

Sample result of DDP benchmark:

Key takeaway:

- 1. In the forward path, Python impl is 1% faster than DPP Core. Python SYNC and ASYNC are on-par
- 2. re2 backward, speed ranking: DDPCore > Python Async > Python SYNC.
- 3. Python ASYNC - backward is [2%-20%] slower than DDPCore, varies by buffer size slightly
  - It's expected since larger buffer size means less parallelization as number of buckets decreases
  - No difference once buffer size is larger than total elements (24.37M) such as 25M, 26M, 27M
- 4. Python SYNC - backward is 20% slower than DDP Core, independent of buffer size

The following is generated summary from compare\_ddp.py

|                                      |         |          |         |          |           |         |           |         |  |
|--------------------------------------|---------|----------|---------|----------|-----------|---------|-----------|---------|--|
| === Summary for buffer_size: 3M ===  |         |          |         |          |           |         |           |         |  |
| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |  |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.141  | 0         | 210.042 | 0         | 210.64  |  |
| 0                                    | 210.728 | 0        | 212.782 | 0        |           |         |           |         |  |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.221  | -0.913365 | 208.235 | -0.860175 | 208.376 |  |
| -1.07512                             | 208.418 | -1.09622 | 208.503 | -2.01078 |           |         |           |         |  |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.272  | -0.889167 | 208.269 | -0.843666 | 208.399 |  |
| -1.06421                             | 208.441 | -1.08532 | 208.526 | -2.00021 |           |         |           |         |  |
|                                      |         |          |         |          |           |         |           |         |  |
| DDP: [backward]                      |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |  |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| DDPOption.DDP_CPP_CORE               |         |          |         | 471.928  | 0         | 471.874 | 0         | 472.614 |  |
| 0                                    | 472.739 | 0        | 472.845 | 0        |           |         |           |         |  |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 483.761  | 2.50722   | 483.565 | 2.4776    | 485.201 |  |
| 2.66322                              | 486.439 | 2.89801  | 487.63  | 3.12684  |           |         |           |         |  |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 566.434  | 20.0254   | 567.739 | 20.3159   | 571.238 |  |
| 20.8676                              | 572.456 | 21.0935  | 574.975 | 21.5991  |           |         |           |         |  |
|                                      |         |          |         |          |           |         |           |         |  |
| === Summary for buffer_size: 4M ===  |         |          |         |          |           |         |           |         |  |
| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |  |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| -----                                |         |          |         |          |           |         |           |         |  |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.668  | 0         | 210.536 | 0         | 211.12  |  |
| 0                                    | 211.243 | 0        | 213.027 | 0        |           |         |           |         |  |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.519  | -1.0202   | 208.526 | -0.954858 | 208.652 |  |
| -1.16933                             | 208.688 | -1.2098  | 208.749 | -2.00843 |           |         |           |         |  |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.17   | -1.18543  | 208.188 | -1.1155   | 208.304 |  |
| -1.33418                             | 208.331 | -1.37868 | 208.375 | -2.18384 |           |         |           |         |  |
|                                      |         |          |         |          |           |         |           |         |  |
| DDP: [backward]                      |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |  |

| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |
|--------------------------------------|---------|----------|---------|----------|-----------|---------|-----------|---------|
| DDPOption.DDP_CPP_CORE               |         |          |         | 470.809  | 0         | 470.785 | 0         | 471.277 |
| 0                                    | 471.3   | 0        | 471.341 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 485.663  | 3.15505   | 484.757 | 2.96779   | 487.478 |
| 3.43773                              | 488.309 | 3.60907  | 492.57  | 4.50399  |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 567.582  | 20.5547   | 569.553 | 20.9794   | 575.34  |
| 22.0812                              | 575.718 | 22.1554  | 579.709 | 22.9916  |           |         |           |         |
| === Summary for buffer_size: 5M ===  |         |          |         |          |           |         |           |         |
| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.501  | 0         | 210.56  | 0         | 211.131 |
| 0                                    | 211.321 | 0        | 211.676 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.274  | -1.05815  | 208.286 | -1.08026  | 208.39  |
| -1.29836                             | 208.419 | -1.373   | 208.502 | -1.49955 |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.205  | -1.09092  | 208.209 | -1.11681  | 208.373 |
| -1.30658                             | 208.413 | -1.37579 | 208.505 | -1.49841 |           |         |           |         |
| DDP: [backward]                      |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 471.921  | 0         | 471.908 | 0         | 472.321 |
| 0                                    | 472.389 | 0        | 472.473 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 491.629  | 4.176     | 491.88  | 4.23226   | 492.99  |
| 4.37604                              | 493.322 | 4.43122  | 493.571 | 4.46542  |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 568.702  | 20.5077   | 570.053 | 20.7975   | 574.92  |
| 21.7225                              | 576.329 | 22.003   | 578.639 | 22.4703  |           |         |           |         |
| === Summary for buffer_size: 6M ===  |         |          |         |          |           |         |           |         |
| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.357  | 0         | 210.192 | 0         | 211.027 |
| 0                                    | 211.17  | 0        | 212.167 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.218  | -1.01707  | 208.208 | -0.943888 | 208.37  |
| -1.2588                              | 208.434 | -1.29541 | 208.527 | -1.7153  |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.299  | -0.978459 | 208.287 | -0.906401 | 208.47  |
| -1.21135                             | 208.509 | -1.26006 | 208.542 | -1.70831 |           |         |           |         |
| DDP: [backward]                      |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
| delta%                               | p95     | delta%%  | p99     | delta%   |           |         |           |         |

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DDPOption.DDP_CPP_CORE          471.916  0          471.911  0          472.311
0          472.452      0          472.552  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 491.337  4.11541  491.197  4.08693  492.112
4.19242  493.681      4.4933  494.128  4.56582
DDPOption.PYTHON_DDP_SYNC_REDUCTION 570.087  20.8028  570.468  20.8848  574.322
21.5982  576.197      21.9589  577.769  22.2656

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=== Summary for buffer\_size: 7M ===

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DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE          210.471  0          210.23  0          211.335
0          211.646      0          212.208  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.3    -1.03175  208.283 -0.926544  208.452
-1.3644  208.516      -1.4787  208.683 -1.66069
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.35   -1.00775  208.322 -0.907727  208.457
-1.36216 208.508      -1.48257 208.64  -1.68102

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DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE          475.447  0          475.652  0          476.054
0          476.204      0          476.343  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 495.606  4.24003  495.646  4.20351  496.405
4.27489  497.102      4.38859  498.552  4.66256
DDPOption.PYTHON_DDP_SYNC_REDUCTION 570.23   19.9356  570.335  19.9059  574.516
20.683    576.003      20.9573  578.729  21.4942

```

=== Summary for buffer\_size: 8M ===

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DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE          210.426  0          210.404  0          210.867
0          211.004      0          211.632  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.223 -1.0471  208.211 -1.04268  208.378
-1.18039 208.418      -1.22576 208.51  -1.47519
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.441 -0.943627 208.416 -0.94522  208.594
-1.07788 208.632      -1.12397 208.839 -1.31983

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DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE          471.366  0          471.394  0          471.727
0          471.945      0          472.15  0

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DDPOption.PYTHON_DDP_ASYNC_REDUCTION 503.342    6.7838  503.624    6.83717  504.701
6.99008  504.88      6.9785  505.829    7.13305
DDPOption.PYTHON_DDP_SYNC_REDUCTION  571.185   21.1767  571.836   21.3075   574.946
21.8813   575.869    22.0202  576.892   22.1839

=== Summary for buffer_size: 9M ===
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                210.666    0          210.605    0          211.053
0          211.409    0          212.955    0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.262  -1.14128   208.247  -1.11954   208.39
-1.26134  208.429    -1.40948   208.532  -2.07704
DDPOption.PYTHON_DDP_SYNC_REDUCTION  208.249  -1.14753   208.231  -1.12721   208.421
-1.24665  208.462    -1.39398   208.581  -2.05385

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                475.742    0          475.783    0          476.311
0          476.586    0          477.329    0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  505.635    6.2835   505.944    6.33916   507.325
6.51129   507.566    6.50028   509.167    6.67001
DDPOption.PYTHON_DDP_SYNC_REDUCTION  571.18    20.0608   570.698   19.9493    574.136
20.538    574.622    20.5704   577.593   21.0052

=== Summary for buffer_size: 10M ===
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                210.235    0          210.238    0          210.766
0          210.975    0          211.777    0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.364  -0.889884  208.367  -0.890317  208.483
-1.08294  208.537    -1.15571   208.622  -1.48964
DDPOption.PYTHON_DDP_SYNC_REDUCTION  208.303  -0.918867  208.306  -0.91942   208.423
-1.11161  208.522    -1.16244   208.663  -1.47023

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                471.262    0          471.33    0          471.687
0          471.798    0          471.91    0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  506.905    7.56332   506.819    7.52959   507.886
7.67448   508.554    7.79049   509.476    7.96033

