

## Tools/perf/example\_stream

### Example perf: stream

- Prepare environment

```
module purge
module add compiler/gnu/12
```

- Build stream benchmark

```
gcc -std=c11 -Ofast -march=native -fopenmp \
    -ggdb \
    stream.OpenMP.c -o stream
```

- Set up perftools and OpenMP environment

```
module add devel/perf
export OMP_NUM_THREADS=76
export OMP_DISPLAY_ENV=VERBOSE
export OMP_PLACES=cores
```

- Record performance data of benchmark stream for use with perf report and perf annotate

```
perf record \
    ./stream -n 2500000000
```

OPENMP **DISPLAY ENVIRONMENT BEGIN**

```
_OPENMP = '201511'
OMP_DYNAMIC = 'FALSE'
OMP_NESTED = 'FALSE'
OMP_NUM_THREADS = '76'
OMP_SCHEDULE = 'DYNAMIC'
OMP_PROC_BIND = 'TRUE'
OMP_PLACES = '{0,76},{1,77},{2,78},{3,79},{4,80},{5,81},{6,82},{7,83},{8,84},{9,85},{10,86},{11,87},{12,88},{13,89},{14,90},{15,91},{16,92},{17,93},{18,94},{19,95},{20,96},{21,97},{22,98},{23,99},{24,100},{25,101},{26,102},{27,103},{28,104},{29,105},{30,106},{31,107},{32,108},{33,109},{34,110},{35,111},{36,112},{37,113},{38,114},{39,115},{40,116},{41,117},{42,118},{43,119},{44,120},{45,121},{46,122},{47,123},{48,124},{49,125},{50,126},{51,127},{52,128},{53,129},{54,130},{55,131},{56,132},{57,133},{58,134},{59,135},{60,136},{61,137},{62,138},{63,139},{64,140},{65,141},{66,142},{67,143},{68,144},{69,145},{70,146},{71,147},{72,148},{73,149},{74,150},{75,151},{76,152},{77,153},{78,154},{79,155},{80,156},{81,157},{82,158},{83,159},{84,160},{85,161},{86,162},{87,163},{88,164},{89,165},{90,166},{91,167},{92,168},{93,169},{94,170},{95,171},{96,172},{97,173},{98,174},{99,175},{100,176},{101,177},{102,178},{103,179},{104,180},{105,181},{106,182},{107,183},{108,184},{109,185},{110,186},{111,187},{112,188},{113,189},{114,190},{115,191},{116,192},{117,193},{118,194},{119,195},{120,196},{121,197},{122,198},{123,199},{124,200},{125,201},{126,202},{127,203},{128,204},{129,205},{130,206},{131,207},{132,208},{133,209},{134,210},{135,211},{136,212},{137,213},{138,214},{139,215},{140,216},{141,217},{142,218},{143,219},{144,220},{145,221},{146,222},{147,223},{148,224},{149,225},{150,226},{151,227},{152,228},{153,229},{154,230},{155,231},{156,232},{157,233},{158,234},{159,235},{160,236},{161,237},{162,238},{163,239},{164,240},{165,241},{166,242},{167,243},{168,244},{169,245},{170,246},{171,247},{172,248},{173,249},{174,250},{175,251},{176,252},{177,253},{178,254},{179,255},{180,256},{181,257},{182,258},{183,259},{184,260},{185,261},{186,262},{187,263},{188,264},{189,265},{190,266},{191,267},{192,268},{193,269},{194,270},{195,271},{196,272},{197,273},{198,274},{199,275},{200,276},{201,277},{202,278},{203,279},{204,280},{205,281},{206,282},{207,283},{208,284},{209,285},{210,286},{211,287},{212,288},{213,289},{214,290},{215,291},{216,292},{217,293},{218,294},{219,295},{220,296},{221,297},{222,298},{223,299},{224,300},{225,301},{226,302},{227,303},{228,304},{229,305},{230,306},{231,307},{232,308},{233,309},{234,310},{235,311},{236,312},{237,313},{238,314},{239,315},{240,316},{241,317},{242,318},{243,319},{244,320},{245,321},{246,322},{247,323},{248,324},{249,325