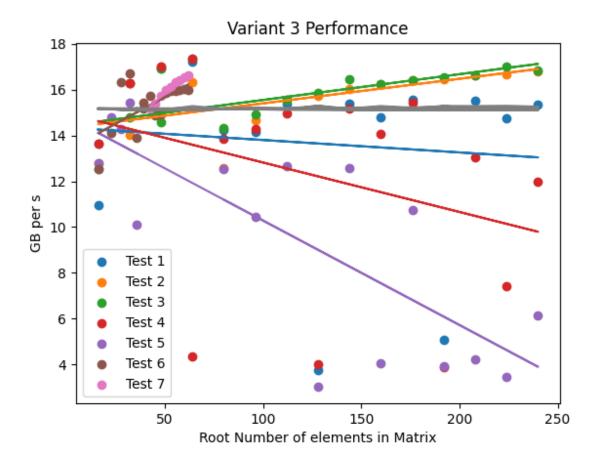
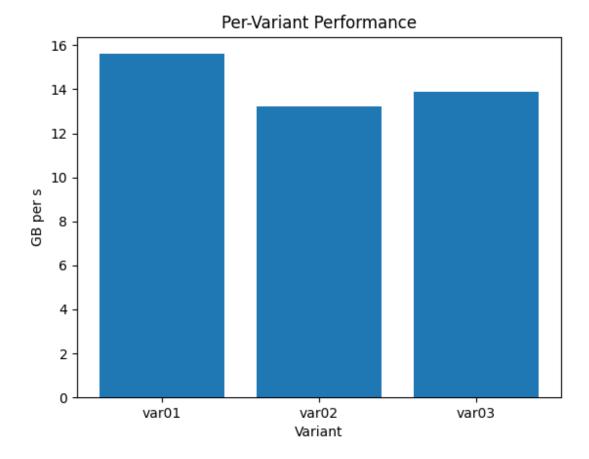
## **Results**











## **Data**

```
awsomeandy911@LAPTOP-IFC4JBFG:~/cs4473-5473-lab/PROB01 TRANSPOSE$ make
./build test op2.sh
baseline op 02.c
optimized_op_02_var_01.c
optimized_op_02_var_02.c
optimized op 02 var 03.c
-std=c99 -O2 -mavx2 -mfma
touch result verification op2 var01.csv
./run test op2 var01.x 16 256 16 1 1 1 -1 1
                                              -1 | tee -a
result verification op2 var01.csv
  m,
       n, rs src, cs src, rs dst, cs dst, result
                            1, PASS
  16,
       16, 16,
                  1,
                      16,
  32,
       32,
            32,
                  1,
                      32,
                            1, PASS
  48,
       48, 48, 1, 48,
                           1, PASS
  64,
       64, 64, 1, 64,
                            1, PASS
       80,
            80, 1,
                      80,
                            1, PASS
  80,
```

```
1,
                          96,
                                 1, PASS
  96,
        96,
               96,
  112,
                                    1, PASS
        112,
               112,
                       1,
                           112,
  128,
        128,
               128,
                       1,
                            128,
                                    1, PASS
        144,
                                    1, PASS
  144,
               144,
                       1,
                            144,
  160,
        160,
               160,
                       1,
                            160,
                                    1, PASS
  176,
        176,
               176,
                       1,
                            176,
                                    1, PASS
  192,
        192,
               192,
                       1,
                            192,
                                    1, PASS
 208,
        208,
               208,
                       1,
                            208,
                                    1, PASS
        224,
                       1,
 224,
               224,
                            224,
                                    1, PASS
        240,
               240,
                       1,
                            240,
                                    1, PASS
 240,
./run test op2 var01.x 16 256 16 1 1 -1
                                           1
                                                  -1
                                                        1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                                16, PASS
        16,
               1,
                    16,
                           1,
  32,
        32,
               1,
                    32,
                           1,
                                32, PASS
  48,
                                48, PASS
        48,
               1,
                    48,
                           1,
                    64,
  64,
        64,
               1,
                           1,
                                64, PASS
  80,
        80,
                    80,
                                80, PASS
               1,
                           1,
        96,
  96,
                    96,
                                96, PASS
               1,
                           1,
  112,
        112,
                                112, PASS
                1,
                    112,
                             1,
  128,
                     128,
                                 128, PASS
        128,
                1,
                             1,
  144,
        144,
                 1,
                     144,
                             1,
                                 144, PASS
  160,
                                 160, PASS
        160,
                 1,
                     160,
                             1,
  176,
        176,
                 1,
                     176,
                             1,
                                 176, PASS
  192,
        192,
                     192,
                             1,
                                 192, PASS
                 1,
 208,
        208,
                 1,
                     208,
                             1,
                                 208, PASS
 224,
        224,
                     224,
                             1,
                                 224, PASS
                 1,
 240,
        240,
                 1,
                     240,
                             1,
                                 240, PASS
./run test op2 var01.x 16 256 16 1 1 1 -1
                                                  -1
                                                        1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                                16, FAIL
        16,
               16,
                      1,
                           1,
  32,
        32,
               32,
                      1,
                           1,
                                32, FAIL
  48,
        48,
               48,
                      1,
                           1,
                                48, FAIL
  64,
        64,
               64,
                      1,
                           1,
                                64, FAIL
  80,
        80,
               80,
                      1,
                           1,
                                80, FAIL
        96,
               96,
                                96, FAIL
  96,
                      1,
                           1,
  112,
        112,
               112,
                       1,
                             1,
                                112, FAIL
  128,
        128,
               128,
                       1,
                             1,
                                 128, FAIL
  144,
        144,
               144,
                       1,
                             1,
                                 144, FAIL
```

```
160, FAIL
  160,
        160,
                160,
                        1,
                             1,
  176,
        176,
                176,
                        1,
                                  176, FAIL
                             1,
  192,
         192,
                192,
                        1,
                             1,
                                  192, FAIL
 208,
        208,
               208,
                        1,
                                  208, FAIL
                             1,
 224,
        224,
               224,
                        1,
                              1,
                                  224, FAIL
                        1,
                              1,
 240,
        240,
               240,
                                  240, FAIL
./run test op2 var01.x 16 256 16 1 1 -1
                                            1
                                                   1
                                                       -1 | tee -a
result verification op2 var01.csv
         n, rs_src, cs_src, rs_dst, cs_dst, result
   m,
  16,
                           16,
                                  1, FAIL
         16,
                1,
                     16,
  32,
        32,
                1,
                     32,
                           32,
                                  1, FAIL
  48,
        48,
                    48,
                           48,
                                  1, FAIL
                1,
  64,
        64,
                1,
                    64,
                           64,
                                  1, FAIL
  80,
        80,
                    80,
                           80,
                                  1, FAIL
                1,
  96,
        96,
                1,
                    96,
                           96,
                                  1, FAIL
  112,
                                    1, FAIL
        112,
                1,
                     112,
                            112,
  128,
         128,
                 1,
                     128,
                            128,
                                    1, FAIL
  144,
         144,
                     144,
                            144,
                                    1, FAIL
                 1,
  160,
         160,
                     160,
                                    1, FAIL
                 1,
                            160,
  176,
         176,
                     176,
                                    1, FAIL
                 1,
                            176,
  192,
         192,
                 1,
                     192,
                            192,
                                    1, FAIL
  208,
        208,
                 1,
                     208,
                            208,
                                    1, FAIL
 224,
        224,
                     224,
                            224,
                                    1, FAIL
                 1,
  240,
        240,
                 1,
                     240,
                            240,
                                    1, FAIL
                                              2
./run test op2 var01.x 16 256 16 1 1 -2
                                                  2
                                                        -2 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
                                  2, FAIL
  16,
         16,
               2,
                    32,
                           32,
  32,
        32,
               2,
                    64,
                           64,
                                  2, FAIL
  48,
        48,
               2,
                    96,
                           96,
                                  2, FAIL
  64,
        64,
               2,
                    128,
                           128,
                                   2, FAIL
  80,
        80,
               2,
                    160,
                           160,
                                   2, FAIL
        96,
                2,
  96,
                    192,
                           192,
                                   2, FAIL
                2,
                                    2, FAIL
  112,
        112,
                     224,
                            224,
  128,
        128,
                 2,
                     256,
                            256,
                                    2, FAIL
  144,
        144,
                 2,
                     288,
                            288,
                                    2, FAIL
                     320,
  160,
        160,
                 2,
                            320,
                                    2, FAIL
  176,
         176,
                 2,
                     352,
                            352,
                                    2, FAIL
  192,
         192,
                 2,
                     384,
                            384,
                                    2, FAIL
 208,
        208,
                 2,
                     416,
                            416,
                                    2, FAIL
```

```
2,
                     448,
                            448,
                                    2, FAIL
 224,
        224,
        240,
                2,
                     480,
                            480,
                                    2, FAIL
 240,
./run test op2 var01.x 16 256 16 1 -16 1 -1
                                                    -1
                                                          1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
        16,
               16,
                      1,
                           1,
                                16, FAIL
                                16, FAIL
  32,
        16,
               16,
                      1,
                           1,
  48,
        16,
               16,
                      1,
                           1,
                                16, FAIL
  64,
        16,
                      1,
                           1,
                                16, FAIL
               16,
  80,
        16,
                                16, FAIL
               16,
                      1,
                           1,
  96,
        16,
                      1,
                           1,
                                16, FAIL
               16,
  112,
         16,
               16,
                            1,
                                 16, FAIL
                      1,
  128,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  144,
                                 16, FAIL
         16,
               16,
                      1,
                            1,
  160,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  176,
                                 16, FAIL
         16,
               16,
                      1,
                            1,
  192,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
 208,
         16,
               16,
                            1,
                                 16, FAIL
                      1,
 224,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
 240,
               16,
                      1,
                            1,
                                 16, FAIL
         16,
./run test op2 var01.x 16 256 16 -16 1 1
                                               -1
                                                    -1
                                                          1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
        16,
                      1,
                           1,
                                16, FAIL
               16,
                                32, FAIL
  16,
        32,
               32,
                      1,
                           1,
  16,
        48,
              48,
                           1,
                                48, FAIL
                      1,
  16,
        64,
               64,
                      1,
                           1,
                                64, FAIL
        80,
                                80, FAIL
  16,
               80,
                      1,
                           1,
        96,
              96,
  16,
                      1,
                           1,
                                96, FAIL
  16,
        112,
               112,
                       1,
                            1,
                                112, FAIL
  16,
        128,
               128,
                            1,
                                 128, FAIL
                       1,
  16,
        144,
               144,
                       1,
                            1,
                                 144, FAIL
  16,
        160,
               160,
                       1,
                            1,
                                 160, FAIL
  16,
        176,
               176,
                       1,
                            1,
                                 176, FAIL
  16,
        192,
               192,
                       1,
                            1,
                                 192, FAIL
        208,
               208,
                       1,
                            1,
                                 208, FAIL
  16,
  16,
        224,
               224,
                       1,
                            1,
                                 224, FAIL
               240,
                       1,
                             1,
                                 240, FAIL
        240,
grep -i "FAIL" result verification op2 var01.csv | wc -l
825
```

```
touch result verification op2 var02.csv
./run test op2 var02.x 16 256 16 1 1 1
                                         -1
                                              1 -1 | tee -a
result verification op2 var02.csv
  m,
         n, rs src, cs src, rs dst, cs dst, result
  16,
        16,
              16,
                     1,
                         16,
                                1, PASS
  32,
        32,
              32,
                     1,
                         32,
                                1, PASS
  48,
        48,
              48,
                     1,
                         48,
                                1, PASS
  64,
        64,
              64,
                     1,
                         64,
                                1, PASS
  80,
        80,
              80,
                     1,
                         80,
                                1, PASS
        96.
  96,
              96.
                     1,
                         96,
                                1, PASS
  112,
        112,
              112,
                      1,
                         112,
                                  1, PASS
  128,
        128,
                      1,
                                  1, PASS
              128,
                          128,
  144,
        144,
               144,
                      1,
                          144,
                                  1, PASS
  160,
        160,
               160,
                      1,
                           160,
                                  1, PASS
  176,
        176,
               176,
                      1,
                          176,
                                  1, PASS
  192,
        192,
               192,
                           192,
                                  1, PASS
                      1,
                      1,
 208,
        208,
               208,
                           208,
                                  1, PASS
 224,
        224,
               224,
                      1,
                           224,
                                  1, PASS
        240,
              240,
                          240,
 240,
                      1,
                                  1, PASS
./run test op2 var02.x 16 256 16 1 1 -1 1
                                                -1
                                                      1 | tee -a
result verification op2 var02.csv
        n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
               1,
                   16,
                          1,
                               16, PASS
  32,
        32,
                   32,
                               32, PASS
               1,
                          1,
  48,
        48,
                   48,
                               48, PASS
               1,
                          1,
  64,
        64,
               1,
                   64,
                          1,
                               64, PASS
  80,
        80,
                   80,
                               80, PASS
               1,
                          1,
  96,
        96,
                   96,
                               96, PASS
               1,
                          1,
  112,
        112,
                1.
                   112,
                           1, 112, PASS
  128,
                               128, PASS
        128,
                1,
                    128,
                            1,
  144,
        144,
                1,
                    144,
                            1, 144, PASS
  160,
        160,
                    160,
                            1,
                               160, PASS
                1,
  176,
        176,
                1,
                    176,
                            1, 176, PASS
  192,
        192,
                    192,
                               192, PASS
                1,
                            1,
 208,
        208,
                1.
                    208,
                            1.
                                208, PASS
                    224,
 224,
        224,
                1.
                            1.
                                224, PASS
 240,
                    240,
                                240, PASS
        240,
                1.
                            1,
./run test op2 var02.x 16 256 16 1 1 1
                                         -1
                                                -1
                                                      1 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
```

m,

```
16, PASS
  16,
        16,
               16,
                     1,
                           1,
  32,
        32,
               32,
                                32, PASS
                     1,
                           1,
  48,
        48,
              48,
                     1,
                           1,
                                48, PASS
                                64, PASS
  64,
        64,
              64,
                     1,
                           1,
  80,
        80,
               80,
                     1,
                           1,
                                80, PASS
        96,
  96,
              96,
                     1,
                           1,
                                96, PASS
  112,
        112,
               112,
                       1,
                            1,
                                112, PASS
  128,
        128,
               128,
                       1,
                             1,
                                 128, PASS
  144,
        144,
               144,
                       1,
                             1,
                                 144, PASS
  160,
        160,
               160,
                       1,
                             1.