```

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DDPOption.PYTHON_DDP_SYNC_REDUCTION 568.922 20.723 569.875 20.9079 572.408
21.3534 573.358 21.5261 576.072 22.0724
```

=== Summary for buffer\_size: 11M ===

```
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 210.124 0 210.003 0 210.431
0 210.52 0 212.437 0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.387 -0.82678 208.382 -0.772006 208.526
-0.905139 208.591 -0.916353 208.661 -1.77738
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.59 -0.730352 208.559 -0.68767 208.795
-0.777346 208.889 -0.775075 209.069 -1.58534
```

```
DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 470.129 0 470.107 0 470.559
0 470.657 0 471.173 0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 512.012 8.90881 510.767 8.64915 516.538
9.77108 517.193 9.88746 517.7 9.87468
DDPOption.PYTHON_DDP_SYNC_REDUCTION 571.999 21.6685 571.894 21.6519 574.109
22.0057 574.949 22.159 576.708 22.3982
```

=== Summary for buffer\_size: 12M ===

```
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 210.276 0 210.11 0 210.724
0 211.507 0 212.171 0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.166 -1.00303 208.158 -0.929433 208.319
-1.14142 208.352 -1.49137 208.43 -1.76306
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.195 -0.989416 208.204 -0.907414 208.337
-1.13315 208.366 -1.48507 208.409 -1.77307
```