},{250,326},{251,327},{252,328},{253,329},{254,330},{255,331},{256,332},{257,333},{258,334},{259,335},{260,336},{261,337},{262,338},{263,339},{264,340},{265,341},{266,342},{267,343},{268,344},{269,345},{270,346},{271,347},{272,348},{273,349},{274,350},{275,351},{276,352},{277,353},{278,354},{279,355},{280,356},{281,357},{282,358},{283,359},{284,360},{285,361},{286,362},{287,363},{288,364},{289,365},{290,366},{291,367},{292,368},{293,369},{294,370},{295,371},{296,372},{297,373},{298,374},{299,375},{300,376},{301,377},{302,378},{303,379},{304,380},{305,381},{306,382},{307,383},{308,384},{309,385},{310,386},{311,387},{312,388},{313,389},{314,390},{315,391},{316,392},{317,393},{318,394},{319,395},{320,396},{321,397},{322,398},{323,399},{324,400},{325,401},{326,402},{327,403},{328,404},{329,405},{330,406},{331,407},{332,408},{333,409},{334,410},{335,411},{336,412},{337,413},{338,414},{339,415},{340,416},{341,417},{342,418},{343,419},{344,420},{345,421},{346,422},{347,423},{348,424},{349,425},{350,426},{351,427},{352,428},{353,429},{354,430},{355,431},{356,432},{357,433},{358,434},{359,435},{360,436},{361,437},{362,438},{363,439},{364,440},{365,441},{366,442},{367,443},{368,444},{369,445},{370,446},{371,447},{372,448},{373,449},{374,450},{375,451},{376,452},{377,453},{378,454},{379,455},{380,456},{381,457},{382,458},{383,459},{384,460},{385,461},{386,462},{387,463},{388,464},{389,465},{390,466},{391,467},{392,468},{393,469},{394,470},{395,471},{396,472},{397,473},{398,474},{399,475},{400,476},{401,477},{402,478},{403,479},{404,480},{405,481},{406,482},{407,483},{408,484},{409,485},{410,486},{411,487},{412,488},{413,489},{414,490},{415,491},{416,492},{417,493},{418,494},{419,495},{420,496},{421,497},{422,498},{423,499},{424,500},{425,501},{426,502},{427,503},{428,504},{429,505},{430,506},{431,507},{432,508},{433,509},{434,510},{435,511},{436,512},{437,513},{438,514},{439,515},{440,516},{441,517},{442,518},{443,519},{444,520},{445,521},{446,522},{447,523},{448,524},{449,525},{450,526},{451,527},{452,528},{453,529},{454,530},{455,531},{456,532},{457,533},{458,534},{459,535},{460,536},{461,537},{462,538},{463,539},{464,540},{465,541},{466,542},{467,543},{468,544},{469,545},{470,546},{471,547},{472,548},{473,549},{474,550},{475,551},{476,552},{477,553},{478,554},{479,555},{480,556},{481,557},{482,558},{483,559},{484,560},{485,561},{486,562},{487,563},{488,564},{489,565},{490,566},{491,567},{492,568},{493,569},{494,570},{495,571},{496,572},{497,573},{498,574},{499,575},{500,576},{501,577},{502,578},{503,579},{504,580},{505,581},{506,582},{507,583},{508,584},{509,585},{510,586},{511,587},{512,588},{513,589},{514,590},{515,591},{516,592},{517,593},{518,594},{519,595},{520,596},{521,597},{522,598},{523,599},{524,600},{525,601},{526,602},{527,603},{528,604},{529,605},{530,606},{531,607},{532,608},{533,609},{534,610},{535,611},{536,612},{537,613},{538,614},{539,615},{540,616},{541,617},{542,618},{543,619},{544,620},{545,621},{546,622},{547,623},{548,624},{549,625},{550,626},{551,627},{552,628},{553,629},{554,630},{555,631},{556,632},{557,633},{558,634},{559,635},