                                 160, PASS
  176,
        176,
               176,
                       1,
                             1,
                                 176, PASS
  192,
        192,
               192,
                       1,
                             1,
                                 192, PASS
                       1,
 208,
        208,
               208,
                             1,
                                 208, PASS
 224,
        224,
               224,
                       1,
                             1,
                                 224, PASS
        240,
               240,
                       1,
                             1,
                                 240, PASS
 240,
./run test op2 var02.x 16 256 16 1 1 -1 1
                                                      -1 | tee -a
                                                 1
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
                                 1, PASS
  16,
        16,
               1,
                    16,
                          16,
  32,
        32,
                    32,
                          32,
                                 1, PASS
               1,
  48,
        48,
                    48,
                          48,
                                 1, PASS
               1,
  64,
        64,
               1,
                    64,
                          64,
                                 1, PASS
  80,
                    80,
                          80,
                                 1, PASS
        80,
               1,
                                 1, PASS
  96,
        96,
               1,
                    96,
                          96,
                    112,
  112,
                                   1, PASS
        112,
                1,
                           112,
  128,
        128,
                1,
                    128,
                            128,
                                    1, PASS
  144,
        144,
                    144,
                                    1, PASS
                1,
                            144,
  160,
        160,
                     160,
                                    1, PASS
                1,
                            160,
                                    1, PASS
  176,
        176,
                1.
                    176,
                           176,
  192,
        192,
                     192,
                            192,
                                    1, PASS
                1,
 208,
        208,
                1,
                    208,
                           208,
                                    1, PASS
 224,
        224,
                1,
                    224,
                           224,
                                    1, PASS
        240,
                    240,
                           240,
                                    1, PASS
 240,
                1,
./run test op2 var02.x 16 256 16 1 1 -2
                                             2
                                                 2
                                                      -2 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
               2,
                    32,
                          32,
                                 2, PASS
        16,
  32,
        32,
               2,
                    64,
                          64,
                                 2, PASS
               2,
                    96,
                          96,
  48,
        48,
                                 2, PASS
  64,
               2,
                    128,
                          128,
                                  2, PASS
        64,
```

```
80,
        80,
               2,
                    160,
                           160,
                                   2, PASS
  96,
        96,
               2,
                    192,
                           192,
                                   2, PASS
                2,
                    224,
                                    2, PASS
  112,
        112,
                            224,
  128,
                2,
                     256,
                            256,
                                    2, PASS
        128,
  144,
        144,
                2,
                     288,
                            288,
                                    2, PASS
  160,
        160,
                2,
                     320,
                            320,
                                    2, PASS
                2,
                     352,
  176,
        176,
                            352,
                                    2, PASS
  192,
                2,
                                    2, PASS
        192,
                     384,
                            384,
 208,
        208,
                2,
                     416,
                            416,
                                    2, PASS
        224,
                2,
                                    2, PASS
 224,
                     448,
                            448,
  240,
        240,
                2.
                     480,
                            480,
                                    2, PASS
./run test op2 var02.x 16 256 16 1 -16 1 -1
                                                    -1
                                                          1 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
               16,
                      1,
                           1,
                                16, PASS
  32,
                                16, PASS
        16,
               16,
                      1,
                           1,
  48,
        16,
               16,
                      1,
                           1,
                                16, PASS
  64,
        16,
               16,
                                16, PASS
                      1,
                           1,
  80,
                      1,
                           1,
                                16, PASS
        16,
               16,
  96,
                                16, PASS
        16,
               16,
                      1,
                           1,
  112,
                      1,
                            1,
                                 16, PASS
         16,
               16,
  128,
         16,
               16,
                      1,
                            1,
                                 16, PASS
  144,
                                 16, PASS
         16,
               16,
                      1,
                            1,
  160,
         16,
               16,
                      1,
                            1,
                                 16, PASS
  176,
                            1,
                                 16, PASS
         16,
               16,
                      1,
  192,
         16,
               16,
                      1,
                            1,
                                 16, PASS
 208,
                      1,
                            1,
                                 16, PASS
         16,
               16,
                            1,
 224,
         16,
               16,
                      1,
                                 16, PASS
  240,
               16,
                      1,
                            1,
                                 16, PASS
         16,
./run test op2 var02.x 16 256 16 -16 1 1
                                               -1
                                                    -1
                                                          1 | tee -a
result verification op2 var02.csv
         n, rs_src, cs_src, rs_dst, cs_dst, result
  m,
  16,
        16,
               16,
                      1,
                           1,
                                16, PASS
  16,
        32,
               32,
                      1,
                           1,
                                32, PASS
  16,
        48,
              48,
                           1,
                                48, PASS
                      1,
  16,
        64,
                      1,
                           1,
                                64, PASS
               64,
                                80, PASS
  16,
        80,
               80,
                      1,
                           1,
  16,
        96,
               96,
                      1,
                           1,
                                96, PASS
  16,
        112,
               112,
                      1,
                            1,
                                112, PASS
  16,
        128,
               128,
                       1,
                            1,
                                 128, PASS
```

```
16,
       144,
              144,
                      1,
                           1,
                                144, PASS
  16,
                      1,
                                160, PASS
       160,
              160,
                           1,
  16,
       176,
              176,
                      1,
                           1.
                                176, PASS
       192,
  16,
              192,
                      1,
                           1,
                                192, PASS
  16,
       208,
              208,
                      1,
                           1,
                                208, PASS
  16,
       224,
              224,
                      1,
                           1,
                                224, PASS
       240,
                      1,
                            1,
                                240, PASS
  16,
              240,
grep -i "FAIL" result verification op2 var02.csv | wc -l
touch result verification op2 var03.csv
./run test op2 var03.x 16 256 16 1 1 1
                                         -1 1
                                                     -1 | tee -a
result verification op2 var03.csv
   m,
         n, rs src, cs src, rs dst, cs dst, result
  16,
        16,
                     1,
                          16,
                                1, PASS
              16,
  32,
        32,
              32,
                     1,
                          32,
                                1, PASS
  48,
        48,
              48,
                          48,
                                1, PASS
                     1,
  64,
        64,
              64,
                     1,
                          64,
                                1, PASS
  80,
        80,
              80,
                     1,
                          80,
                                1, PASS
        96,
                          96,
  96,
              96,
                     1,
                                1, PASS
  112,
        112,
               112,
                      1,
                          112,
                                  1, PASS
  128,
        128,
               128,
                           128,
                                   1, PASS
                       1,
 144,
        144,
               144,
                       1,
                           144,
                                   1, PASS
 160,
        160,
               160,
                                   1, PASS
                       1,
                           160,
 176,
        176,
               176,
                       1,
                           176,
                                   1, PASS
 192,
        192,
               192,
                       1,
                           192,
                                   1, PASS
 208,
        208,
               208,
                       1,
                           208,
                                   1, PASS
 224,
        224,
               224,
                       1,
                           224,
                                   1, PASS
 240,
        240,
               240,
                       1,
                           240,
                                   1, PASS
./run test op2 var03.x 16 256 16 1 1 -1 1
                                                -1
                                                      1 | tee -a
result verification op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                          1,
                               16, PASS
        16,
               1,
                    16,
  32,
        32,
               1,
                    32,
                          1,
                               32, PASS
  48,
        48,
               1,
                   48,
                          1,
                               48, PASS
  64,
        64,
               1,
                   64,
                          1,
                               64, PASS
        80,
                   80,
  80,
               1,
                          1,
                               80, PASS
  96,
        96,
                   96,
                               96, PASS
               1,
                          1,
  112,
        112,
                1,
                    112,
                            1, 112, PASS
  128,
        128,
                1,
                    128,
                            1,
                                128, PASS
 144,
        144,
                1,
                    144,
                            1,
                                144, PASS
```

```
160,
        160,
                                 160, PASS
                 1,
                     160,
                             1,
  176,
        176,
                                 176, PASS
                 1,
                     176,
                             1,
  192,
        192,
                 1.
                     192,
                             1.
                                 192, PASS
 208,
        208,
                                 208, PASS
                 1,
                     208,
                             1,
 224,
        224,
                 1,
                     224,
                             1,
                                 224, PASS
 240,
        240,
                 1,
                     240,
                             1,
                                 240, PASS
./run test op2 var03.x 16 256 16 1 1 1 -1
                                                  -1
                                                        1 | tee -a
result verification_op2_var03.csv
         n, rs_src, cs_src, rs_dst, cs_dst, result
   m,
  16,
        16,
                      1,
                           1,
                                16, PASS
               16,
  32,
        32,
               32,
                      1,
                           1,
                                32, PASS
  48,
        48,
              48,
                      1,
                           1,
                                48, PASS
  64,
        64,
               64,
                      1,
                           1,
                                64, PASS
  80,
        80,
               80,
                      1,
                           1,
                                80, PASS
                      1,
                           1,
  96,
        96,
               96,
                                96, PASS
  112,
                       1,
                             1,
                                 112, PASS
        112,
               112,
  128,
        128,
               128,
                       1,
                             1,
                                 128, PASS
  144,
        144,
               144,
                       1,
                             1,
                                 144, PASS
  160,
        160,
               160,
                       1,
                             1,
                                 160, PASS
  176,
        176,
               176,
                       1,
                             1,
                                 176, PASS
  192,
        192,
               192,
                       1,
                             1,
                                 192, PASS
  208,
        208,
               208,
                       1,
                             1,
                                 208, PASS
 224,
        224,
               224,
                       1,
                             1,
                                 224, PASS
                                 240, PASS
  240,
        240,
               240,
                       1,
                             1,
./run test op2 var03.x 16 256 16 1 1 -1 1
                                                  1
                                                       -1 | tee -a
result verification op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                                 1, PASS
        16,
               1,
                    16,
                           16,
  32,
        32,
               1,
                    32,
                           32,
                                 1, PASS
                                 1, PASS
  48,
        48,
               1,
                    48,
                          48,
  64,
        64,
               1,
                    64,
                          64,
                                 1, PASS
                    80,
  80,
        80,
               1,
                          80,
                                 1, PASS
  96,
        96,
                    96,
                          96,
                                 1, PASS
               1,
                                    1, PASS
  112,
        112,
                1,
                    112,
                           112,
  128,
        128,
                     128,
                            128,
                                    1, PASS
                1,
  144,
        144,
                     144,
                            144,
                                    1, PASS
                 1,
  160,
                                    1, PASS
        160,
                 1.
                     160,
                            160,
  176,
        176,
                 1,
                     176,
                            176,
                                    1, PASS
  192,
        192,
                 1,
                     192,
                            192,
                                    1, PASS
 208,
        208,
                 1,
                     208,
                            208,
                                    1, PASS
```

```
224,
                1, 224, 224,
                                    1, PASS
 224,
 240,
        240,
                1,
                    240,
                           240,
                                    1, PASS
                                             2
./run test op2 var03.x 16 256 16 1 1 -2
                                                 2
                                                      -2 | tee -a
result verification op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
               2,
                    32,
                          32,
                                 2, PASS
               2,
  32,
        32,
                    64,
                          64,
                                 2, PASS
  48,
        48,
               2,
                    96,
                          96,
                                 2, PASS
  64,
        64,
               2,
                    128,
                          128,
                                  2, PASS
               2,
  80,
        80,
                    160,
                          160,
                                  2, PASS
               2,
                                  2, PASS
  96,
        96,
                    192,
                          192,
                2,
                                   2, PASS
  112,
        112,
                    224,
                           224,
  128,
        128,
                2,
                    256,
                           256,
                                   2, PASS
  144,
        144,
                2,
                    288,
                           288,
                                   2, PASS
  160,
        160,
                2,
                    320,
                           320,
                                   2, PASS
  176,
        176,
                2,
                    352,
                           352,
                                   2, PASS
  192,
        192,
                2,
                    384,
                           384,
                                   2, PASS
 208,
        208,
                2,
                    416,
                           416,
                                   2, PASS
                2,
 224,
        224,
                    448,
                           448,
                                   2, PASS
 240,
        240,
                2,
                    480,
                           480,
                                   2, PASS
./run test op2 var03.x 16 256 16 1 -16 1 -1
                                                   -1
                                                         1 | tee -a
result verification op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
               16,
                     1,
                           1,
                                16, PASS
  32,
        16,
               16,
                     1,
                           1,
                                16, PASS
  48,
        16,
               16,
                           1,
                                16, PASS
                     1,
  64,
                                16, PASS
        16,
               16,
                     1,
                           1,
  80,
                                16, PASS
        16,
               16,
                     1,
                           1,
  96,
        16,
                     1,
                           1,
                                16, PASS
               16,
  112,
         16,
               16,
                      1,
                           1,
                                16, PASS
  128,
         16,
               16,
                      1,
                           1,
                                16, PASS
  144,
                      1,
                            1,
                                16, PASS
         16,
               16,
  160,
         16,
               16,
                      1,
                            1,
                                 16, PASS
  176,
         16,
               16,
                      1,
                            1,
                                16, PASS
  192,
               16,
                      1,
                           1,
                                 16, PASS
         16,
  208,
         16,
                      1,
                            1,
                                 16, PASS
               16,
                            1,
 224,
         16,
               16,
                      1,
                                 16, PASS
 240,
         16,
               16,
                      1,
                            1,
                                 16, PASS
./run_test_op2_var03.x 16 256 16 -16 1 1
                                              -1
                                                   -1
                                                         1 | tee -a
result verification op2 var03.csv
```

```
n, rs src, cs src, rs dst, cs dst, result
  m,
                         1,
  16,
        16,
              16,
                    1,
                              16, PASS
        32,
              32,
                    1,
                              32, PASS
  16,
                         1,
        48,
              48,
                              48, PASS
  16,
                    1,
                         1,
  16,
        64,
              64,
                    1,
                         1,
                              64, PASS
  16,
        80,
              80,
                    1,
                         1,
                              80, PASS
        96,
              96,
                    1,
                         1,
  16,
                              96, PASS
                     1,
                          1,
                              112, PASS
  16,
       112,
              112,
  16,
       128,
              128,
                     1,
                           1.
                              128, PASS
                               144, PASS
  16,
       144,
              144,
                     1,
                           1.
                           1.
  16,
       160,
              160,
                     1.