```
DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 477.764 0 477.682 0 478.799
0 479.107 0 479.753 0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 518.928 8.61592 519.858 8.82943 521.836
8.98841 522.852 9.13037 527.113 9.87188
DDPOption.PYTHON_DDP_SYNC_REDUCTION 570.09 19.3244 571.131 19.5631 574.142
19.9129 574.744 19.9613 576.002 20.0623
```

=== Summary for buffer\_size: 13M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%   | mean    | delta%   | p90     |
|--------------------------------------|---------|----------|---------|----------|----------|---------|----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |          |         |          |         |
| -----                                |         |          |         |          |          |         |          |         |
| -----                                |         |          |         |          |          |         |          |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.758  | 0        | 210.618 | 0        | 211.531 |
| 0                                    | 211.888 | 0        | 212.169 | 0        |          |         |          |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.119  | -1.25216 | 208.104 | -1.19357 | 208.269 |
| -1.54205                             | 208.325 | -1.68138 | 208.382 | -1.78527 |          |         |          |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.122  | -1.25057 | 208.106 | -1.19253 | 208.245 |
| -1.55357                             | 208.318 | -1.68506 | 208.378 | -1.78703 |          |         |          |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         |         |         |         |         |         |
| -----                                |         |         |         |         |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 471.435 | 0       | 471.443 | 0       | 471.977 |
| 0                                    | 472.104 | 0       | 472.534 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 514.153 | 9.06126 | 512.027 | 8.60847 | 521.519 |
| 10.4968                              | 522.174 | 10.6057 | 523.45  | 10.7752 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 567.48  | 20.3729 | 567.488 | 20.3725 | 570.315 |
| 20.8354                              | 571.16  | 20.9817 | 572.468 | 21.1486 |         |         |         |         |

=== Summary for buffer\_size: 14M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%   | mean    | delta%   | p90     |
|--------------------------------------|---------|----------|---------|----------|----------|---------|----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |          |         |          |         |
| -----                                |         |          |         |          |          |         |          |         |
| -----                                |         |          |         |          |          |         |          |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.501  | 0        | 210.384 | 0        | 210.973 |
| 0                                    | 211.675 | 0        | 212.68  | 0        |          |         |          |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.199  | -1.09343 | 208.211 | -1.03275 | 208.334 |
| -1.25111                             | 208.375 | -1.55885 | 208.471 | -1.97944 |          |         |          |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.285  | -1.0527  | 208.27  | -1.0047  | 208.434 |
| -1.20361                             | 208.49  | -1.50462 | 208.591 | -1.92271 |          |         |          |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         |         |         |         |         |         |
| -----                                |         |         |         |         |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 475.438 | 0       | 475.465 | 0       | 476.153 |
| 0                                    | 476.409 | 0       | 476.711 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 524.349 | 10.2876 | 527.475 | 10.9388 | 530.305 |
| 11.3729                              | 530.555 | 11.3654 | 532.441 | 11.6906 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 573.611 | 20.649  | 573.127 | 20.5405 | 577.294 |
| 21.2415                              | 578.41  | 21.4104 | 579.276 | 21.5153 |         |         |         |         |

=== Summary for buffer\_size: 15M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%   | mean    | delta%   | p90     |
|--------------------------------------|---------|----------|---------|----------|----------|---------|----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |          |         |          |         |
| -----                                |         |          |         | -----    | -----    | -----   | -----    | -----   |
| -----                                |         |          |         | -----    |          |         |          |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.461  | 0        | 210.391 | 0        | 210.934 |
| 0                                    | 211.032 | 0        | 211.317 | 0        |          |         |          |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.274  | -1.03918 | 208.266 | -1.01032 | 208.43  |
| -1.18727                             | 208.484 | -1.20772 | 208.59  | -1.29049 |          |         |          |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.227  | -1.06146 | 208.226 | -1.02924 | 208.357 |
| -1.22186                             | 208.422 | -1.23705 | 208.522 | -1.32288 |          |         |          |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         | -----   | -----   | -----   | -----   | -----   |
| -----                                |         |         |         | -----   |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 473.942 | 0       | 473.82  | 0       | 474.751 |
| 0                                    | 474.806 | 0       | 475.033 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 531.04  | 12.0476 | 532.847 | 12.4576 | 534.748 |
| 12.6376                              | 535.075 | 12.6935 | 536.357 | 12.9093 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 572.339 | 20.7615 | 572.451 | 20.816  | 574.846 |
| 21.0838                              | 575.131 | 21.1299 | 576.538 | 21.3679 |         |         |         |         |

=== Summary for buffer\_size: 16M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%   | mean    | delta%   | p90     |
|--------------------------------------|---------|----------|---------|----------|----------|---------|----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |          |         |          |         |
| -----                                |         |          |         | -----    | -----    | -----   | -----    | -----   |
| -----                                |         |          |         | -----    |          |         |          |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 211.386  | 0        | 211.473 | 0        | 211.924 |
| 0                                    | 211.985 | 0        | 212.352 | 0        |          |         |          |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.352  | -1.43535 | 208.349 | -1.47735 | 208.534 |
| -1.5998                              | 208.588 | -1.60253 | 208.614 | -1.76059 |          |         |          |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.166  | -1.52366 | 208.154 | -1.56983 | 208.277 |
| -1.72072                             | 208.32  | -1.7291  | 208.387 | -1.86733 |          |         |          |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         | -----   | -----   | -----   | -----   | -----   |
| -----                                |         |         |         | -----   |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 471.396 | 0       | 471.431 | 0       | 471.741 |
| 0                                    | 471.807 | 0       | 472.008 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 532.423 | 12.946  | 532.087 | 12.8663 | 534.801 |
| 13.3674                              | 535.472 | 13.4938 | 536.216 | 13.6032 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 570.831 | 21.0937 | 573.693 | 21.6918 | 576.25  |
| 22.1538                              | 577.139 | 22.3251 | 578.038 | 22.4638 |         |         |         |         |

=== Summary for buffer\_size: 17M ===

| DDP: [forward] |  |  |  | Mean | delta% | mean | delta% | p90 |
|----------------|--|--|--|------|--------|------|--------|-----|
|----------------|--|--|--|------|--------|------|--------|-----|

| delta%                               | p95     | delta%   | p99     | delta%   |          |         |          |         |
|--------------------------------------|---------|----------|---------|----------|----------|---------|----------|---------|
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.329  | 0        | 210.456 | 0        | 210.703 |
| 0                                    | 210.802 | 0        | 210.855 | 0        |          |         |          |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.179  | -1.02248 | 208.168 | -1.08692 | 208.31  |
| -1.13592                             | 208.374 | -1.15169 | 208.406 | -1.16142 |          |         |          |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.107  | -1.05666 | 208.081 | -1.1281  | 208.288 |
| -1.14616                             | 208.345 | -1.16578 | 208.397 | -1.16564 |          |         |          |         |

  

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 485.222 | 0       | 485.197 | 0       | 486.18  |
| 0                                    | 486.698 | 0       | 488     | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 527.389 | 8.69042 | 526.905 | 8.59613 | 534.23  |
| 9.88322                              | 535.235 | 9.97259 | 536.053 | 9.84694 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 575.94  | 18.6963 | 576.127 | 18.7408 | 578.749 |
| 19.04                                | 579.275 | 19.0214 | 580.449 | 18.9443 |         |         |         |         |

  

=== Summary for buffer\_size: 18M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%   | mean    | delta%    | p90     |
|--------------------------------------|---------|----------|---------|----------|----------|---------|-----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |          |         |           |         |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.382  | 0        | 210.297 | 0         | 210.785 |
| 0                                    | 211.018 | 0        | 211.427 | 0        |          |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.444  | -0.92151 | 208.417 | -0.893902 | 208.535 |
| -1.06755                             | 208.554 | -1.16772 | 208.694 | -1.29247 |          |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.25   | -1.01326 | 208.241 | -0.977957 | 208.412 |
| -1.12568                             | 208.437 | -1.22291 | 208.468 | -1.39955 |          |         |           |         |

  

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 480.523 | 0       | 480.491 | 0       | 481.178 |
| 0                                    | 481.298 | 0       | 481.661 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 537.206 | 11.796  | 539.801 | 12.3435 | 542.149 |
| 12.6713                              | 542.589 | 12.7344 | 543.361 | 12.8099 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 561.54  | 16.8601 | 561.221 | 16.8016 | 563.942 |
| 17.2003                              | 568.921 | 18.2054 | 572.956 | 18.9543 |         |         |         |         |

  

=== Summary for buffer\_size: 19M ===

| DDP: [forward] |     |        |     | Mean   | delta% | mean | delta% | p90 |
|----------------|-----|--------|-----|--------|--------|------|--------|-----|
| delta%         | p95 | delta% | p99 | delta% |        |      |        |     |