{560,636},{561,637},{562,638},{563,639},{564,640},{565,641},{566,642},{567,643},{568,644},{569,645},{570,646},{571,647},{572,648},{573,649},{574,650},{575,651},{576,652},{577,653},{578,654},{579,655},{580,656},{581,657},{582,658},{583,659},{584,660},{585,661},{586,662},{587,663},{588,664},{589,665},{590,666},{591,667},{592,668},{593,669},{594,670},{595,671},{596,672},{597,673},{598,674},{599,675},{600,676},{601,677},{602,678},{603,679},{604,680},{605,681},{606,682},{607,683},{608,684},{609,685},{610,686},{611,687},{612,688},{613,689},{614,690},{615,691},{616,692},{617,693},{618,694},{619,695},{620,696},{621,697},{622,698},{623,699},{624,700},{625,701},{626,702},{627,703},{628,704},{629,705},{630,706},{631,707},{632,708},{633,709},{634,710},{635,711},{636,712},{637,713},{638,714},{639,715},{640,716},{641,717},{642,718},{643,719},{644,720},{645,721},{646,722},{647,723},{648,724},{649,725},{650,726},{651,727},{652,728},{653,729},{654,730},{655,731},{656,732},{657,733},{658,734},{659,735},{660,736},{661,737},{662,738},{663,739},{664,740},{665,741},{666,742},{667,743},{668,744},{669,745},{670,746},{671,747},{672,748},{673,749},{674,750},{675,751},{676,752},{677,753},{678,754},{679,755},{680,756},{681,757},{682,758},{683,759},{684,760},{685,761},{686,762},{687,763},{688,764},{689,765},{690,766},{691,767},{692,768},{693,769},{694,770},{695,771},{696,772},{697,773},{698,774},{699,775},{700,776},{701,777},{702,778},{703,779},{704,780},{705,781},{706,782},{707,783},{708,784},{709,785},{710,786},{711,787},{712,788},{713,789},{714,790},{715,791},{716,792},{717,793},{718,794},{719,795},{720,796},{721,797},{722,798},{723,799},{724,800},{725,801},{726,802},{727,803},{728,804},{729,805},{730,806},{731,807},{732,808},{733,809},{734,810},{735,811},{736,812},{737,813},{738,814},{739,815},{740,816},{741,817},{742,818},{743,819},{744,820},{745,821},{746,822},{747,823},{748,824},{749,825},{750,826},{751,827},{752,828},{753,829},{754,830},{755,831},{756,832},{757,833},{758,834},{759,835},{760,836},{761,837},{762,838},{763,839},{764,840},{765,841},{766,842},{767,843},{768,844},{769,845},{770,846},{771,847},{772,848},{773,849},{774,850},{775,851},{776,852},{777,853},{778,854},{779,855},{780,856},{781,857},{782,858},{783,859},{784,860},{785,861},{786,862},{787,863},{788,864},{789,865},{790,866},{791,867},{792,868},{793,869},{794,870},{795,871},{796,872},{797,873},{798,874},{799,875},{800,876},{801,877},{802,878},{803,879},{804,880},{805,881},{806,882},{807,883},{808,884},{809,885},{810,886},{811,887},{812,888},{813,889},{814,890},{815,891},{816,892},{817,893},{818,894},{819,895},{820,896},{821,897},{822,898},{823,899},{824,900},{825,901},{826,902},{827,903},{828,904},{829,905},{830,906},{831,907},{832,908},{833,909},{834,910},{835,911},{836,912},{837,913},{838,914},{839,915},{840,916},{841,917},{842,918},{843,919},{844,920},{845,921},{846,922},{847,923},{848,924},{849,925},{850,926},{851,927},{852,928},{853,929},{854,930},{855,931},{856,932},{857,933},{858,934},{859,935},{860,936},{861,937},{862,938},{863,939},{864,940},{865,941},{866,942},{867,943},{868,944},{869,945},{