                               160, PASS
  16.
                     1,
                           1,
                              176, PASS
       176,
              176.
                           1,
  16,
       192,
              192,
                     1,
                              192, PASS
  16,
       208,
              208,
                     1,
                           1,
                               208, PASS
              224,
  16, 224,
                           1, 224, PASS
                     1,
                           1.
  16.
       240,
              240,
                     1,
                               240, PASS
grep -i "FAIL" result verification op2 var03.csv | wc -l
./build bench op2.sh
baseline op 02.c
optimized op 02 var 01.c
optimized op 02 var 02.c
optimized op 02 var 03.c
-std=c99 -O2 -mavx2 -mfma
touch result bench op2 var01.csv
./run bench op2 var01.x 16 256 16 1 1 1 -1 1
                                                      -1 | tee -a result bench op2 var01.csv
        n, rs src, cs src, rs dst, cs dst, GB per s
  m,
  16,
                    1,
                         16,
                                1, 19.200001
        16,
              16,
  32,
        32,
                         32,
              32,
                    1.
                               1, 22.341818
  48,
                         48,
        48,
              48,
                    1,
                               1, 22.030279
  64,
        64,
              64,
                    1,
                         64,
                               1, 21.510721
  80,
        80,
              80,
                    1,
                         80,
                                1, 22.358078
        96,
              96,
  96,
                    1,
                         96,
                               1, 22.296774
  112,
                         112,
        112,
              112,
                      1,
                                 1, 21.926876
 128,
        128,
              128,
                          128,
                                  1, 14.499115
                      1,
 144,
        144,
              144,
                      1,
                          144,
                                  1, 22.138079
 160,
        160,
              160,
                      1.
                          160,
                                  1, 22.252808
 176,
        176,
              176,
                      1,
                          176,
                                  1, 22.112551
 192,
        192,
              192,
                          192,
                      1,
                                  1, 20.881189
 208,
       208,
              208,
                      1,
                          208,
                                  1, 22.139360
```

```
224,
                                    1, 22.22254
 224,
        224,
               224,
                       1,
                       1,
        240,
               240,
                            240,
                                    1, 21.974249
 240.
./run bench op2 var01.x 16 256 16 1 1 -1
                                              1 -1
                                                          1 | tee -a result bench op2 var01.csv
  m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
                    16,
                           1,
                                16, 19.200001
        16,
  32,
        32,
               1,
                    32,
                           1,
                                32, 22.341818
  48,
        48,
               1,
                    48,
                           1,
                                48, 22.030279
  64,
        64,
               1,
                    64,
                           1,
                                64, 21.416994
  80,
        80,
               1,
                    80,
                           1,
                                80, 22.100719
                    96,
  96,
        96,
               1,
                                96, 22.251911
                           1,
  112,
        112,
                    112,
                             1.
                                112, 21.910917
                1,
  128,
        128,
                     128,
                             1.
                                 128, 14.504463
                1.
  144,
        144,
                1,
                     144,
                             1,
                                 144, 22.207230
  160,
        160,
                     160,
                                 160, 22.244749
                1,
                             1,
  176,
        176,
                1,
                     176,
                             1,
                                 176, 22.132301
  192,
        192,
                     192,
                                 192, 19.385101
                1,
                             1,
 208,
        208,
                1.
                     208,
                             1.
                                 208, 22.134640
 224,
        224,
                     224,
                                 224, 22.091799
                1,
                             1,
 240,
        240,
                1,
                     240,
                                 240, 21.974249
                             1,
./run bench op2 var01.x 16 256 16 1 1 1
                                                    -1
                                                          1 | tee -a result bench op2 var01.csv
                                             -1
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
                      1,
                           1,
                                16, 19.200001
        16,
               16,
  32,
        32,
                      1,
               32,
                           1,
                                32, 22.140541
  48,
        48,
              48,
                      1,
                           1,
                                48, 22.030279
        64,
  64,
                      1,
                           1,
               64,
                                64, 20.915745
  80,
        80,
               80,
                      1,
                           1,
                                80, 22.260870
        96,
               96,
                      1,
                                96, 22.639099
  96,
                           1,
  112,
                             1,
        112,
               112,
                       1,
                                112, 22.450111
  128,
        128,
               128,
                       1,
                             1.
                                 128, 15.438398
        144,
  144,
               144,
                       1,
                             1,
                                 144, 22.610813
  160,
        160,
               160,
                       1,
                             1,
                                 160, 22.814705
  176,
        176,
               176,
                       1,
                             1,
                                 176, 22.706903
  192,
        192,
               192,
                       1,
                             1,
                                 192, 17.344362
        208,
               208,
 208,
                       1,
                             1,
                                 208, 22.671091
 224,
        224,
               224,
                       1,
                             1,
                                 224, 22.746960
 240,
        240,
               240,
                       1,
                             1,
                                 240, 22.710695
./run bench op2 var01.x 16 256 16 1 1 -1
                                             1
                                                   1
                                                         -1 | tee -a result bench op2 var01.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
        16,
               1,
                    16,
                           16,
                                 1, 18.070587
                    32,
                           32,
  32,
        32,
               1,
                                 1, 15.170370
```

```
48,
  48,
        48,
                1,
                     48,
                                  1, 21.684706
  64,
        64,
                     64,
               1,
                           64,
                                  1, 20.480000
                     80,
  80,
        80,
                1,
                           80,
                                  1, 22.228655
        96,
                     96,
  96,
                1,
                           96,
                                  1, 16.121283
  112,
        112,
                     112,
                            112,
                                    1, 18.910553
  128,
        128,
                     128,
                            128,
                                     1, 15.474853
  144,
        144,
                 1,
                     144,
                             144,
                                     1, 16.258217
  160,
        160,
                 1,
                     160,
                             160,
                                     1, 15.917098
  176,
         176,
                 1,
                     176,
                            176,
                                     1, 16.008268
  192,
        192,
                 1,
                     192,
                            192,
                                     1, 15.801679
 208,
        208,
                     208,
                 1.
                            208,
                                     1, 15.227100
                     224,
                            224,
 224,
        224,
                 1.
                                     1, 15.753846
        240,
                     240,
 240,
                 1,
                            240,
                                     1, 14.623929
./run bench op2 var01.x 16 256 16 1 1 -2
                                                     2
                                                          -2 | tee -a result bench op2 var01.csv
                                                 2
   m,
         n, rs_src, cs_src, rs_dst, cs_dst, GB_per_s
  16,
               2,
                     32,
                           32,
        16,
                                  2, 19.819355
               2,
  32,
        32,
                     64,
                           64,
                                  2, 22.341818
  48,
        48,
               2,
                    96,
                           96,
                                  2, 22.030279
               2,
  64,
                    128,
                           128,
        64,
                                   2, 18.103867
               2,
  80,
        80,
                    160,
                           160,
                                   2, 22.196531
               2,
  96,
        96,
                    192,
                           192,
                                   2, 22.184956
  112,
        112,
                2,
                     224,
                            224,
                                    2, 22.023117
  128,
                     256,
                            256,
                                    2, 14.451158
        128,
                 2,
  144,
        144,
                 2,
                     288,
                            288,
                                     2, 22.266846
  160,
        160,
                 2,
                     320,
                            320,
                                    2, 22.220613
  176,
        176,
                 2,
                     352,
                            352,
                                    2, 22.258204
  192,
         192,
                 2,
                     384,
                            384,
                                    2, 19.617207
 208,
        208,
                 2,
                     416,
                            416,
                                    2, 22.267553
 224,
        224,
                 2.
                     448,
                            448,
                                     2, 22.623032
 240,
        240,
                 2,
                     480,
                            480,
                                     2, 22.246540
./run bench op2 var01.x 16 256 16 1 -16 1 -1
                                                       -1
                                                              1 | tee -a
result bench op2 var01.csv
   m,
         n, rs_src, cs_src, rs_dst, cs_dst, GB_per_s
  16,
         16,
               16,
                      1,
                            1,
                                 16, 19.200001
  32,
                      1,
                            1,
                                 16, 38.400002
        16,
               16,
  48,
        16,
               16,
                      1,
                            1,
                                 16, 52.662857
  64,
        16,
                      1,
                            1,
               16,
                                 16, 70.217148
  80,
               16,
                      1,
                            1,
                                 16, 78.769234
         16,
  96,
         16,
               16,
                      1,
                            1,
                                 16, 94.523079
  112,
               16,
                       1,
                            1,
                                 16, 100.018608
         16,
```

```
128,
                                  16, 111.709084
         16,
                16,
                      1,
                            1,
  144,
         16,
                16,
                      1,
                            1,
                                  16, 115.199997
  160,
         16,
                16,
                      1,
                            1,
                                  16, 130.723404
  176,
         16,
                16,
                      1,
                            1,
                                  16, 127.516975
  192,
         16,
                16,
                      1,
                            1,
                                  16, 139.109436
 208,
         16,
                16,
                      1,
                            1,
                                  16, 142.628571
         16,
                16,
                       1,
                            1,
 224,
                                  16, 153.599991
 240,
         16,
                16,
                       1,
                             1,
                                  16, 156.203384
./run bench op2 var01.x 16 256 16 -16 1 1 -1
                                                       -1
                                                             1 | tee -a
result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
         16,
               16,
                      1,
                            1,
                                 16, 19.200001
  16,
        32,
               32,
                      1,
                            1,
                                 32, 10.971428
  16,
        48,
               48,
                                 48, 11.307976
                      1,
                            1,
                                 64, 10.547639
  16,
        64,
               64,
                      1,
                            1,
  16,
        80,
               80,
                      1,
                                 80, 11.420074
                            1,
  16,
        96,
               96,
                      1,
                            1,
                                 96, 11.484112
  16,
        112,
               112,
                       1,
                             1.
                                 112, 11.499466
  16,
        128,
               128,
                             1.
                                 128, 7.752682
                       1,
  16,
        144,
               144,
                             1,
                                 144, 10.374484
                       1,
  16,
        160,
               160,
                       1,
                             1,
                                 160, 10.413560
  16,
        176,
               176,
                       1,
                             1,
                                 176, 10.318169
  16,
        192,
               192,
                             1,
                       1,
                                 192, 9.562646
  16,
        208,
               208,
                       1,
                             1,
                                 208, 10.440784
        224,
  16,
               224,
                       1,
                             1,
                                 224, 10.363373
  16,
        240,
               240,
                       1,
                             1,
                                 240, 10.605293
touch result bench op2 var02.csv
./run bench op2 var02.x 16 256 16 1 1 1 -1
                                                    1
                                                          -1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                           16,
        16,
               16,
                      1,
                                  1, 21.186207
  32,
        32,
               32,
                      1,
                           32,
                                  1, 23.405714
  48,
        48,
               48,
                      1,
                           48,
                                  1, 21.942858
  64,
        64,
               64,
                      1,
                           64,
                                  1, 22.090786
        80,
                           80,
  80,
               80,
                      1,
                                  1, 23.522203
                           96,
  96,
        96,
               96,
                      1,
                                  1, 19.926487
  112,
        112,
               112,
                       1,
                           112,
                                    1, 21.321247
  128,
        128,
               128,
                        1.
                            128,
                                     1, 8.769313
        144,
                144,
  144,
                            144,
                                     1, 22.118401
                        1,
  160,
        160,
                160,
                        1,
                            160,
                                     1, 21.982111
  176,
        176,
                176,
                            176,
                                     1, 22.916893
```

```
1, 12.114693
  192,
        192,
               192,
                       1,
                            192,
 208,
        208,
               208,
                                    1, 22.224657
                       1,
                            208,
        224,
               224,
                            224,
 224,
                       1,
                                    1, 22.395834
 240,
        240,
               240,
                       1,
                            240,
                                    1, 22.293179
./run bench op2 var02.x 16 256 16 1 1 -1
                                                1
                                                   -1
                                                          1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               1,
                    16,
                           1,
                                16, 20.480000
  32,
        32,
               1,
                    32,
                           1,
                                32, 21.748672
  48,
        48,
               1,
                    48,
                           1,
                                48, 23.040001
  64,
        64,
                    64,
                                64, 22.090786
               1,
                           1,
                    80,
  80,
        80,
               1,
                           1,
                                80, 23.063063
  96,
        96.
               1,
                    96.
                           1,
                                96, 16.743679
  112,
        112,
                1,
                    112,
                             1,
                                112, 19.397938
  128,
        128,
                     128,
                                 128, 12.775049
                1,
                             1,
  144,
        144,
                1,
                     144,
                             1,
                                 144, 16.205275
  160,
        160,
                 1,
                     160,
                             1,
                                 160, 16.062746
                     176,
  176,
        176,
                 1,
                             1, 176, 16.042814
  192,
        192,
                     192,
                 1,
                             1.
                                 192, 15.776319
 208,
        208,
                     208,
                1,
                             1,
                                 208, 15.952312
 224,
        224,
                     224,
                 1,
                             1,
                                 224, 15.905746
 240,
        240,
                1,
                     240,
                                 240, 15.773619
                             1,
./run bench op2 var02.x 16 256 16 1 1 1
                                               -1
                                                    -1
                                                          1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               16,
                      1,
                           1,
                                16, 20.480000
  32,
        32,
               32,
                      1,
                           1,
                                32, 23.184904
  48,
        48,
              48,
                           1,
                                48, 23.040001
                      1,
                      1,
  64,
        64,
               64,
                           1,
                                64, 23.517702
        80,
               80,
                      1,
  80,
                           1,
                                80, 23.777090
        96,
               96,
  96,
                      1,
                           1.
                                96, 21.065144
  112,
        112,
               112,
                       1,
                             1,
                                112, 22.185408
  128,
        128,
               128,
                       1,
                             1,
                                 128, 22.456654
  144,
        144,
               144,
                             1,
                                 144, 22.590286
                       1,
  160,
        160,
               160,
                       1,
                             1,
                                 160, 22.959641
  176,
        176,
               176,
                       1,
                             1,
                                 176, 22.938107
  192,
        192,
               192,
                       1,
                             1,
                                 192, 23.239716
 208,
        208,
               208,
                       1,
                             1.
                                 208, 23.700891
 224,
        224,
               224,
                       1,
                             1.