```

-----
DDPOption.DDP_CPP_CORE                209.971  0          209.939  0          210.15
0          210.364  0          210.762  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.381 -0.757295  208.33   -0.766203  208.497
-0.7869   208.516 -0.878442  208.721 -0.96848
DDPOption.PYTHON_DDP_SYNC_REDUCTION   208.311 -0.790664  208.309 -0.776575  208.457
-0.805903 208.487 -0.892226  208.557 -1.04625

DDP: [backward]
delta%      p95      delta%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                478.77   0          478.715  0          479.343
0          479.566  0          479.833  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  540.249 12.8409   538.619 12.5133   547.754
14.2719  548.267   14.3257  549.454   14.5094
DDPOption.PYTHON_DDP_SYNC_REDUCTION   570.878 19.2385   571.444 19.3702   574.852
19.925   575.923   20.0926  581.559   21.2002

=== Summary for buffer_size: 20M ===
DDP: [forward]
delta%      p95      delta%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                210.733  0          210.718  0          211.035
0          211.225  0          212.012  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.228 -1.18869   208.236 -1.17816   208.353
-1.27058 208.376   -1.34851 208.425   -1.69187
DDPOption.PYTHON_DDP_SYNC_REDUCTION   208.293 -1.15816   208.277 -1.1586    208.444
-1.22736 208.521   -1.28011 208.615   -1.60261

