

PAPER ARTIFACT DESCRIPTION APPENDIX

.1 Summarize the experiments reported in the paper and how they were run.

Hardware: We use PALEO simulator. The experiment setup is 256 NVIDIA TITAN X GPUs with PCIe3.0. An enhancement is made on the Paleo to simulate the case each server uses PCIe3.0 (16GBps) connecting 8 GPUs with 20 Gbps Ethernet between servers. The Butterfly AllReduce scheme is adopted for gradient aggregation.

Software: Based on Fast.Ai deep learning framework, we add the code based on DaSGD algorithm and integrate it into Fast.Ai. We implemented our system based on the Fast.Ai platform upon CIFAR-10 dataset. The learning rate is linearly increased from 0.0001 to 0.01 in the first 30% epochs and then decreased from 0.01 to 0.0001 in latter 70% epochs. The weight decay is 0.01 and the momentum is 0.9. The baseline is set as: the number of workers is 32, the number of local steps is 4, the delay is 2, the local batch size is 32, and the local update percentage is 0.25.

.2 Relevant hardware details:

```
>> env | sed "s/$USER/USER/g"
CUDNN_VERSION=7.6.1.34
NSIGHT_SYSTEMS_VERSION=2019.3.6
LC_ALL=C.UTF-8
NVM_DIR=/usr/local/nvm
LD_LIBRARY_PATH=/usr/local/cuda/compat/lib:/usr/local/nvidia/lib:/usr/local/nvidia/lib64
NVIDIA_PYTORCH_VERSION=19.07
COCOAPI_VERSION=2.0+nv0.3.1
MOFED_VERSION=4.4-1.0.0
PYTHONIOENCODING=utf-8
NVIDIA_VISIBLE_DEVICES=all
TENSORBOARD_PORT=6006
ENV=/etc/shinit_v2
CUDA_DRIVER_VERSION=418.67
PYTORCH_BUILD_VERSION=1.2.0a0+f6aac41
NCCL_VERSION=2.4.7
DALI_VERSION=0.11.0
HOME=/USER
TRT_VERSION=5.1.5.0
JUPYTER_PORT=8888
PYTORCH_VERSION=1.2.0a0+f6aac41
OPENMPI_VERSION=3.1.3
BASH_ENV=/etc/bash.bashrc
LIBRARY_PATH=/usr/local/cuda/lib64/stubs:
SSH_TTY=/dev/pts/0
NVIDIA_BUILD_ID=7195382
MAIL=/var/mail/USER
TERM=xterm
SHELL=/bin/bash
CUDA_VERSION=10.1.168
PYTORCH_BUILD_NUMBER=0
NVIDIA_DRIVER_CAPABILITIES=compute,utility,video
SHLVL=1
NVIDIA_REQUIRE_CUDA=cuda
CUDA_CACHE_DISABLE=1
```

```
DALI_BUILD=781234
LOGNAME=USER
CUBLAS_VERSION=10.2.0.168
PATH=/opt/intel/vtune_profiler_2020.1.0.607630/bin64:/opt/conda/bin:/usr/local/mpi/bin:/usr/local/nvidia/bin:/usr/local/cuda/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
OMPI_MCA_btl_vader_single_copy_mechanism=none
_CUDA_COMPAT_PATH=/usr/local/cuda/compat
_=usr/bin/env
>> lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description: Ubuntu 18.04.2 LTS
Release: 18.04
Codename: bionic
>> uname -a
Linux 4a9d3dc86cb4 4.15.0-72-generic #81-Ubuntu SMP Tue Nov 26 12:20:02 UTC 2019 x86_64 x86_64 x86_64 GNU/Linux
>> lscpu || cat /proc/cpuinfo
+ lscpu
Architecture: x86_64
CPU op-mode(s): 32-bit, 64-bit
Byte Order: Little Endian
CPU(s): 96
On-line CPU(s) list: 0-95
Thread(s) per core: 2
Core(s) per socket: 24
Socket(s): 2
NUMA node(s): 1
Vendor ID: GenuineIntel
CPU family: 6
Model: 85
Model name: Intel(R) Xeon(R) Platinum 8163 CPU @ 2.50GHz
Stepping: 4
CPU MHz: 1251.139
CPU max MHz: 2501.0000
CPU min MHz: 1000.0000
BogoMIPS: 5000.00
Virtualization: VT-x
L1d cache: 32K
L1i cache: 32K
L2 cache: 1024K
L3 cache: 33792K
NUMA node0 CPU(s): 0-95
Flags: fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm constant_tsc art arch_perfmon pebs bts rep_good nopl xtopology nonstop_tsc cpuid aperfmperf pni pclmulqdq dtes64 monitor ds_cpl vmx smx est tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid dca sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes xsave avx f16c rdrand lahf_lm abm 3dnow-prefetch cpuid_fault epb cat_l3 cdp_l3 invpcid_single pti intel_ppin ssbd mba ibrs ibpb stibp tpr_shadow vnmi flexpriority ept vpid fsgsbase tsc_adjust bmi1 hle avx2 smep bmi2 erms invpcid rtm cqm mpx rdt_a avx512f avx512dq rdseed adx smap clflushopt clwb intel_pt avx512cd avx512bw avx512vl xsaveopt xsavec xgetbv1 xsaves
```

```

1393 cqm_llc cqm_occup_llc cqm_mbm_total cqm_mbm_local dtherm
1394 ida arat pln pts pku ospke md_clear flush_l1d
1395 >> cat /proc/meminfo
1396 + cat /proc/meminfo
1397 MemTotal: 528019640 kB
1398 MemFree: 68691800 kB
1399 MemAvailable: 440392172 kB
1400 Buffers: 2848704 kB
1401 Cached: 367731744 kB
1402 SwapCached: 3212 kB
1403 Active: 325296560 kB
1404 Inactive: 114836280 kB
1405 Active(anon): 65633584 kB
1406 Inactive(anon): 8564280 kB
1407 Active(file): 259662976 kB
1408 Inactive(file): 106272000 kB
1409 Unevictable: 0 kB
1410 Mlocked: 0 kB
1411 SwapTotal: 999420 kB
1412 SwapFree: 456 kB
1413 Dirty: 48 kB
1414 Writeback: 0 kB
1415 AnonPages: 69549564 kB
1416 Mapped: 8700248 kB
1417 Shmem: 4684236 kB
1418 Slab: 12468736 kB
1419 SReclaimable: 9672308 kB
1420 SUNreclaim: 2796428 kB
1421 KernelStack: 552560 kB
1422 PageTables: 895684 kB
1423 NFS_Unstable: 0 kB
1424 Bounce: 0 kB
1425 WritebackTmp: 0 kB
1426 CommitLimit: 265009240 kB
1427 Committed_AS: 937895348 kB
1428 VmallocTotal: 34359738367 kB
1429 VmallocUsed: 0 kB
1430 VmallocChunk: 0 kB
1431 HardwareCorrupted: 0 kB
1432 AnonHugePages: 75776 kB
1433 ShmemHugePages: 0 kB
1434 ShmemPmdMapped: 0 kB
1435 CmaTotal: 0 kB
1436 CmaFree: 0 kB
1437 HugePages_Total: 0
1438 HugePages_Free: 0
1439 HugePages_Rsvd: 0
1440 HugePages_Surp: 0
1441 Hugepagesize: 2048 kB
1442 DirectMap4k: 192135688 kB
1443 DirectMap2M: 335986688 kB
1444 DirectMap1G: 10485760 kB
1445 >> lsblk -a
1446 NAME MAJ:MIN RM SIZE RO TYPE MOUNTPOINT
1447 loop0 7:0 0 91.4M 1 loop
1448 loop1 7:1 0 9.1M 1 loop
1449 loop2 7:2 0 9.1M 1 loop