                                 224, 23.252056
 240,
        240,
               240,
                       1,
                             1,
                                 240, 23.602526
./run bench op2 var02.x 16 256 16 1 1 -1
                                                1
                                                   1
                                                         -1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
```

```
1, 21.186207
  16,
         16,
                1,
                     16,
                           16,
  32,
        32,
                    32,
                           32,
                                  1, 22.75556
                1,
  48,
                           48,
        48,
                1,
                    48,
                                  1, 23.430508
  64,
        64,
                1,
                    64,
                           64,
                                  1, 22.090786
  80,
        80,
                1,
                    80,
                           80,
                                  1, 21.157024
  96,
        96,
                1,
                    96,
                           96,
                                  1, 16.655422
  112,
        112,
                1,
                     112,
                            112,
                                    1, 18.413212
  128,
        128,
                     128,
                            128,
                                    1, 6.262398
  144,
         144,
                 1,
                     144,
                            144,
                                    1, 15.894730
  160,
        160,
                 1,
                     160,
                            160,
                                    1, 14.278411
  176,
         176,
                 1.
                     176,
                            176,
                                    1, 15.601763
  192,
        192,
                 1.
                     192,
                            192,
                                    1, 6.959849
 208,
        208,
                 1,
                     208,
                            208,
                                    1, 15.546279
 224,
        224,
                 1,
                     224,
                            224,
                                    1, 8.126765
        240,
                 1,
                     240,
 240,
                            240,
                                    1, 15.387356
./run bench op2 var02.x 16 256 16 1 1 -2
                                                     2
                                                          -2 | tee -a result bench op2 var02.csv
                                                 2
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
               2,
                     32,
                           32,
                                  2, 21.186207
         16,
               2,
  32,
        32,
                    64,
                           64,
                                  2, 22.341818
  48,
               2,
                    96,
                           96,
                                  2, 22.849586
        48,
               2,
  64,
                    128,
                           128,
                                   2, 6.898526
        64,
               2,
  80,
        80,
                    160,
                           160,
                                   2, 15.073601
  96,
        96,
                2,
                    192,
                           192,
                                   2, 12.132968
  112,
        112,
                2,
                     224,
                            224,
                                    2, 14.370214
  128,
        128,
                 2,
                     256,
                            256,
                                    2, 2.292537
  144,
        144,
                 2,
                     288,
                            288,
                                    2, 13.824000
  160,
        160,
                 2,
                     320,
                            320,
                                    2, 7.215502
  176,
        176,
                 2,
                     352,
                            352,
                                    2, 10.533070
  192,
        192,
                 2.
                     384,
                            384,
                                    2, 5.988466
 208,
        208,
                 2,
                     416,
                            416,
                                    2, 8.715260
 224,
        224,
                 2,
                     448,
                            448,
                                    2, 6.902975
 240,
        240,
                 2,
                     480,
                            480,
                                    2, 7.705686
./run bench op2 var02.x 16 256 16 1 -16 1 -1
                                                       -1
                                                             1 | tee -a
result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                      1,
                            1,
                                 16, 21.186207
        16,
               16,
                                 16, 21.942856
  32,
               16,
                      1,
                           1,
        16,
  48,
                                 16, 22.755556
         16,
               16,
                      1,
                           1,
  64,
         16,
               16,
                      1,
                           1,
                                 16, 22.755556
  80,
               16,
                      1,
                                 16, 22.755556
         16,
                           1,
```

```
96,
         16,
                                 16, 22.755556
               16,
                      1,
                            1,
  112,
         16,
               16,
                      1,
                            1,
                                 16, 22.876595
  128,
         16,
                16,
                      1,
                            1,
                                 16, 22.861395
  144,
                                 16, 22.944399
         16,
                16,
                      1,
                            1,
  160,
         16,
                16,
                      1,
                            1,
                                 16, 22.925373
  176,
         16,
                16,
                      1,
                            1,
                                 16, 21.871845
                            1,
  192,
         16,
                16,
                      1,
                                 16, 23.040001
 208,
                            1,
         16,
                16,
                      1,
                                 16, 23.084393
 224,
         16,
                16,
                      1,
                            1,
                                 16, 22.937599
 240,
         16,
                16,
                      1,
                            1,
                                 16, 22.925373
./run bench op2 var02.x 16 256 16 -16 1 1 -1
                                                       -1
                                                             1 | tee -a
result bench op2 var02.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
         16,
                      1,
                            1,
                                 16, 15.753846
               16,
  16,
        32,
               32,
                      1,
                            1,
                                 32, 21.557896
  16,
        48,
               48,
                                 48, 22.207230
                      1,
                            1,
  16,
        64,
               64,
                      1,
                            1,
                                 64, 22.755556
  16,
        80,
               80,
                      1,
                            1,
                                 80, 22.75556
        96,
               96,
                      1,
                            1,
                                 96, 21.186207
  16,
        112,
               112,
                       1,
                             1,
                                 112, 21.504000
  16,
  16,
        128,
               128,
                             1,
                                 128, 21.748672
                       1,
  16,
        144,
               144,
                       1,
                             1,
                                 144, 22.118401
        160,
               160,
                             1,
                                 160, 22.588234
  16,
                       1,
  16,
        176,
               176,
                       1,
                             1,
                                 176, 22.755556
  16,
        192,
               192,
                       1,
                             1.
                                 192, 22.896894
  16,
        208,
               208,
                       1,
                             1,
                                 208, 21.528841
  16,
        224,
               224,
                       1,
                             1,
                                 224, 23.122581
                             1,
        240,
               240,
                       1,
                                 240, 23.331646
  16,
touch result bench op2 var03.csv
./run bench op2 var03.x 16 256 16 1 1 1
                                                          -1 | tee -a result bench op2 var03.csv
                                               -1
                                                    1
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                      1,
                           16,
                                  1, 15.360001
         16,
               16,
  32,
        32,
               32,
                      1,
                           32,
                                  1, 16.384001
                           48,
  48,
        48,
               48,
                      1,
                                  1, 16.506269
  64,
        64,
               64,
                      1,
                           64,
                                  1, 16.493959
        80,
                           80,
  80,
               80,
                      1,
                                  1, 16.516129
               96,
        96,
                           96,
  96,
                      1,
                                  1, 16.530941
  112,
        112,
               112,
                       1,
                            112,
                                    1, 16.642122
        128,
  128,
               128,
                        1,
                            128,
                                     1, 16.647587
  144,
        144,
                144,
                        1,
                            144,
                                     1, 16.649851
```

```
1, 16.851345
  160,
        160,
               160,
                       1,
                            160,
  176,
        176,
               176,
                       1,
                            176,
                                    1, 16.842411
        192,
  192,
               192,
                       1.
                            192,
                                    1, 16.756363
 208,
        208,
               208,
                       1,
                            208,
                                    1, 16.853369
 224,
        224,
               224,
                       1,
                            224,
                                    1, 16.854080
 240,
        240,
               240,
                       1,
                            240,
                                    1, 16.953642
./run bench op2 var03.x 16 256 16 1 1 -1
                                                1
                                                   -1
                                                          1 | tee -a result bench op2 var03.csv
awsomeandy911@LAPTOP-IFC4JBFG:~/cs4473-5473-lab/PROB01 TRANSPOSE$
  16,
        16,
               1,
                           1,
                                16, 2.292537
                    16,
  32,
        32,
               1,
                    32,
                           1,
                                32, 2.204125
  48,
        48,
               1,
                    48,
                           1,
                                48, 2.154949
  64,
        64,
                    64,
                                64, 2.175349
               1,
                           1,
  80,
        80,
               1,
                    80,
                           1,
                                80, 2.111921
  96,
        96,
               1,
                    96,
                           1,
                                96, 2.056760
  112,
        112,
                1,
                    112,
                            1,
                                112, 2.046608
  128,
        128,
                     128,
                                 128, 2.066295
                1,
                             1.
  144,
        144,
                1,
                     144,
                             1,
                                 144, 2.055189
  160,
        160,
                     160,
                             1.
                                 160, 2.051762
                1,
                             1,
  176,
        176,
                     176,
                                 176, 2.027336
                1,
  192,
        192,
                     192,
                1,
                             1,
                                 192, 2.013326
                                 208, 2.003272
 208,
        208,
                1,
                     208,
                             1,
 224,
        224,
                1,
                     224,
                             1,
                                 224, 1.980338
  240,
        240,
                1,
                     240,
                                 240, 1.959239
                             1,
./run bench op2 var03.x 16 256 16 1 1 1
                                              -1
                                                    -1
                                                          1 | tee -a result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               16,
                     1,
                           1,
                                16, 15.753846
  32,
        32,
              32,
                     1,
                           1,
                                32, 16.605406
  48,
        48,
              48,
                     1,
                           1,
                                48, 16.807295
  64,
        64,
              64,
                     1,
                           1,
                                64, 16.861750
        80,
               80,
  80,
                     1,
                           1,
                                80, 16.805252
  96,
        96,
              96,
                     1,
                           1,
                                96, 16.820076
  112,
        112,
               112,
                       1,
                            1,
                                112, 16.932283
  128,
        128,
               128,
                       1,
                             1,
                                 128, 16.941664
        144,
               144,
  144,
                       1,
                             1,
                                 144, 16.950409
  160,
        160,
               160,
                       1,
                             1.
                                 160, 16.948965
  176,
        176,
               176,
                       1,
                             1.
                                 176, 16.953796
        192,
  192,
               192,
                       1,
                             1.
                                 192, 16.955462
        208,
 208,
               208,
                       1,
                             1.
                                 208, 16.988482
               224,
 224,
        224,
                       1,
                             1,
                                 224, 16.906134
 240,
        240,
               240,
                       1,
                                 240, 16.838003
                             1,
```

```
./run bench op2 var03.x 16 256 16 1 1 -1 1 1
                                                         -1 | tee -a result bench op2 var03.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
        16,
               1,
                    16,
                           16,
                                 1, 15.753846
  32,
        32,
               1,
                    32,
                          32,
                                 1, 16.605406
  48,
        48,
               1,
                    48,
                          48,
                                 1, 16.705740
  64,
        64,
               1,
                    64,
                          64,
                                 1, 16.775427
                    80,
  80,
        80,
               1,
                          80,
                                 1, 16.805252
                    96,
  96,
        96,
               1,
                          96,
                                 1, 16.923031
  112,
        112,
                1,
                    112,
                           112,
                                    1, 16.932283
  128,
        128,
                     128,
                            128,
                                    1, 16.941664
                1.
  144,
        144,
                     144,
                            144,
                                    1, 16.950409
                1.
  160,
        160,
                     160,
                            160,
                                    1, 16.948965
                 1.
  176,
        176,
                 1,
                     176,
                            176,
                                    1, 16.953796
  192,
        192,
                     192,
                            192,
                                    1, 16.855326
                 1,
                     208,
 208,
        208,
                 1,
                           208,
                                    1, 16.847898
 224,
        224,
                     224,
                            224,
                 1,
                                    1, 16.771921
                     240,
  240,
        240,
                1.
                           240,
                                    1, 16.854425
./run bench op2 var03.x 16 256 16 1 1 -2
                                                    2
                                                         -2 | tee -a result bench op2 var03.csv
                                                2
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
               2,
                    32,
                          32,
  16,
        16,
                                 2, 22.755556
               2,
  32,
        32,
                    64,
                          64,
                                 2, 27.927271
  48,
        48,
               2,
                    96,
                          96,
                                 2, 28.356922
               2,
                   128,
                          128,
  64,
        64,
                                  2, 7.325186
  80,
        80,
               2,
                   160,
                          160,
                                  2, 14.898157
               2,
  96,
        96,
                   192,
                          192,
                                  2, 8.375010
                                   2, 14.714370
  112,
        112,
                2,
                    224,
                           224,
  128,
                     256,
                           256,
        128,
                2,
                                    2, 2.385296
  144,
        144,
                2,
                     288,
                            288,
                                    2, 13.082650
  160,
                     320,
        160,
                2.
                            320,
                                    2, 7.328244
                     352,
  176,
        176,
                2,
                            352,
                                    2, 12.632524
  192,
        192,
                2,
                     384,
                            384,
                                    2, 6.158541
 208,
        208,
                2,
                     416,
                            416,
                                    2, 9.649962
                2,
                     448,
                            448,
 224,
        224,
                                    2, 8.095079
        240,
                2,
                     480,
                            480,
 240,
                                    2, 7.923425
./run bench op2 var03.x 16 256 16 1 -16 1
                                                      -1
                                              -1
                                                            1 | tee -a
result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                      1,
                           1,
                                16, 15.753846
        16,
               16,
  32,
        16,
               16,
                      1,
                           1,
                                16, 16.384001
  48,
                      1,
                                16, 16.605406
        16,
               16,
                           1,
```

```
64,
        16,
                               16, 16.605406
              16,
                     1,
                          1,
        16,
  80,
              16,
                     1,
                          1,
                               16, 16.695652
  96,
        16,
              16,
                     1,
                          1,
                               16, 16.832876
  112,
                               16, 16.734631
         16,
               16,
                     1,
                          1,
  128,
         16,
               16,
                     1,
                           1,
                               16, 16.890722
  144,
         16,
               16,
                     1,
                           1,
                               16, 16.807295
  160,
                           1,
         16,
               16,
                     1,
                                16, 16.832878
  176,
                           1,
                               16, 16.811941
         16,
               16,
                     1,
  192,
         16,
               16,
                     1,
                           1,
                               16, 16.832876
 208,
                           1,
         16.
               16.
                     1,
                               16, 16.850634
 224,
                           1,
         16.
               16,
                     1.
                                16, 16.865883
 240,
         16.
               16,
                     1.
                           1,
                                16, 16.879122
/run bench op2 var03.x 16 256 16 -16 1 1 -1
                                                    -1
                                                          1 | tee -a
result bench op2 var03.csv
   m,
         n, rs_src, cs_src, rs_dst, cs_dst, GB_per_s
  16,
        16,
              16,
                     1,
                          1,
                               16, 15.753846
  16,
        32,
              32,
                     1,
                          1,
                               32, 16.384001
  16,
        48,
              48,
                     1,
                               48, 16.457142
                          1,
  16,
        64,
              64,
                     1,
                          1,
                               64, 16.493959
  16,
        80,
              80,
                     1,
                          1,
                               80, 16.605406
        96,
              96,
  16,
                     1,
                          1,
                               96, 16.605406
  16,
       112,
              112,
                     1,
                           1,
                               112, 16.669767
  16,
       128,
              128,
                               128, 16.661695
                      1,
                           1,
  16,
       144,
              144,
                      1,
                           1,
                               144, 16.605406
  16,
       160,
              160,
                      1,
                           1.