DDP: [backward]
delta%      p95      delta%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                475.089  0          475.206  0          475.633
0          475.834  0          476.355  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  550.877 15.9523   553.077 16.3869   555.351
16.7605  555.897   16.8258  556.576   16.8405
DDPOption.PYTHON_DDP_SYNC_REDUCTION   574.111 20.8427   574.816 20.9615   578.774
21.6851  580.185   21.9301  586.553   23.1335

=== Summary for buffer_size: 21M ===
DDP: [forward]
delta%      p95      delta%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE                210.853  0          210.825  0          211.183

```

```

0          211.308      0          211.53      0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.372 -1.1765    208.361 -1.16885  208.561
-1.24157 208.596    -1.28325 208.692  -1.34181
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.202 -1.25715  208.198 -1.24621  208.368
-1.333   208.407    -1.37313 208.501  -1.43188

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 473.293  0      473.282  0      473.808
0      473.933      0      474.12      0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 538.12  13.697  536.046  13.2614  551.029
16.298  553.37      16.7611  554.301  16.9114
DDPOption.PYTHON_DDP_SYNC_REDUCTION 575.191  21.5296  574.89  21.4687  578.517
22.0996  578.801      22.127  583.41  23.0512

=== Summary for buffer_size: 22M ===
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 210.444  0      210.341  0      210.864
0      211.106      0      212.947  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.367 -0.986748  208.36  -0.941914  208.51
-1.11658 208.55    -1.21056 208.603  -2.03981
DDPOption.PYTHON_DDP_SYNC_REDUCTION 208.511 -0.918347  208.496 -0.877387  208.637
-1.05606 208.656    -1.16059 208.805  -1.94498

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 482.097  0      482.406  0      483.012
0      483.234      0      484.214  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 560.875  16.3408  560.893  16.2698  562.507
16.4582  563.033      16.5135  563.883  16.4531
DDPOption.PYTHON_DDP_SYNC_REDUCTION 575.81  19.4387  575.681  19.3353  578.208
19.7089  580.115      20.0483  583.628  20.531

=== Summary for buffer_size: 23M ===
DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE 210.215  0      210.037  0      210.684
0      211.337      0      213.123  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION 208.129 -0.992138  208.114 -0.915331  208.252

```

```

-1.15452  208.304  -1.43533  208.426  -2.20396
DDPOption.PYTHON_DDP_SYNC_REDUCTION  208.427  -0.850357  208.408  -0.77528  208.616
-0.981803  208.655  -1.26914  208.706  -2.07245

```

```

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE  481.245  0  481.24  0  481.688
0  482.084  0  482.664  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  564.44  17.2875  566.225  17.6597  568.807
18.0862  569.019  18.033  569.317  17.953
DDPOption.PYTHON_DDP_SYNC_REDUCTION  571.43  18.7401  573.479  19.1671  576.317
19.6453  578.183  19.9341  588.235  21.8725

```

=== Summary for buffer\_size: 24M ===

```

DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE  210.227  0  210.143  0  210.604
0  210.722  0  210.87  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.228  -0.95065  208.224  -0.913135  208.358
-1.06628  208.426  -1.0898  208.654  -1.05091
DDPOption.PYTHON_DDP_SYNC_REDUCTION  208.23  -0.949705  208.218  -0.915672  208.435
-1.02967  208.484  -1.06235  208.557  -1.09691

```

```

DDP: [backward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE  478.429  0  478.608  0  479.358
0  479.68  0  480.215  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  553.532  15.6977  548.179  14.536  566.12
18.0998  567.022  18.2083  572.705  19.2602
DDPOption.PYTHON_DDP_SYNC_REDUCTION  572.728  19.71  572.48  19.6134  574.355
19.8176  574.741  19.8175  582.827  21.3679

```

=== Summary for buffer\_size: 25M ===