870,946},{871,947},{872,948},{873,949},{874,950},{875,951},{876,952},{877,953},{878,954},{879,955},{880,956},{881,957},{882,958},{883,959},{884,960},{885,961},{886,962},{887,963},{888,964},{889,965},{890,966},{891,967},{892,968},{893,969},{894,970},{895,971},{896,972},{897,973},{898,974},{899,975},{900,976},{901,977},{902,978},{903,979},{904,980},{905,981},{906,982},{907,983},{908,984},{909,985},{910,986},{911,987},{912,988},{913,989},{914,990},{915,991},{916,992},{917,993},{918,994},{919,995},{920,996},{921,997},{922,998},{923,999},{924,1000},{925,1001},{926,1002},{927,1003},{928,1004},{929,1005},{930,1006},{931,1007},{932,1008},{933,1009},{934,1010},{935,1011},{936,1012},{937,1013},{938,1014},{939,1015},{940,1016},{941,1017},{942,1018},{943,1019},{944,1020},{945,1021},{946,1022},{947,1023},{948,1024},{949,1025},{950,1026},{951,1027},{952,1028},{953,1029},{954,1030},{955,1031},{956,1032},{957,1033},{958,1034},{959,1035},{960,1036},{961,1037},{962,1038},{963,1039},{964,1040},{965,1041},{966,1042},{967,1043},{968,1044},{969,1045},{970,1046},{971,1047},{972,1048},{973,1049},{974,1050},{975,1051},{976,1052},{977,1053},{978,1054},{979,1055},{980,1056},{981,1057},{982,1058},{983,1059},{984,1060},{985,1061},{986,1062},{987,1063},{988,1064},{989,1065},{990,1066},{991,1067},{992,1068},{993,1069},{994,1070},{995,1071},{996,1072},{997,1073},{998,1074},{999,1075},{1000,1076},{1001,1077},{1002,1078},{1003,1079},{1004,1080},{1005,1081},{1006,1082},{1007,1083},{1008,1084},{1009,1085},{1010,1086},{1011,1087},{1012,1088},{1013,1089},{1014,1090},{1015,1091},{1016,1092},{1017,1093},{1018,1094},{1019,1095},{1020,1096},{1021,1097},{1022,1098},{1023,1099},{1024,1100},{1025,1101},{1026,1102},{1027,1103},{1028,1104},{1029,1105},{1030,1106},{1031,1107},{1032,1108},{1033,1109},{1034,1110},{1035,1111},{1036,1112},{1037,1113},{1038,1114},{1039,1115},{1040,1116},{1041,1117},{1042,1118},{1043,1119},{1044,1120},{1045,1121},{1046,1122},{1047,1123},{1048,1124},{1049,1125},{1050,1126},{1051,1127},{1052,1128},{1053,1129},{1054,1130},{1055,1131},{1056,1132},{1057,1133},{1058,1134},{1059,1135},{1060,1136},{1061,1137},{1062,1138},{1063,1139},{1064,1140},{1065,1141},{1066,1142},{1067,1143},{1068,1144},{1069,1145},{1070,1146},{1071,1147},{1072,1148},{1073,1149},{1074,1150},{1075,1151},{1076,1152},{1077,1153},{1078,1154},{1079,1155},{1080,1156},{1081,1157},{1082,1158},{1083,1159},{1084,1160},{1085,1161},{1086,1162},{1087,1163},{1088,1164},{1089,1165},{1090,1166},{1091,1167},{1092,1168},{1093,1169},{1094,1170},{1095,1171},{1096,1172},{1097,1173},{1098,1174},{1099,1175},{1100,1176},{1101,1177},{1102,1178},{1103,1179},{1104,1180},{1105,1181},{1106,1182},{1107,1183},{1108,1184},{1109,1185},{1110,1186},{1111,1187},{1112,1188},{1113,1189},{1114,1190},{1115,1191},{1116,1192},{1117,1193},{1118,1194},{1119,1195},{1120,1196},{1121,1197},{1122,1198},{1123,1199},{1124,1200},{1125,1201},{1126,1202},{1127,1203},{1128,1204},{1129,1205},{1130,1206},{1131,1207},{1132,1208},{1133,1209},{1134,1210},{1135,1211},{1136,1212},{1137,1213},{1138,1214},{1139,1215},{1140,1216},{1141,1217},{1142,1218},{1143,1219},