                               160, 16.741144
  16,
       176,
              176,
                      1,
                           1,
                               176, 16.728714
  16, 192,
              192,
                      1,
                           1,
                               192, 16.642889
  16,
       208,
              208,
                      1,
                           1,
                               208, 16.744654
       224,
              224,
                               224, 16.865883
  16.
                      1.
                           1.
       240,
              240,
                           1,
                               240, 16.756363
  16,
                      1,
awsomeandy911@LAPTOP-IFC4JBFG:~/cs4473-5473-lab/PROB01 TRANSPOSE$ make
./build test op2.sh
baseline op 02.c
optimized op 02 var 01.c
optimized op 02 var 02.c
optimized op 02 var 03.c
-std=c99 -O2 -mavx2 -mfma
touch result verification op2 var01.csv
./run test op2 var01.x 16 256 16 1 1 1
                                         -1 1
                                                     -1 | tee -a
result verification op2 var01.csv
```

```
n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
        16,
                     1,
                          16,
                                 1, PASS
               16,
                          32,
  32,
        32,
               32,
                     1,
                                 1, PASS
  48,
        48,
              48,
                     1,
                          48,
                                 1, PASS
  64,
        64,
              64,
                     1,
                          64,
                                 1, PASS
  80,
        80,
               80,
                     1,
                          80,
                                 1, PASS
        96,
                     1,
                          96,
  96,
               96,
                                 1, PASS
  112,
        112,
               112,
                       1,
                           112,
                                   1, PASS
  128,
        128,
               128,
                       1,
                           128,
                                    1, PASS
                                    1, PASS
  144,
        144,
               144,
                       1,
                           144,
  160,
        160,
               160,
                       1,
                           160,
                                    1, PASS
  176,
        176,
               176,
                       1,
                           176,
                                    1, PASS
  192,
        192,
               192,
                       1,
                           192,
                                    1, PASS
 208,
        208,
               208,
                       1,
                           208,
                                    1, PASS
        224,
               224,
                           224,
 224,
                       1,
                                    1, PASS
                           240,
               240,
 240,
        240,
                       1,
                                    1, PASS
./run test op2 var01.x 16 256 16 1 1 -1 1
                                                 -1
                                                       1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
               1,
                    16,
                           1,
                                16, PASS
  32,
        32,
                    32,
                                32, PASS
               1,
                           1,
  48,
        48,
                    48,
                                48, PASS
               1,
                           1,
  64,
                                64, PASS
        64,
               1,
                    64,
                           1,
  80,
        80,
               1,
                    80,
                           1,
                                80, PASS
                    96,
  96,
        96,
                           1,
                                96, PASS
               1,
  112,
        112,
                1,
                    112,
                            1,
                                112, PASS
  128,
                    128,
                                 128, PASS
        128,
                1,
                             1,
  144,
        144,
                     144,
                                 144, PASS
                1,
                             1,
  160,
                                 160, PASS
        160,
                1.
                     160,
                             1.
  176,
                                 176, PASS
        176,
                1,
                     176,
                             1,
  192,
        192,
                1,
                     192,
                             1,
                                 192, PASS
        208,
 208,
                1,
                    208,
                             1,
                                 208, PASS
        224,
 224,
                    224,
                                 224, PASS
                1,
                             1,
        240,
                1,
                     240,
                             1,
                                 240, PASS
 240,
/run test op2 var01.x 16 256 16 1 1 1
                                          -1
                                                 -1
                                                       1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                     1,
                           1,
                                16, FAIL
        16,
               16,
  32,
        32,
               32,
                     1,
                           1,
                                32, FAIL
  48,
        48,
              48,
                     1,
                           1,
                                48, FAIL
```

```
64, FAIL
  64,
        64,
              64,
                     1,
                           1,
  80,
        80,
                     1,
                           1,
                                80, FAIL
              80,
        96,
                     1,
                           1,
                                96, FAIL
  96,
              96,
  112,
        112,
               112,
                       1,
                            1,
                                112, FAIL
  128,
        128,
               128,
                       1,
                            1,
                                 128, FAIL
  144,
        144,
               144,
                       1,
                            1,
                                 144, FAIL
  160,
        160,
               160,
                       1,
                             1,
                                 160, FAIL
                       1,
  176,
        176,
               176,
                            1,
                                 176, FAIL
  192,
        192,
               192,
                       1,
                            1,
                                 192, FAIL
  208,
        208,
                                 208, FAIL
               208,
                       1,
                            1.
 224,
        224,
               224,
                       1,
                             1.
                                 224, FAIL
        240,
               240,
                       1,
                             1.
                                 240, FAIL
 240,
./run test op2 var01.x 16 256 16 1 1 -1 1
                                                 1
                                                      -1 | tee -a
result verification op2 var01.csv
   m,
         n, rs_src, cs_src, rs_dst, cs_dst, result
  16,
        16,
               1,
                    16,
                          16,
                                 1, FAIL
  32,
        32,
               1,
                    32,
                          32,
                                 1, FAIL
  48,
        48,
                    48,
                          48,
                                 1, FAIL
               1,
  64,
                    64,
                          64,
                                 1, FAIL
        64,
               1,
  80,
        80,
                    80,
                          80,
                                 1, FAIL
               1,
                    96,
  96,
        96,
               1,
                          96,
                                 1, FAIL
  112,
        112,
                1,
                    112,
                          112,
                                   1, FAIL
  128,
                                   1, FAIL
        128,
                1,
                    128,
                           128,
awsomeandy911@LAPTOP-IFC4JBFG:~/cs4473-5473-lab/PROB01 TRANSPOSE$
  160,
                    160,
                                   1, FAIL
        160,
                           160,
  176,
        176,
                1,
                    176,
                           176,
                                   1, FAIL
  192,
                    192,
                           192,
                                   1, FAIL
        192,
                1,
 208,
        208,
                    208,
                           208,
                                   1, FAIL
                1,
                                   1, FAIL
 224,
        224,
                    224,
                           224,
                1.
        240,
                1,
                    240,
                           240,
                                   1, FAIL
 240,
./run test op2 var01.x 16 256 16 1 1 -2
                                             2
                                                 2
                                                      -2 | tee -a
result verification op2 var01.csv
         n, rs_src, cs_src, rs_dst, cs_dst, result
   m,
  16,
        16,
               2,
                    32,
                          32,
                                 2, FAIL
  32,
        32,
               2,
                    64,
                          64,
                                 2, FAIL
  48,
        48,
               2,
                    96,
                          96,
                                 2, FAIL
               2,
  64,
        64,
                   128,
                          128,
                                  2, FAIL
               2,
  80,
        80,
                   160,
                          160,
                                  2, FAIL
  96,
               2,
        96,
                   192,
                          192,
                                  2, FAIL
  112,
                2,
                    224,
                                   2, FAIL
        112,
                           224,
```

```
2, FAIL
  128,
         128,
                 2,
                     256,
                            256,
  144,
                 2,
                     288,
                            288,
                                     2, FAIL
         144,
  160,
         160,
                 2,
                     320,
                            320,
                                     2, FAIL
  176,
                 2,
         176,
                     352,
                            352,
                                     2, FAIL
  192,
         192,
                 2,
                     384,
                            384,
                                     2, FAIL
                 2,
 208,
         208,
                     416,
                            416,
                                     2, FAIL
         224,
                 2,
                            448,
                                     2, FAIL
 224,
                     448,
                 2,
                            480,
 240,
         240,
                     480,
                                     2, FAIL
./run test op2 var01.x 16 256 16 1 -16 1
                                                -1
                                                     -1
                                                           1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
         16,
               16,
                      1,
                                 16, FAIL
                            1,
  32,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  48,
                                 16, FAIL
         16,
               16,
                      1,
                            1,
  64,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  80,
                                 16, FAIL
         16,
               16,
                      1,
                            1,
  96,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  112,
                                  16, FAIL
         16,
                16,
                       1,
                            1,
  128,
                                  16, FAIL
         16,
                16,
                       1,
                            1,
  144,
                                  16, FAIL
         16,
                16,
                       1,
                             1,
  160,
                             1,
                                  16, FAIL
         16,
                16,
                       1,
  176,
         16,
                16,
                       1,
                             1,
                                  16, FAIL
  192,
         16,
                16,
                       1,
                             1,
                                  16, FAIL
  208,
         16,
                16,
                       1,
                             1,
                                  16, FAIL
 224,
         16,
                16,
                       1,
                             1,
                                  16, FAIL
 240,
         16,
                16,
                       1,
                             1,
                                  16, FAIL
./run test op2 var01.x 16 256 16 -16 1 1
                                                -1
                                                     -1
                                                           1 | tee -a
result verification op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
         16,
               16,
                      1,
                            1,
                                 16, FAIL
  16,
         32,
               32,
                      1,
                            1,
                                 32, FAIL
  16,
                                 48, FAIL
         48,
               48,
                      1,
                            1,
  16,
         64,
               64,
                      1,
                            1,
                                 64, FAIL
         80,
                                 80, FAIL
  16,
               80,
                      1,
                            1,
  16,
         96,
               96,
                      1,
                            1,
                                 96, FAIL
  16,
        112,
               112,
                       1,
                             1,
                                 112, FAIL
  16,
        128,
               128,
                             1,
                                  128, FAIL
                       1,
  16,
        144,
               144,
                       1,
                             1,
                                  144, FAIL
  16,
        160,
               160,
                       1,
                             1,
                                  160, FAIL
  16,
                             1,
                                  176, FAIL
        176,
               176,
                       1,
```

```
192, FAIL
  16,
        192,
              192,
                       1,
                            1,
  16,
       208,
                       1,
                            1,
                                208, FAIL
              208,
       224,
              224,
                                224, FAIL
  16,
                       1,
                            1,
       240,
                       1,
                            1,
                                240, FAIL
              240,
grep -i "FAIL" result verification op2 var01.csv | wc -l
900
touch result verification op2 var02.csv
                                          -1 1
./run test op2 var02.x 16 256 16 1 1 1
                                                      -1 | tee -a
result_verification_op2_var02.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
                     1,
                          16,
                                 1, PASS
              16,
  32,
        32,
              32,
                          32,
                                 1, PASS
                     1,
  48,
        48,
              48,
                     1,
                          48,
                                 1, PASS
  64,
        64,
                     1,
                          64,
                                 1, PASS
              64,
  80,
        80,
              80,
                     1,
                          80,
                                 1, PASS
  96,
        96,
              96,
                     1,
                          96,
                                 1, PASS
  112,
        112,
               112,
                       1,
                          112,
                                   1, PASS
  128,
        128,
               128,
                           128,
                                   1, PASS
                       1,
  144,
        144,
               144,
                           144,
                                   1, PASS
                       1,
  160,
        160,
               160,
                                   1, PASS
                       1,
                           160,
  176,
        176,
               176,
                       1,
                           176,
                                   1, PASS
  192,
        192,
               192,
                       1,
                           192,
                                   1, PASS
  208,
        208,
               208,
                           208,
                                   1, PASS
                       1,
 224,
        224,
               224,
                       1,
                           224,
                                   1, PASS
  240,
        240,
               240,
                       1,
                           240,
                                   1, PASS
./run test op2 var02.x 16 256 16 1 1 -1
                                            1
                                                 -1
                                                       1 | tee -a
result verification_op2_var02.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
                           1,
                                16, PASS
        16,
               1,
                    16,
  32,
        32,
               1,
                    32,
                           1,
                                32, PASS
  48,
        48,
                    48,
                           1,
                                48, PASS
               1,
  64,
                    64,
                           1,
                                64, PASS
        64,
               1,
                    80,
                                80, PASS
  80,
        80,
               1,
                           1,
        96,
  96,
                    96,
                                96, PASS
               1,
                           1,
  112,
                    112,
                            1,
                                112, PASS
        112,
                1,
  128,
        128,
                     128,
                                 128, PASS
                1,
                             1,
  144,
        144,
                1.
                    144,
                             1,
                                 144, PASS
  160,
        160,
                     160,
                             1,
                                 160, PASS
                1,
  176,
        176,
                     176,
                             1,
                                 176, PASS
  192,
        192,
                     192,
                                 192, PASS
                1,
                             1,
```

```
208,
                    208,
                                 208, PASS
 208,
                1,
                             1,
 224,
        224,
                    224,
                             1,
                                 224, PASS
                1,
 240,
        240,
                    240,
                             1,
                                 240, PASS
                1.
./run test op2 var02.x 16 256 16 1 1 1 -1
                                                 -1
                                                       1 | tee -a
result verification op2 var02.csv
         n, rs_src, cs_src, rs_dst, cs_dst, result
  m,
  16,
        16,
               16,
                     1,
                           1,
                                16, PASS
  32,
        32,
               32,
                     1,
                           1,
                                32, PASS
  48,
        48,
              48,
                     1,
                           1,
                                48, PASS
  64,
        64,
              64,
                     1,
                           1,
                                64, PASS
                     1,
  80,
        80,
               80,
                           1,
                                80, PASS
        96,
                     1,
  96,
              96,
                           1,
                                96, PASS
  112,
        112,
               112,
                       1,
                            1,
                                112, PASS
  128,
        128,
               128,
                       1,
                             1,
                                 128, PASS
  144,
        144,
               144,
                       1,
                             1,
                                 144, PASS
  160,
        160,
               160,
                       1,
                             1,
                                 160, PASS
  176,
        176,
               176,
                       1,
                             1,
                                 176, PASS
  192,
        192,
               192,
                       1,
                             1,
                                 192, PASS
 208,
        208,
               208,
                       1,
                             1,
                                 208, PASS
                       1,
 224,
        224,
               224,
                             1,
                                 224, PASS
               240,
                       1,
                             1,
                                 240, PASS
 240,
        240,
./run test op2 var02.x 16 256 16 1 1 -1
                                           1
                                                 1
                                                      -1 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
                                 1, PASS
  16,
        16,
               1,
                    16,
                          16,
  32,
        32,
               1,
                    32,
                          32,
                                 1, PASS
  48,
                    48,
                          48,
                                 1, PASS
        48,
               1,
                    64,
                                 1, PASS
  64,
        64,
               1,
                          64,
                    80,
                          80,
                                 1, PASS
  80,
        80,
               1,
        96,
                    96,
                          96,
                                 1, PASS
  96,
               1,
  112,
        112,
                1,
                    112,
                           112,
                                   1, PASS
  128,
        128,
                     128,
                            128,
                                    1, PASS
                1,
  144,
                                    1, PASS
        144,
                1,
                     144,
                            144,
  160,
        160,
                                    1, PASS
                1,
                     160,
                            160,
  176,
        176,
                     176,
                            176,
                                    1, PASS
                1,
  192,
        192,
                     192,
                            192,
                                    1, PASS
                1,
 208,
        208,
                    208,
                           208,
                                    1, PASS
                1.