```

DDP: [forward]
delta%      p95      delta%%      p99      Mean      delta%      mean      delta%      p90
-----
DDPOption.DDP_CPP_CORE  210.478  0  210.405  0  210.763
0  210.963  0  212.506  0
DDPOption.PYTHON_DDP_ASYNC_REDUCTION  208.363  -1.00473  208.344  -0.979519  208.545
-1.05199  208.591  -1.12464  208.724  -1.77946
DDPOption.PYTHON_DDP_SYNC_REDUCTION  208.297  -1.03607  208.289  -1.00562  208.429

```

-1.10732 208.449 -1.19205 208.495 -1.88737

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         | -----   | -----   | -----   | -----   | -----   |
| DDPOption.DDP_CPP_CORE               |         |         |         | 478.977 | 0       | 478.951 | 0       | 479.407 |
| 0                                    | 479.564 | 0       | 480.253 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 569.299 | 18.8573 | 573.043 | 19.6453 | 574.805 |
| 19.8991                              | 575.978 | 20.1046 | 583.574 | 21.5137 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 572.347 | 19.4937 | 573.636 | 19.7691 | 575.768 |
| 20.1                                 | 576.877 | 20.292  | 577.819 | 20.3156 |         |         |         |         |

=== Summary for buffer\_size: 26M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
|--------------------------------------|---------|----------|---------|----------|-----------|---------|-----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |           |         |           |         |
| -----                                |         |          |         | -----    | -----     | -----   | -----     | -----   |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.289  | 0         | 210.129 | 0         | 210.915 |
| 0                                    | 211.356 | 0        | 212.755 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.237  | -0.975918 | 208.204 | -0.91614  | 208.435 |
| -1.17554                             | 208.573 | -1.31667 | 208.692 | -1.90987 |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.108  | -1.03731  | 208.098 | -0.966869 | 208.264 |
| -1.25662                             | 208.335 | -1.4294  | 208.446 | -2.02556 |           |         |           |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         | -----   | -----   | -----   | -----   | -----   |
| DDPOption.DDP_CPP_CORE               |         |         |         | 475.649 | 0       | 475.81  | 0       | 476.438 |
| 0                                    | 476.584 | 0       | 476.782 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 574.232 | 20.726  | 574.333 | 20.7063 | 577.995 |
| 21.316                               | 578.914 | 21.4716 | 579.428 | 21.5289 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 574.607 | 20.8051 | 574.994 | 20.8453 | 577.543 |
| 21.221                               | 578.45  | 21.3741 | 578.905 | 21.4192 |         |         |         |         |

=== Summary for buffer\_size: 27M ===

| DDP: [forward]                       |         |          |         | Mean     | delta%    | mean    | delta%    | p90     |
|--------------------------------------|---------|----------|---------|----------|-----------|---------|-----------|---------|
| delta%                               | p95     | delta%   | p99     | delta%   |           |         |           |         |
| -----                                |         |          |         | -----    | -----     | -----   | -----     | -----   |
| DDPOption.DDP_CPP_CORE               |         |          |         | 210.39   | 0         | 210.259 | 0         | 210.829 |
| 0                                    | 211.385 | 0        | 211.908 | 0        |           |         |           |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |          |         | 208.36   | -0.964811 | 208.358 | -0.903892 | 208.496 |
| -1.10633                             | 208.555 | -1.33865 | 208.614 | -1.55409 |           |         |           |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |          |         | 208.45   | -0.922151 | 208.443 | -0.863724 | 208.581 |
| -1.06633                             | 208.681 | -1.27889 | 208.742 | -1.49412 |           |         |           |         |

| DDP: [backward]                      |         |         |         | Mean    | delta%  | mean    | delta%  | p90     |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| delta%                               | p95     | delta%  | p99     | delta%  |         |         |         |         |
| -----                                |         |         |         | -----   | -----   | -----   | -----   | -----   |
| -----                                |         |         |         | -----   |         |         |         |         |
| DDPOption.DDP_CPP_CORE               |         |         |         | 475.294 | 0       | 475.299 | 0       | 476.014 |
| 0                                    | 476.119 | 0       | 476.351 | 0       |         |         |         |         |
| DDPOption.PYTHON_DDP_ASYNC_REDUCTION |         |         |         | 570.313 | 19.9917 | 572.485 | 20.4473 | 574.882 |
| 20.77                                | 575.329 | 20.8371 | 576.284 | 20.9788 |         |         |         |         |
| DDPOption.PYTHON_DDP_SYNC_REDUCTION  |         |         |         | 571.216 | 20.1816 | 572.884 | 20.5313 | 574.973 |
| 20.7891                              | 575.856 | 20.9478 | 576.293 | 20.9807 |         |         |         |         |