{1144,1220},{1145,1221},{1146,1222},{1147,1223},{1148,1224},{1149,1225},{1150,1226},{1151,1227},{1152,1228},{1153,1229},{1154,1230},{1155,1231},{1156,1232},{1157,1233},{1158,1234},{1159,1235},{1160,1236},{1161,1237},{1162,1238},{1163,1239},{1164,1240},{1165,1241},{1166,1242},{1167,1243},{1168,1244},{1169,1245},{1170,1246},{1171,1247},{1172,1248},{1173,1249},{1174,1250},{1175,1251},{1176,1252},{1177,1253},{1178,1254},{1179,1255},{1180,1256},{1181,1257},{1182,1258},{1183,1259},{1184,1260},{1185,1261},{1186,1262},{1187,1263},{1188,1264},{1189,1265},{1190,1266},{1191,1267},{1192,1268},{1193,1269},{1194,1270},{1195,1271},{1196,1272},{1197,1273},{1198,1274},{1199,1275},{1200,1276},{1201,1277},{1202,1278},{1203,1279},{1204,1280},{1205,1281},{1206,1282},{1207,1283},{1208,1284},{1209,1285},{1210,1286},{1211,1287},{1212,1288},{1213,1289},{1214,1290},{1215,1291},{1216,1292},{1217,1293},{1218,1294},{1219,1295},{1220,1296},{1221,1297},{1222,1298},{1223,1299},{1224,1300},{1225,1301},{1226,1302},{1227,1303},{1228,1304},{1229,1305},{1230,1306},{1231,1307},{1232,1308},{1233,1309},{1234,1310},{1235,1311},{1236,1312},{1237,1313},{1238,1314},{1239,1315},{1240,1316},{1241,1317},{1242,1318},{1243,1319},{1244,1320},{1245,1321},{1246,1322},{1247,1323},{1248,1324},{1249,1325},{1250,1326},{1251,1327},{1252,1328},{1253,1329},{1254,1330},{1255,1331},{1256,1332},{1257,1333},{1258,1334},{1259,1335},{1260,1336},{1261,1337},{1262,1338},{1263,1339},{1264,1340},{1265,1341},{1266,1342},{1267,1343},{1268,1344},{1269,1345},{1270,1346},{1271,1347},{1272,1348},{1273,1349},{1274,1350},{1275,1351},{1276,1352},{1277,1353},{1278,1354},{1279,1355},{1280,1356},{1281,1357},{1282,1358},{1283,1359},{1284,1360},{1285,1361},{1286,1362},{1287,1363},{1288,1364},{1289,1365},{1290,1366},{1291,1367},{1292,1368},{1293,1369},{1294,1370},{1295,1371},{1296,1372},{1297,1373},{1298,1374},{1299,1375},{1300,1376},{1301,1377},{1302,1378},{1303,1379},{1304,1380},{1305,1381},{1306,1382},{1307,1383},{1308,1384},{1309,1385},{1310,1386},{1311,1387},{1312,1388},{1313,1389},{1314,1390},{1315,1391},{1316,1392},{1317,1393},{1318,1394},{1319,1395},{1320,1396},{1321,1397},{1322,1398},{1323,1399},{1324,1400},{1325,1401},{1326,1402},{1327,1403},{1328,1404},{1329,1405},{1330,1406},{1331,1407},{1332,1408},{1333,1409},{1334,1410},{1335,1411},{1336,1412},{1337,1413},{1338,1414},{1339,1415},{1340,1416},{1341,1417},{1342,1418},{1343,1419},{1344,1420},{1345,1421},{1346,1422},{1347,1423},{1348,1424},{1349,1425},{1350,1426},{1351,1427},{1352,1428},{1353,1429},{1354,1430},{1355,1431},{1356,1432},{1357,1433},{1358,1434},{1359,1435},{1360,1436},{1361,1437},{1362,1438},{1363,1439},{1364,1440},{1365,1441},{1366,1442},{1367,1443},{1368,1444},{1369,1445},{1370,1446},{1371,1447},{1372,1448},{1373,1449},{1374,1450},{1375,1451},{1376,1452},{1377,1453},{1378,1454},{1379,1455},{1380,1456},{138
```

```

OMP_DEFAULT_DEVICE = '0'
OMP_MAX_TASK_PRIORITY = '0'
OMP_DISPLAY_AFFINITY = 'FALSE'
OMP_AFFINITY_FORMAT = 'level %L thread %i affinity %A'
GOMP_CPU_AFFINITY = ''
GOMP_STACKSIZE = '0'
GOMP_SPINCOUNT = '300000'
OPENMP DISPLAY ENVIRONMENT END