```

```

loop3 7:3 0 55M 1 loop
loop4 7:4 0 93.9M 1 loop
loop5 7:5 0 1 loop
loop6 7:6 0 93.8M 1 loop
loop7 7:7 0 55M 1 loop
sda 8:0 0 223.6G 0 disk
nvme0n1 259:0 0 3.5T 0 disk
nvme2n1 259:1 0 3.5T 0 disk
nvme3n1 259:2 0 3.5T 0 disk
nvme1n1 259:3 0 3.5T 0 disk
>> nvidia-smi

```

NVIDIA-SMI 430.26				Driver Version: 430.26		CUDA Version: 10.2	
GPU	Name	Persistence-M	Bus-Id	Disp.A	Volatile	Uncorr.	ECC
Fan	Temp	Perf	Pwr:Usage/Cap	Memory-Usage	GPU-Util	Compute	M.
0	Tesla	V100-SXM2...	Off	00000000:1B:00.0	Off		0
N/A	41C	P0	67W / 300W	8694MiB / 16160MiB	72%	Default	
1	Tesla	V100-SXM2...	Off	00000000:1C:00.0	Off		0
N/A	52C	P0	273W / 300W	16072MiB / 16160MiB	62%	Default	
2	Tesla	V100-SXM2...	Off	00000000:3D:00.0	Off		0
N/A	53C	P0	284W / 300W	15973MiB / 16160MiB	46%	Default	
3	Tesla	V100-SXM2...	Off	00000000:3E:00.0	Off		0
N/A	51C	P0	225W / 300W	15967MiB / 16160MiB	96%	Default	
4	Tesla	V100-SXM2...	Off	00000000:B1:00.0	Off		0
N/A	45C	P0	74W / 300W	12055MiB / 16160MiB	94%	Default	
5	Tesla	V100-SXM2...	Off	00000000:B2:00.0	Off		0
N/A	46C	P0	177W / 300W	10727MiB / 16160MiB	96%	Default	
6	Tesla	V100-SXM2...	Off	00000000:DB:00.0	Off		0
N/A	44C	P0	83W / 300W	10452MiB / 16160MiB	98%	Default	
7	Tesla	V100-SXM2...	Off	00000000:DC:00.0	Off		0
N/A	48C	P0	167W / 300W	10584MiB / 16160MiB	96%	Default	

Processes:				GPU Memory
GPU	PID	Type	Process name	Usage