 224,
        224,
                1,
                     224,
                           224,
                                    1, PASS
 240,
        240,
                1,
                    240,
                           240,
                                    1, PASS
```

```
./run test op2 var02.x 16 256 16 1 1 -2
                                            2
                                                 2
                                                      -2 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
                          32,
                                 2, PASS
        16,
               2,
                    32,
  32,
        32,
               2,
                    64,
                          64,
                                 2, PASS
  48,
        48,
               2,
                    96,
                          96,
                                 2, PASS
               2,
  64,
        64,
                   128,
                          128,
                                  2, PASS
        80,
               2,
                   160,
                          160,
  80,
                                  2, PASS
               2,
                                  2, PASS
  96,
        96,
                   192,
                          192,
                2,
                                   2, PASS
  112,
        112,
                    224,
                           224,
                    256,
                                   2, PASS
  128,
        128,
                2,
                           256,
  144,
                    288,
                           288,
                                   2, PASS
        144,
                2,
  160,
        160,
                2,
                    320,
                           320,
                                   2, PASS
  176,
        176,
                2,
                    352,
                           352,
                                   2, PASS
  192,
                2,
        192,
                    384,
                           384,
                                   2, PASS
  208,
        208,
                2,
                    416,
                           416,
                                   2, PASS
 224,
        224,
                2,
                    448,
                           448,
                                   2, PASS
 240,
        240,
                2,
                    480,
                           480,
                                   2, PASS
/run test op2 var02.x 16 256 16 1 -16 1
                                              -1
                                                   -1
                                                         1 | tee -a
result verification op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, result
   m,
  16,
        16,
              16,
                     1,
                           1,
                                16, PASS
  32,
                                16, PASS
        16,
              16,
                     1,
                           1,
  48,
        16,
              16,
                     1,
                           1,
                                16, PASS
  64,
        16,
                     1,
                           1,
                                16, PASS
              16,
  80,
        16,
              16,
                     1,
                           1,
                                16, PASS
  96,
                     1,
                                16, PASS
        16,
              16,
                           1,
  112,
                      1,
                           1,
                                16, PASS
         16,
               16,
  128,
                                16, PASS
         16,
               16,
                      1,
                           1.
  144,
                                16, PASS
         16,
               16,
                      1,
                           1,
  160,
         16,
               16,
                      1,
                           1,
                                16, PASS
  176,
         16,
               16,
                      1,
                           1,
                                16, PASS
  192,
         16,
               16,
                      1,
                           1,
                                16, PASS
 208,
                           1,
                                16, PASS
         16,
               16,
                      1,
 224,
         16,
               16,
                      1,
                           1,
                                 16, PASS
  240,
                           1,
                                16, PASS
         16,
               16,
                      1,
./run test op2 var02.x 16 256 16 -16 1 1
                                              -1
                                                   -1
                                                         1 | tee -a
result verification op2 var02.csv
  m,
         n, rs src, cs src, rs dst, cs dst, result
  16,
        16,
                     1,
                           1,
                                16, PASS
              16,
```

```
32, PASS
  16,
        32,
              32,
                     1,
                          1,
              48,
  16,
        48,
                               48, PASS
                     1,
                          1,
  16,
        64,
              64,
                     1,
                          1,
                               64, PASS
        80,
  16,
              80,
                     1,
                          1,
                               80, PASS
  16,
        96,
              96,
                     1,
                           1,
                               96, PASS
  16,
        112,
              112,
                      1,
                           1,
                                112, PASS
  16,
        128,
              128,
                      1,
                            1,
                                128, PASS
  16,
       144,
              144,
                      1,
                            1,
                                144, PASS
  16,
       160,
              160,
                      1,
                            1,
                                160, PASS
  16,
       176,
              176,
                      1,
                            1,
                                176, PASS
  16,
       192,
              192,
                      1,
                            1.
                                192, PASS
                      1,
                                208, PASS
  16,
       208,
              208,
                            1.
                                224, PASS
  16,
       224,
              224,
                      1,
                            1,
  16,
       240,
              240,
                      1,
                            1,
                                240, PASS
grep -i "FAIL" result_verification_op2_var02.csv | wc -l
0
touch result verification op2 var03.csv
./run test op2 var03.x 16 256 16 1 1 1
                                           -1
                                                1
                                                     -1 | tee -a
result verification_op2_var03.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
                     1,
                          16,
                                 1, PASS
        16,
              16,
  32,
        32,
              32,
                     1,
                          32,
                                 1, PASS
  48,
                          48,
                                 1, PASS
        48,
              48,
                     1,
  64,
        64,
              64,
                     1,
                          64,
                                 1, PASS
  80,
        80,
              80,
                     1,
                          80,
                                 1, PASS
  96,
        96,
              96,
                     1,
                          96,
                                 1, PASS
  112,
                                   1, PASS
        112,
               112,
                       1,
                          112,
  128,
        128,
               128,
                           128,
                                   1, PASS
                       1,
 144,
                                   1, PASS
        144,
               144,
                       1.
                           144,
 160,
        160,
               160,
                                   1, PASS
                       1,
                           160,
 176,
        176,
               176,
                       1,
                           176,
                                   1, PASS
 192,
        192,
               192,
                       1,
                           192,
                                   1, PASS
        208,
 208,
                           208,
                                   1, PASS
               208,
                       1,
 224,
        224,
               224,
                           224,
                                   1, PASS
                       1,
               240,
 240,
        240,
                       1,
                           240,
                                   1, PASS
./run test op2 var03.x 16 256 16 1 1 -1 1
                                                 -1
                                                       1 | tee -a
result verification op2 var03.csv
   m,
         n, rs src, cs src, rs dst, cs dst, result
  16,
        16,
               1,
                    16,
                          1,
                                16, PASS
  32,
                    32,
        32,
               1,
                          1,
                                32, PASS
```

```
48,
                                48, PASS
        48,
               1,
                    48,
                           1,
        64,
                    64,
                                64, PASS
  64,
               1,
                           1,
  80,
        80,
               1,
                    80,
                           1,
                                80, PASS
        96,
                                96, PASS
  96,
               1,
                    96,
                           1,
  112,
        112,
                1,
                    112,
                             1,
                                112, PASS
  128,
        128,
                1,
                     128,
                             1,
                                 128, PASS
  144,
        144,
                1,
                     144,
                             1,
                                 144, PASS
  160,
        160,
                1,
                     160,
                             1,
                                 160, PASS
  176,
        176,
                1,
                     176,
                             1,
                                 176, PASS
  192,
        192,
                1,
                     192,
                             1.
                                 192, PASS
 208,
        208,
                     208,
                                 208, PASS
                1.
                             1.
                     224,
                                 224, PASS
 224,
        224,
                1,
                             1.
        240,
                     240,
                                 240, PASS
 240,
                1,
                             1,
./run test op2_var03.x 16 256 16 1 1 1
                                          -1
                                                  -1
                                                        1 | tee -a
result_verification_op2_var03.csv
  m,
         n, rs src, cs src, rs dst, cs dst, result
  16,
        16,
               16,
                     1,
                           1,
                                16, PASS
  32,
        32,
               32,
                                32, PASS
                     1,
                           1,
  48,
        48,
              48,
                           1,
                                48, PASS
                     1,
                     1,
                                64, PASS
  64,
        64,
              64,
                           1,
  80,
        80,
               80,
                     1,
                           1,
                                80, PASS
  96,
        96,
               96,
                     1,
                           1,
                                96, PASS
                       1,
                            1,
  112,
        112,
               112,
                                112, PASS
  128,
        128,
               128,
                       1,
                             1,
                                 128, PASS
  144,
        144,
               144,
                       1,
                             1,
                                 144, PASS
  160,
        160,
               160,
                       1,
                             1,
                                 160, PASS
  176,
        176,
                       1,
                             1,
                                 176, PASS
               176,
  192,
        192,
               192,
                       1,
                             1,
                                 192, PASS
  208,
        208,
               208,
                       1,
                             1.
                                 208, PASS
 224,
        224,
               224,
                       1,
                             1,
                                 224, PASS
  240,
        240,
               240,
                       1,
                             1,
                                 240, PASS
./run test op2 var03.x 16 256 16 1 1 -1 1
                                                 1
                                                       -1 | tee -a
result_verification_op2_var03.csv
   m,
         n, rs_src, cs_src, rs_dst, cs_dst, result
  16,
                          16,
                                 1, PASS
        16,
               1,
                    16,
  32,
        32,
                    32,
                          32,
                                 1, PASS
               1,
  48,
        48,
                    48,
                          48,
                                 1, PASS
               1,
  64,
                    64,
                          64,
                                 1, PASS
        64,
               1,
                    80,
                          80,
  80,
        80,
               1,
                                 1, PASS
  96,
        96,
               1,
                    96,
                          96,
                                 1, PASS
```

```
1, PASS
  112,
        112,
                1,
                     112,
                            112,
  128,
        128,
                                    1, PASS
                 1,
                     128,
                            128,
  144,
        144,
                 1,
                     144,
                            144,
                                    1, PASS
                                    1, PASS
  160,
        160,
                 1,
                     160,
                            160,
  176,
        176,
                 1,
                     176,
                            176,
                                    1, PASS
  192,
        192,
                 1,
                     192,
                            192,
                                    1, PASS
 208,
                     208,
        208,
                 1,
                            208,
                                    1, PASS
                     224,
                            224,
                                    1, PASS
 224,
        224,
                 1,
 240,
        240,
                 1,
                     240,
                            240,
                                    1, PASS
./run test op2 var03.x 16 256 16 1 1 -2
                                             2
                                                  2
                                                       -2 | tee -a
result verification op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
        16,
               2,
                    32,
                          32,
                                 2, PASS
  32,
        32,
               2,
                    64,
                          64,
                                 2, PASS
  48,
        48,
               2,
                    96,
                          96,
                                 2, PASS
               2,
                    128,
                           128,
                                   2, PASS
  64,
        64,
               2,
  80,
        80,
                    160,
                           160,
                                   2, PASS
  96,
        96,
               2,
                    192,
                           192,
                                   2, PASS
        112,
                                    2, PASS
  112,
                2,
                    224,
                           224,
  128,
        128,
                2,
                     256,
                            256,
                                    2, PASS
  144,
        144,
                2,
                     288,
                            288,
                                    2, PASS
  160,
        160,
                2,
                     320,
                            320,
                                    2, PASS
  176,
                2,
                     352,
                            352,
                                    2, PASS
        176,
  192,
        192,
                2,
                     384,
                            384,
                                    2, PASS
 208,
        208,
                2,
                     416,
                            416,
                                    2, PASS
 224,
        224,
                2,
                     448,
                            448,
                                    2, PASS
  240,
        240,
                2,
                     480,
                            480,
                                    2, PASS
./run test op2 var03.x 16 256 16 1 -16 1
                                              -1
                                                    -1
                                                          1 | tee -a
result verification op2 var03.csv
         n, rs_src, cs_src, rs_dst, cs dst, result
   m,
  16,
        16,
               16,
                      1,
                           1,
                                16, PASS
  32,
                                16, PASS
        16,
               16,
                      1,
                           1,
  48,
        16,
               16,
                      1,
                           1,
                                16, PASS
  64,
        16,
               16,
                      1,
                           1,
                                16, PASS
  80,
                      1,
                           1,
                                16, PASS
        16,
               16,
  96,
                                16, PASS
        16,
               16,
                      1,
                           1,
  112,
         16,
                      1,
                            1,
                                 16, PASS
               16,
  128,
                            1,
                                 16, PASS
         16,
               16,
                      1,
  144,
         16,
               16,
                      1,
                            1,
                                 16, PASS
  160,
                            1,
                                 16, PASS
         16,
               16,
                      1,
```

```
176,
                               16, PASS
         16,
              16,
                     1,
                          1,
  192,
                               16, PASS
         16,
              16,
                     1,
                          1,
                               16, PASS
 208,
                     1,
                          1,
         16.
              16.
                          1,
                               16, PASS
 224,
         16,
              16,
                     1,
 240,
         16,
              16,
                     1,
                          1,
                               16, PASS
./run test op2 var03.x 16 256 16 -16 1 1
                                            -1
                                                 -1
                                                      1 | tee -a
result verification op2 var03.csv
        n, rs src, cs src, rs dst, cs dst, result
  m,
  16,
        16,
              16,
                    1,
                          1,
                              16, PASS
                              32, PASS
  16,
        32,
              32,
                    1,
                          1,
                              48, PASS
  16,
        48,
              48,
                    1,
                          1,
        64,
                              64, PASS
  16,
              64,
                    1,
                          1,
  16,
        80,
              80,
                    1,
                          1,
                              80, PASS
  16,
        96,
              96,
                    1,
                          1,
                              96, PASS
  16,
       112,
              112,
                     1,
                          1,
                              112, PASS
  16,
       128,
              128,
                     1,
                           1,
                               128, PASS
  16,
       144,
              144,
                     1,
                           1.
                               144, PASS
  16,
       160,
              160,
                      1,
                           1,
                               160, PASS
                           1,
  16,
       176,
              176,
                      1,
                              176, PASS
                              192, PASS
  16,
      192,
              192,
                      1,
                           1,
                              208, PASS
  16, 208,
              208,
                      1,
                           1,
  16, 224,
              224,
                      1,
                           1,
                               224, PASS
  16, 240,
              240,
                      1,
                           1,
                               240, PASS
grep -i "FAIL" result verification op2 var03.csv | wc -l
./build bench op2.sh
baseline op 02.c
optimized op 02 var 01.c
optimized op 02 var 02.c
optimized op 02 var 03.c
-std=c99 -O2 -mavx2 -mfma
touch result bench op2 var01.csv
./run bench op2 var01.x 16 256 16 1 1 1 -1 1
                                                      -1 | tee -a result bench op2 var01.csv
        n, rs src, cs src, rs dst, cs dst, GB per s
  m,
  16,
        16,
              16,
                    1,
                         16,
                                1, 19.200001
  32,
        32,
              32,
                    1,
                         32,
                               1, 22.546789
                         48,
  48,
        48,
              48,
                    1.