```

```

-----
STREAM version $Revision: 5.10 $
-----

```

This system uses 8 bytes per array element.

```

-----
Array size = 2499999936 (elements)
Memory per array = 19073.5 MiB (= 18.6 GiB).
Total memory required = 57220.5 MiB (= 55.9 GiB).
Each kernel will be executed 10 times.
  The *best* time for each kernel (excluding the first iteration)
  will be used to compute the reported bandwidth.
-----

```

```

OpenMP version (yyyymm): 201511
Number of Threads requested = 76
Number of Threads counted = 76
-----

```

Your clock granularity appears to be 1000 ticks per microseconds.  
Each test below will take on the order of 138796 microseconds.  
(= 138796910 clock ticks)  
Increase the size of the arrays if this shows that  
you are not getting at least 20 clock ticks per test.

```

-----
WARNING -- The above is only a rough guideline.
For best results, please be sure you know the
precision of your system timer.
-----

```

| Function | Best Rate MB/s | Med time | Min time | Max time |
|----------|----------------|----------|----------|----------|
| Copy:    | 294387.4       | 0.136475 | 0.135875 | 0.138270 |
| Scale:   | 296457.2       | 0.135449 | 0.134927 | 0.142989 |
| Add:     | 306837.1       | 0.195771 | 0.195544 | 0.196339 |
| Triad:   | 305035.9       | 0.197035 | 0.196698 | 0.206095 |

```

-----
Solution Validates: avg error less than 1.000000e-13 on all three arrays
-----

```

```

[ perf record: Woken up 9 times to write data ]
[ perf record: Captured and wrote 91.847 MB perf.data (2407320 samples) ]

```

- Create performance report

```
perf report
```

```
27.13%  stream  stream          [...] tuned_STREAM_Triad._omp_fn.0
27.09%  stream  stream          [...] tuned_STREAM_Add._omp_fn.0
19.45%  stream  libc-2.28.so       [...] __memcpy_avx_unaligned_erms
18.52%  stream  stream          [...] tuned_STREAM_Scale._omp_fn.0
...
```

– Interactive navigation in performance report:

- \* **h**: get help
- \* **a**: jump to annotated assembler code

- Create report with annotated source

```
perf annotate --source --disassembler-style=intel
```

```
...
                // Instructs the compiler to use non-temporal (that is, streaming) stor
                #pragma vector nontemporal
            #endif
            #pragma omp simd aligned (a, b, c : alignment_bytes)
            for (long int j = 0; j < STREAM_ARRAY_SIZE_thread; j++)
                a[j] = b[j] + scalar * c[j];
...
48.54 50:  vmovupd      ymm1, YMMWORD PTR [rsi+rax*1]
48.71      vfmadd213pd ymm1, ymm2, YMMWORD PTR [rcx+rax*1]
1.33      vmovupd      YMMWORD PTR [rdx+rax*1], ymm1
0.00      add          rax, 0x20
          cmp          rax, r8
1.42      ↑ jne          50
...
Source file location: <...>/stream.OpenMP.c:387
...
```

– Interactive navigation in annotated assembler code:

- \* **h**: get help
- \* **H**: jump to hottest place (most often called place)
- \* **k**: toggle line number view on/off
- \* **s**: toggle source code view on/off

– Assembler code:

- \* **vfmadd**: Vector fused-multiply-add
- \* **vmovupd**: Vector move unaligned packed double-precision floating-point values

Why does this example use GNU compiler instead of Intel Compiler?

- Intel compiler inlines all functions -> All time is spent in main-function

- Intel heavily optimizes assembler code -> Matching between assembler instruction and C source code line is difficult