                               1, 22.207230
  64,
        64,
              64,
                    1,
                         64,
                               1, 21.510721
  80,
        80,
              80,
                         80,
                    1,
                                1, 22.228655
                         96,
  96,
        96,
              96,
                    1,
                                1, 22.364408
```

```
1, 22.007017
  112,
        112,
               112,
                        1,
                            112,
  128,
        128,
               128,
                        1,
                            128,
                                     1, 14.477762
                        1,
  144,
        144,
                144,
                            144,
                                     1, 22.138079
  160,
        160,
                160,
                        1,
                            160,
                                     1, 22.228655
  176,
        176,
                176,
                        1,
                            176,
                                     1, 22.514355
  192,
        192,
                192,
                        1,
                            192,
                                     1, 19.617207
        208,
 208,
               208,
                        1,
                            208,
                                     1, 22.134640
        224,
               224,
                            224,
 224,
                        1,
                                     1, 22.185408
 240,
        240,
               240,
                        1,
                            240,
                                     1, 22.037302
./run bench op2 var01.x 16 256 16 1 1 -1
                                                 1
                                                     -1
                                                           1 | tee -a result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                     16,
                            1,
                                 16, 18.618181
        16,
                1,
  32,
        32,
                1,
                     32,
                            1,
                                 32, 22.341818
  48,
                    48,
                                48, 22.207230
        48,
                1,
                            1,
                                 64, 21.416994
  64,
        64,
                1,
                    64,
                            1,
  80,
        80,
                    80,
                1,
                            1,
                                 80, 22.325583
                    96,
                                 96, 22.409727
  96,
        96,
                1,
                            1,
  112,
                     112,
                             1,
                                 112, 22.055384
        112,
                1,
  128,
                     128,
        128,
                 1,
                             1,
                                  128, 14.579755
  144,
        144,
                 1,
                     144,
                             1,
                                  144, 22.256887
  160,
        160,
                     160,
                                  160, 22.358078
                 1,
                             1,
 176,
        176,
                 1,
                     176,
                             1,
                                  176, 22.264870
 192,
        192,
                     192,
                 1,
                             1,
                                  192, 19.552177
 208,
        208,
                 1,
                     208,
                             1,
                                  208, 22.125208
 224,
        224,
                     224,
                                  224, 22.095854
                 1,
                              1,
 240,
        240,
                 1,
                     240,
                              1,
                                  240, 21.953312
./run bench op2 var01.x 16 256 16 1 1 1
                                                -1
                                                     -1
                                                           1 | tee -a result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
  m,
  16,
               16,
                      1,
                            1,
                                 16, 19.200001
        16,
  32,
        32,
               32,
                      1,
                            1,
                                 32, 18.904615
  48,
        48,
               48,
                      1,
                            1,
                                48, 21.942858
  64,
                      1,
                            1,
                                64, 20.960340
        64,
               64,
                      1,
  80,
        80,
               80,
                            1,
                                 80, 22.260870
               96,
        96,
                      1,
  96,
                            1,
                                 96, 22.75556
  112,
        112,
               112,
                        1,
                             1,
                                 112, 22.567917
 128,
        128,
               128,
                             1.
                        1,
                                  128, 15.474853
                                  144, 22.672621
 144,
        144,
               144,
                        1,
                             1.
  160,
        160,
                160,
                        1,
                             1.
                                  160, 22.797775
 176,
        176,
                176,
                        1,
                             1,
                                  176, 22.860518
  192,
        192,
                192,
                        1,
                             1,
                                  192, 20.783087
```

```
208, 22.484539
 208,
        208,
               208,
                        1,
                             1,
 224,
        224,
               224,
                        1,
                             1,
                                  224, 22.597559
        240,
               240,
                                  240, 22.343622
  240,
                       1,
                             1,
./run bench op2 var01.x 16 256 16 1 1 -1
                                              1
                                                    1
                                                         -1 | tee -a result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
                    16,
                           16,
                                  1, 17.554287
               1,
  32,
        32,
               1,
                    32,
                           32,
                                  1, 14.804820
  48,
        48,
               1,
                    48,
                          48,
                                  1, 20.945454
  64,
        64,
               1,
                    64,
                           64,
                                  1, 20.310743
  80,
        80,
                    80,
                           80,
                                  1, 21.911554
               1,
  96,
        96,
               1,
                    96,
                           96,
                                  1, 15.923974
  112,
        112,
                1.
                    112,
                           112,
                                    1, 18.641237
  128,
        128,
                 1,
                     128,
                            128,
                                    1, 15.223228
  144,
        144,
                     144,
                                    1, 16.064041
                 1,
                            144,
  160,
        160,
                 1,
                     160,
                            160,
                                    1, 15.709537
  176,
        176,
                     176,
                 1,
                            176,
                                    1, 16.080986
  192,
        192,
                 1.
                     192,
                            192,
                                    1, 15.706303
 208,
        208,
                     208,
                            208,
                 1,
                                    1, 15.200352
 224,
        224,
                     224,
                            224,
                 1,
                                    1, 15.745606
 240,
        240,
                 1,
                     240,
                            240,
                                    1, 14.550047
./run bench op2 var01.x 16 256 16 1 1 -2
                                                     2
                                                          -2 | tee -a result bench op2 var01.csv
                                                2
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               2,
                    32,
                           32,
                                  2, 19.200001
  32,
        32,
               2,
                    64,
                           64,
                                  2, 22.140541
  48,
               2,
                    96,
                          96,
        48,
                                  2, 21.942858
  64,
        64,
               2,
                    128,
                           128,
                                   2, 19.051163
               2,
                    160,
  80,
        80,
                           160,
                                   2, 22.293179
  96,
        96,
               2,
                    192,
                           192,
                                   2, 22.296774
                2,
  112,
        112,
                    224,
                           224,
                                    2, 22.316977
                     256,
                                    2, 14.612263
  128,
        128,
                 2,
                            256,
  144,
        144,
                 2,
                     288,
                            288,
                                    2, 22.397120
  160,
        160,
                 2,
                     320,
                            320,
                                    2, 22.366217
  176,
        176,
                 2,
                     352,
                            352,
                                    2, 22.258204
  192,
        192,
                 2,
                     384,
                            384,
                                    2, 19.621557
 208,
        208,
                 2,
                     416,
                            416,
                                    2, 22.248468
 224,
        224,
                 2,
                     448,
                            448,
                                    2, 22.027143
                            480,
 240,
        240,
                     480,
                                    2, 22.200096
./run bench op2 var01.x 16 256 16 1 -16 1
                                                       -1
                                                 -1
                                                             1 | tee -a
result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
```

```
16,
         16,
                                 16, 19.200001
               16,
                      1,
                           1,
  32,
        16,
               16,
                      1,
                           1,
                                 16, 38.400002
  48,
         16,
               16,
                      1,
                           1,
                                 16, 49.816216
  64,
         16,
               16,
                      1,
                           1,
                                 16, 68.266670
  80,
         16,
               16,
                      1,
                           1,
                                 16, 65.361702
  96,
         16,
               16,
                      1,
                           1,
                                 16, 94.523079
  112,
                            1,
         16,
               16,
                      1,
                                 16, 100.018608
  128,
                            1,
         16,
                16,
                      1,
                                 16, 114.306984
  144,
         16,
                16,
                      1,
                            1,
                                 16, 120.208702
  160,
         16,
                16,
                      1,
                            1,
                                 16, 133.565216
  176,
         16,
                16,
                      1,
                            1,
                                 16, 140.800003
  192,
                            1,
         16,
                16,
                      1,
                                 16, 150.465317
                            1,
 208,
         16,
                16,
                      1,
                                 16, 142.628571
 224,
         16,
                16,
                      1,
                            1,
                                 16, 153.599991
 240,
         16,
                16,
                       1,
                            1,
                                 16, 153.600006
./run bench op2 var01.x 16 256 16 -16 1 1 -1
                                                       -1
                                                             1 | tee -a
result bench op2 var01.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
         16,
               16,
                      1,
                            1,
                                 16, 19.200001
  16,
        32,
               32,
                      1,
                                32, 9.675591
                           1,
                                48, 11.377778
  16,
        48,
               48,
                      1,
                           1,
  16,
        64,
               64,
                      1,
                           1,
                                64, 10.638961
        80,
               80,
                      1,
                           1,
                                 80, 11.462687
  16,
  16,
        96,
               96,
                      1,
                            1,
                                96, 11.484112
                                 112, 11.499466
  16,
        112,
               112,
                            1,
                       1,
  16,
        128,
               128,
                       1,
                             1,
                                 128, 7.777215
        144,
               144,
                             1,
                                 144, 11.520000
  16,
                       1,
                                 160, 11.548872
  16,
        160,
               160,
                       1,
                             1,
        176,
  16,
               176,
                       1,
                             1.
                                 176, 11.474363
        192,
               192,
  16,
                       1,
                             1,
                                 192, 10.577906
  16,
        208,
               208,
                       1,
                             1,
                                 208, 11.492373
  16,
        224,
               224,
                       1,
                             1,
                                 224, 11.561291
                             1, 240, 11.505618
        240,
               240,
                       1,
  16,
touch result bench op2 var02.csv
./run bench op2 var02.x 16 256 16 1 1 1 -1 1
                                                          -1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
                           16,
  16,
        16,
               16,
                      1,
                                  1, 17.066668
                           32,
  32,
        32,
               32,
                      1,
                                  1, 22.968225
  48,
                           48,
        48,
               48,
                      1,
                                  1, 23.233614
  64,
        64,
               64,
                      1,
                           64,
                                  1, 23.461576
```

```
80,
  80,
        80,
               80,
                      1,
                                  1, 23.850931
        96,
               96,
                      1,
                          96,
  96,
                                  1, 19.419140
  112,
        112,
               112,
                       1,
                           112,
                                    1, 20.648560
        128,
  128,
               128,
                       1,
                            128,
                                    1, 8.674520
  144,
        144,
               144,
                       1,
                            144,
                                    1, 21.875340
  160,
        160,
               160,
                       1,
                            160,
                                    1, 21.982111
 176,
        176,
               176,
                       1,
                            176,
                                    1, 22.224934
        192,
 192,
               192,
                       1,
                            192,
                                    1, 12.137961
 208,
        208,
               208,
                       1,
                            208,
                                    1, 22.661196
        224,
               224,
 224,
                       1,
                            224,
                                    1, 22.275694
        240,
               240,
                            240,
 240,
                       1,
                                    1, 22.503664
./run bench op2 var02.x 16 256 16 1 1 -1
                                                     -1
                                                           1 | tee -a result bench op2 var02.csv
                                              1
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                    16,
                           1,
                                16, 20.480000
        16,
               1,
  32,
        32,
               1,
                    32,
                           1,
                                32, 21.942856
  48,
                    48,
        48,
               1,
                           1,
                                48, 23.331646
                                64, 22.392710
  64,
        64,
               1,
                    64,
                           1,
  80,
        80,
               1,
                    80,
                                80, 23.132530
                           1,
  96,
               1,
                    96,
        96,
                           1,
                                96, 17.106264
                             1,
  112,
        112,
                    112,
                                112, 19.236805
                1,
  128,
        128,
                     128,
                1,
                             1,
                                 128, 12.926232
 144,
        144,
                1,
                     144,
                             1,
                                 144, 16.386698
 160,
        160,
                 1,
                     160,
                             1,
                                 160, 16.253969
 176,
        176,
                 1,
                     176,
                             1,
                                 176, 16.122837
                             1,
 192,
        192,
                     192,
                1,
                                 192, 15.949811
 208,
        208,
                 1,
                     208,
                             1,
                                 208, 16.055916
 224,
        224,
                     224,
                                 224, 15.916257
                 1,
                             1,
 240,
        240,
                 1,
                     240,
                                  240, 18.375648
                             1,
./run bench op2 var02.x 16 256 16 1 1 1
                                               -1
                                                    -1
                                                           1 | tee -a result bench op2 var02.csv
         n, rs src, cs src, rs_dst, cs_dst, GB_per_s
   m,
  16,
        16,
               16,
                      1,
                           1,
                                16, 21.186207
  32,
        32,
               32,
                      1,
                           1,
                                32, 23.630770
  48,
        48,
              48,
                      1,
                           1,
                                48, 23.530214
  64,
        64,
               64,
                      1,
                           1,
                                64, 23.630770
  80,
        80,
               80,
                      1,
                           1,
                                80, 24.497608
        96,
  96,
               96,
                      1,
                           1,
                                96, 21.308670
  112,
        112,
               112,
                       1,
                             1.
                                112, 22.618784
  128,
        128,
               128,
                             1,
                                 128, 22.928047
                       1,
        144,
               144,
  144,
                       1,
                             1,
                                  144, 23.136402
  160,
        160,
               160,
                       1,
                                  160, 23.405714
                             1,
```

```
176, 23.518633
  176,
        176,
               176,
                        1,
                             1,
  192,
        192,
                192,
                        1,
                                  192, 23.719465
                             1,
 208,
        208,
               208,
                        1,
                             1.
                                  208, 23.550373
        224,
               224,
 224,
                        1,
                             1,
                                  224, 23.879120
 240,
        240,
               240,
                        1,
                             1,
                                  240, 23.801653
./run bench op2 var02.x 16 256 16 1 1 -1
                                                1
                                                    1
                                                          -1 | tee -a result bench op2 var02.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
         16,
                1,
                     16,
                           16,
                                  1, 20.480000
  32,
        32,
               1,
                     32,
                           32,
                                  1, 22.968225
  48,
        48,
                    48,
                           48,
                                  1, 23.630770
               1,
  64,
        64,
               1,
                    64,
                           64,
                                  1, 22.392710
                    80,
  80,
        80,
                1,
                           80,
                                  1, 22.789316
                    96,
  96,
        96,
                1,
                           96,
                                  1, 16.731014
  112,
        112,
                1,
                     112,
                           112,
                                    1, 18.664352
  128,
        128,
                     128,
                            128,
                                    1, 6.247474
  144,
        144,
                     144,
                                    1, 16.074419
                 1,
                            144,
                                    1, 14.490566
  160,
        160,
                 1,
                     160,
                            160,
  176,
        176,
                     176,
                            176,
                                    1, 15.794009
                 1,
                                    1, 7.147072
  192,
         192,
                     192,
                            192,
                 1,
 208,
        208,
                     208,
                            208,
                                    1, 15.658814
                 1,
        224,
 224,
                 1,
                     224,
                            224,
                                    1, 8.203161
 240,
        240,
                 1,
                     240,
                            240,
                                    1, 15.581605
./run bench op2 var02.x 16 256 16 1 1 -2
                                                     2
                                                          -2 | tee -a result bench op2 var02.csv
                                                 2
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
                     32,
                           32,
  16,
         16,
               2,
                                  2, 21.186207
  32,
        32,
               2,
                    64,
                           64,
                                  2, 20.310743
               2,
                    96,
                           96,
  48,
        48,
                                  2, 23.136400
               2,
                    128,
                           128,
  64,
        64,
                                   2, 7.801905
               2,
  80,
        80,
                    160,
                           160,
                                   2, 15.452717
        96,
                2,
                    192,
                           192,
  96,
                                   2, 12.220110
  112,
        112,
                2,
                     224,
                            224,
                                    2, 14.714370
  128,
        128,
                2,
                     256,
                            256,
                                    2, 1.599219
  144,
        144,
                 2,
                     288,
                            288,
                                    2, 14.086159
  160,
                     320,
        160,
                 2,
                            320,
                                    2, 7.346646
  176,
        176,
                 2,
                     352,
                            352,
                                    2, 12.585475
  192,
        192,
                 2,
                     384,
                            384,
                                    2, 3.636848
 208,
        208,
                 2,
                                    2, 9.569917
                     416,
                            416,
 224,
        224,
                 2,
                     448,
                            448,
                                    2, 7.089926
 240,
        240,
                 2,
                     480,
                            480,
                                    2, 7.871541
```

```
./run bench op2 var02.x 16 256 16 1 -16 1 -1 -1
                                                             1 | tee -a
result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
                      1,
         16,
               16,
                           1,
                                 16, 18.618181
  32,
         16,
               16,
                      1,
                           1,
                                 16, 19.200001
  48,
         16,
               16,
                      1,
                           1,
                                 16, 19.608509
  64,
         16,
               16,
                      1,
                           1,
                                 16, 19.819355
  80,
         16,
               16,
                      1,
                           1,
                                 16, 19.819355
  96,
         16,
               16,
                      1,
                           1,
                                 16, 20.144262
  112,
         16,
               16,
                      1,
                            1,
                                 16, 21.612061
  128,
         16,
               16,
                      1,
                            1,
                                 16, 20.915745
  144,
         16,
               16,
                      1,
                            1,
                                 16, 19.962456
  160,
         16,
               16,
                      1,
                            1,
                                 16, 19.883495
  176,
         16,
               16,
                      1,
                            1,
                                 16, 20.604877
                            1,
  192,
         16,
               16,
                      1,
                                 16, 20.537048
  208,
         16,
               16,
                      1,
                            1,
                                 16, 23.630770
 224,
         16,
               16,
                      1.
                            1.
                                 16, 23.761326
 240,
         16,
               16,
                      1,
                            1,
                                 16, 23.813953
./run bench op2 var02.x 16 256 16 -16 1 1
                                                       -1
                                                 -1
                                                             1 | tee -a
result bench op2 var02.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               16,
                      1,
                           1,
                                 16, 21.186207
        32,
               32,
                      1,
  16,
                           1,
                                 32, 18.618181
  16,
        48,
               48,
                      1,
                           1,
                                48, 22.755556
        64,
               64,
                      1,
                           1,
                                64, 23.405714
  16,
        80,
  16,
               80,
                      1,
                           1,
                                80, 23.272728
        96,
               96,
                      1,
                                96, 20.594412
  16,
                           1,
        112,
               112,
                       1,
                            1.
                                112, 22.283939
  16,
        128,
  16,
               128,
                       1,
                             1.
                                 128, 22.650692
        144,
  16,
               144,
                       1,
                             1,
                                 144, 23.040001
  16,
        160,
               160,
                       1,
                             1,
                                 160, 23.450382
  16,
        176,
               176,
                       1,
                             1,
                                 176, 23.304827
        192,
               192,
  16,
                       1,
                             1,
                                 192, 23.258045
        208,
               208,
  16,
                       1,
                             1,
                                 208, 21.882740
        224,
  16,
               224,
                       1,
                             1.
                                 224, 23.437601
        240,
               240,
                       1,
                             1.
  16.
                                 240, 23.450382
touch result bench op2 var03.csv
./run bench op2 var03.x 16 256 16 1 1 1
                                             -1
                                                    1
                                                          -1 | tee -a result bench op2 var03.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
               16,
                      1,
                           16,
                                  1, 15.753846
         16,
```

```
32,
        32,
               32,
                      1,
                           32,
                                  1, 16.718367
  48,
        48,
                           48,
               48,
                      1,
                                  1, 16.910091
  64,
        64,
               64,
                      1,
                           64,
                                  1, 16.861750
  80,
        80,
               80,
                      1,
                           80,
                                  1, 17.009966
  96,
        96,
               96,
                      1,
                           96,
                                  1, 16.923031
  112,
        112,
               112,
                        1,
                            112,
                                     1, 16.932283
  128,
         128,
                128,
                        1,
                             128,
                                     1, 16.941664
  144,
        144,
                144,
                        1,
                             144,
                                     1, 16.944637
  160,
         160,
                160,
                        1,
                             160,
                                     1, 16.953642
  176,
        176,
                176,
                        1,
                            176,
                                     1, 16.953796
 192,
         192,
                192,
                        1.
                            192,
                                     1, 16.955462
 208,
        208,
               208,
                        1.
                            208,
                                     1, 16.946890
        224,
               224,
 224,
                        1,
                            224,
                                     1, 16.910883
 240,
        240,
               240,
                        1,
                            240,
                                     1, 16.852371
./run bench op2 var03.x 16 256 16 1 1 -1
                                                 1
                                                     -1
                                                            1 | tee -a result bench op2 var03.csv
   m,
         n, rs src, cs src, rs dst, cs dst, GB per s
  16,
         16,
                1,
                     16,
                            1,
                                 16, 2.292537
  32,
        32,
                     32,
                                 32, 2.204125
                1,
                            1,
  48,
        48,
                1,
                     48,
                            1,
                                 48, 2.154949
  64,
        64,
                1,
                     64,
                            1,
                                 64, 2.162429
                                 80, 2.111630
  80,
        80,
                     80,
                1,
                            1,
  96,
        96,
                1,
                     96,
                            1,
                                 96, 2.060209
  112,
        112,
                 1,
                     112,
                             1,
                                  112, 2.054289
  128,
        128,
                     128,
                              1,
                                  128, 2.085695
                 1,
  144,
                     144,
        144,
                 1,
                              1,
                                  144, 2.067999
  160,
         160,
                 1,
                     160,
                              1,
                                  160, 2.049845
  176,
         176,
                 1,
                     176,
                              1,
                                  176, 2.046365
  192,
        192,
                     192,
                 1,
                              1,
                                  192, 2.020130
 208,
        208,
                     208,
                 1.
                              1.
                                  208, 1.995074
 224,
        224,
                     224,
                 1,
                              1,
                                  224, 1.978191
 240,
        240,
                 1,
                     240,
                              1,
                                  240, 1.967661
./run bench op2 var03.x 16 256 16 1 1 1
                                                -1
                                                      -1
                                                            1 | tee -a result bench op2 var03.csv
         n, rs_src, cs_src, rs_dst, cs_dst, GB_per_s
   m,
  16,
         16,
               16,
                      1,
                            1,
                                 16, 15.753846
  32,
        32,
               32,
                      1,
                            1,
                                 32, 16.832876
  48,
        48,
               48,
                      1,
                            1,
                                 48, 17.014153
  64,
        64,
               64,
                      1,
                            1,
                                 64, 17.066668
  80,
        80,
               80,
                      1,
                            1,
                                 80, 17.009966
        96,
  96,
               96,
                      1,
                            1,
                                 96, 17.119505
  112,
                       1,
                             1,
                                 112, 17.037691
        112,
               112,
```

```
128,
        128,
               128,
                        1,
                              1,
                                  128, 17.044474
  144,
        144,
               144,
                        1,
                             1,
                                  144, 17.049126
  160,
        160,
               160,
                        1,
                              1.
                                  160, 17.052456
        176,
               176,
  176,
                        1,
                             1,
                                  176, 17.054920
  192,
        192,
               192,
                        1,
                             1,
                                  192, 17.056795
        208,
 208,
               208,
                        1,
                             1,
                                  208, 17.055452
               224,
        224,
                        1,
                              1,
 224,
                                  224, 17.059414
               240,
        240,
                        1,
                              1,
                                  240, 16.959883
 240,
./run bench op2 var03.x 16 256 16 1 1 -1
                                                 1
                                                     1
                                                          -1 | tee -a result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               1,
                     16,
                           16,
                                  1, 15.753846
  32,
        32,
               1,
                     32,
                           32,
                                  1, 16.605406
  48,
        48,
               1,
                    48,
                           48,
                                  1, 16.910091
        64,
                    64,
                           64,
                                  1, 16.978239
  64,
               1,
  80,
        80,
               1,
                    80,
                           80,
                                  1, 17.009966
  96,
        96,
                    96,
                           96,
               1,
                                  1, 16.923031
  112,
        112,
                1,
                     112,
                           112,
                                    1, 16.941813
  128,
        128,
                     128,
                            128,
                                    1, 16.847301
  144,
                     144,
        144,
                 1,
                            144,
                                     1, 16.944637
  160,
        160,
                     160,
                 1,
                            160,
                                     1, 16.948965
  176,
        176,
                     176,
                 1,
                            176,
                                     1, 16.853867
 192,
        192,
                 1,
                     192,
                            192,
                                     1, 16.858536
 208,
        208,
                     208,
                            208,
                 1,
                                     1, 16.856104
 224,
        224,
                 1,
                     224,
                            224,
                                     1, 16.858799
 240,
        240,
                 1.
                     240,
                            240,
                                     1, 16.858536
./run bench op2 var03.x 16 256 16 1 1 -2
                                                 2
                                                     2
                                                          -2 | tee -a result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
                           32,
  16,
        16,
               2,
                     32,
                                  2, 24.575998
               2,
                           64,
  32,
        32,
                    64,
                                  2, 22.755556
  48,
        48,
               2,
                    96,
                           96,
                                  2, 27.374258
  64,
        64,
               2,
                    128,
                           128,
                                   2, 6.908222
  80,
        80,
               2,
                    160,
                           160,
                                   2, 15.088409
               2,
                    192,
  96,
        96,
                           192,
                                   2, 13.165714
                2,
  112,
        112,
                     224,
                            224,
                                    2, 22.152760
 128,
        128,
                2,
                     256,
                            256,
                                    2, 2.358824
 144,
        144,
                 2,
                     288,
                            288,
                                    2, 13.901230
                     320,
                                    2, 7.360728
 160,
        160,
                 2,
                            320,
 176,
        176,
                 2,
                     352,
                            352,
                                    2, 12.775804
 192,
        192,
                 2,
                     384,
                            384,
                                    2, 6.181777
 208,
        208,
                     416,
                            416,
                                    2, 9.596451
```

```
224,
                2, 448,
                           448,
                                    2, 7.994052
 224,
                2,
 240.
        240,
                     480,
                           480,
                                    2, 7.939808
./run bench op2 var03.x 16 256 16 1 -16 1 -1
                                                      -1
                                                            1 | tee -a
result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
               16,
                      1,
                           1,
                                16, 15.753846
  32,
        16,
               16,
                      1,
                           1,
                                16, 16.384001
  48,
        16,
               16,
                      1,
                           1,
                                16, 16.457142
  64,
        16,
               16,
                      1,
                           1,
                                16, 16.605406
  80,
        16,
               16,
                      1,
                           1,
                                16, 16.695652
  96,
        16,
               16,
                      1,
                           1,
                                16, 16.756365
  112,
         16,
               16,
                      1,
                           1,
                                 16, 16.734631
  128,
         16,
               16,
                      1,
                            1,
                                 16, 16.661695
  144,
                            1,
                                 16, 16.807295
         16,
               16,
                      1,
  160,
         16,
               16,
                      1,
                            1,
                                 16, 16.832878
  176,
                            1,
         16,
               16,
                      1,
                                 16, 16.853867
  192,
         16,
               16,
                      1,
                            1,
                                 16, 16.832876
 208,
         16,
               16,
                      1,
                            1,
                                 16, 16.850634
 224,
         16,
               16,
                      1,
                            1,
                                 16, 16.865883
 240,
         16,
               16,
                      1,
                            1,
                                 16, 16.756363
./run bench op2 var03.x 16 256 16 -16 1 1 -1
                                                     -1
                                                            1 | tee -a
result bench op2 var03.csv
         n, rs src, cs src, rs dst, cs dst, GB per s
   m,
  16,
        16,
               16,
                      1,
                           1,
                                16, 15.753846
        32,
  16,
               32,
                      1,
                           1,
                                32, 16.384001
  16,
        48,
              48,
                      1,
                           1,
                                48, 16.605406
  16,
        64,
               64,
                      1,
                           1,
                                64, 16.605406
        80,
               80,
                      1,
  16,
                           1,
                                80, 16.695652
              96,
        96,
  16,
                      1,
                           1,
                                96, 16.832876
  16,
        112,
              112,
                      1,
                            1,
                                112, 16.734631
  16,
        128,
               128,
                            1,
                                128, 16.775427
                       1,
  16,
        144,
               144,
                       1,
                            1,
                                 144, 16.910091
  16,
        160,
               160,
                       1,
                            1,
                                 160, 16.925619
  16,
        176,
               176,
                       1,
                            1,
                                 176, 16.853867
  16,
        192,
               192,
                       1,
                            1.
                                 192, 16.832876
  16,
        208,
               208,
                       1,
                            1,
                                 208, 16.850634
       224,
              224,
  16,
                       1,
                            1,
                                 224, 16.865883
        240,
              240,
                       1,
                                 240, 16.879122
  16,
                            1,
awsomeandy911@LAPTOP-IFC4JBFG:~/cs4473-5473-lab/PROB01 TRANSPOSE$
```