

Assignment - 2

Introduction

In this experiment, we deployed and configured Tensorflow to run two applications: Logistic Regression and LeNet. Different experiments were run with Synchronous and Asynchronous SGD, Using Tensorflow Core and Keras API, running in single and distributed modes as well as checking the system parameters like CPU/MEM/Network usage to get a deeper understanding about Tensorflow's performance.

Experiment Setup

As part of the experiment setup, we used a 3 node cluster running on Ubuntu 16. Each of these nodes has the following configuration:

tensorflow	v1.14.0
tensorflow-datasets	v1.2.0
RAM	32 GB
Number of physical cores	1
Number of processing units	5
python	v3.5.2

Implementation

Part 1: Logistic Regression

Job parameters

learning_rate	0.50
training_epochs	50
batch_size	200

In this task, we ran the Logistic regression on a single node. The following numbers and accuracy were reported in this task. Since this is running on a single node, the synchronous and asynchronous mode doesn't matter in this case.

```

CPU      35.2% nice: 0.0%          LOAD   5-core
user:    22.9% irq: 0.0%         1 min:  0.88
system:  11.7% iowait: 0.0%     5 min:  0.39
idle:    64.7% steal: 0.6%     15 min:  0.23

MEM      3.1% active: 1.61G
total:   31.2G inactive: 1.92G
used:    994M buffers: 183M
free:    30.3G cached: 2.90G

SWAP      0.0%
total:   1024M
used:    0
free:    1024M

TASKS 129 (192 thr), 1 run, 128 slp, 0 oth sorted automatically by cpu_percent, flat view

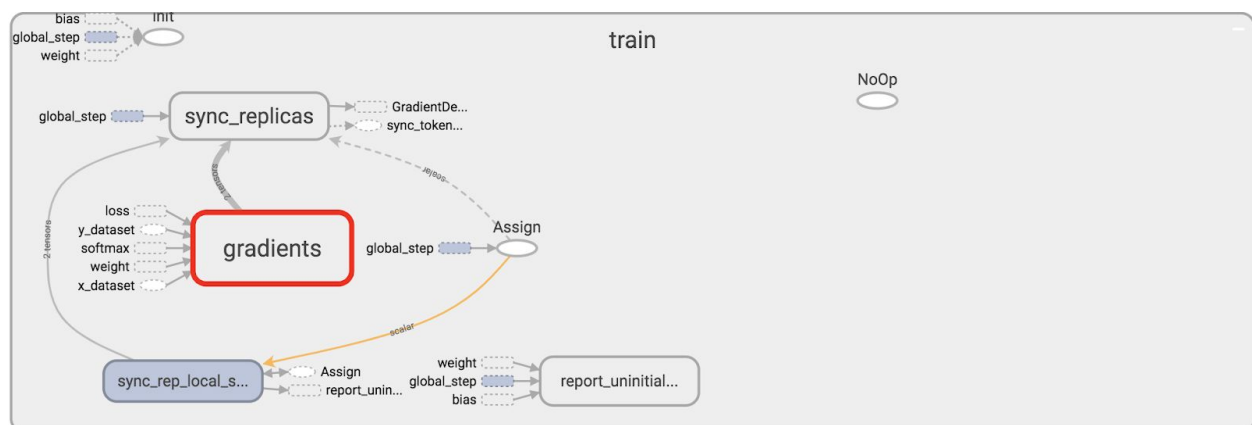
NETWORK  Rx/s    Tx/s
eth0     275Kb   190b
eth1     0b     0b
lo        504b     504b

CPU% MEM% VIRT RES PID USER NI S TIME+ IOR/s IOW/s Command
lo      185.7 1.7 3.83G 555M 10240 anshu 0 S 0:17.16 0 0 python3 code_template.py --deploy_mode=single
        4.4 0.1 97.3M 31.9M 7140 anshu 0 R 0:14.73 0 0 /usr/bin/python3 /usr/bin/glances
DISK L/O  R/s     W/s
loop0    0 0 0.3 0.0 0 5.10M 144K 926 root 0 S 0:27.62 0 0 rcu_sched
loop1    0 0 0.3 0.0 94.1M 6.65M 2864 anshu 0 S 0:12.53 0 0 /sbin/scsid
loop2    0 0 0.0 0.0 0 0 23345 root 0 S 0:00.18 0 0 kworker/3:2
loop3    0 0 0.0 0.0 0 0 18 root 0 S 0:01.63 0 0 ksftirqd/2
loop4    0 0 0.0 0.0 0 0 23320 root 0 S 0:00.21 0 0 kworker/1:0
loop5    0 0 0.0 0.0 90.6M 2.95M 10241 anshu 0 S 0:00.00 0 0 sshd: anshu@natty
loop6    0 0 0.0 0.0 0 0 3 root 0 S 0:00.51 0 0 ksftirqd/0
loop7    0 0 0.0 0.0 36.8M 5.56M 1 root 0 S 2:14.59 0 0 /sbin/init
xvda0    0 0 0.0 0.0 0 0 10 root 0 S 0:01.85 0 0 watchdog/0
xvda1    0 0 0.0 0.0 13.1M 324K 929 root -S 0:00.00 0 0 /usr/local/libexec/pubsubd -e /var/run/pubsubd.pid
xvda2    0 0 0.0 0.0 0 0 78 root -20 S 0:00.00 0 0 bioset
xvda3    0 0 0.0 0.0 0 0 101 root -20 S 0:00.00 0 0 charger_manager
xvda4    0 0 0.0 0.7 782M 219M 10222 anshu 0 S 0:02.59 0 0 /usr/bin/python3 /users/anshu/.local/bin/tensorboard --logdir=summaries
FILE SYS Used Total 0.0 0.0 34.4M 8.22M 267 root 0 S 0:03.99 0 0 /lib/systemd/systemd-journal
/ (xvda1) 4.46G 15.6G 0.0 0.0 10.6M 1.62M 1036 root 0 S 4:12.89 0 0 /usr/local/etc/emulab/slothd -s boss.wisc.cloudlab.us -i 300 -g 5 -l 1 -c 5 -n 1000
            0.0 0.0 25.4M 2.15M 620 root 0 S 0:00.00 0 0 /usr/sbin/atd -f
            0.1 39.2M 17.0M 903 root 0 S 0:00.23 0 0 /usr/bin/perl -w /usr/local/etc/emulab/ntpstart /usr/sbin/ntpd -n -u ntp:ntp -g
            0.0 0.0 0 0 17 root 0 S 0:00.22 0 0 migration/2
            0.0 0.0 0 0 26 root 0 S 0:01.88 0 0 watchdog/4
            0.0 0.0 0 0 2939 root 0 S 0:00.00 0 0 kworker/0:1
            0.0 0.0 0 0 182 root 0 S 0:06.53 0 0 jbd2/xvda1-8
            0.0 0.0 90.6M 6.57M 2845 root 0 S 0:00.22 0 0 sshd: anshu [priv]
            0.0 0.0 0 0 9 root 0 S 0:00.25 0 0 migration/0
            0.0 0.0 0 0 39 root -20 S 0:00.00 0 0 crypto
            0.0 0.0 0 0 1765 root 0 S 0:00.60 0 0 kworker/u10:0
            0.0 0.0 0 0 76 root -20 S 0:00.00 0 0 bioset
            0.0 0.0 0 0 80 root -20 S 0:00.00 0 0 bioset
            0.0 0.0 0 0 42 root -20 S 0:00.00 0 0 kbldock
            0.0 0.0 0 0 3043 root 0 S 0:00.25 0 0 kworker/u10:1

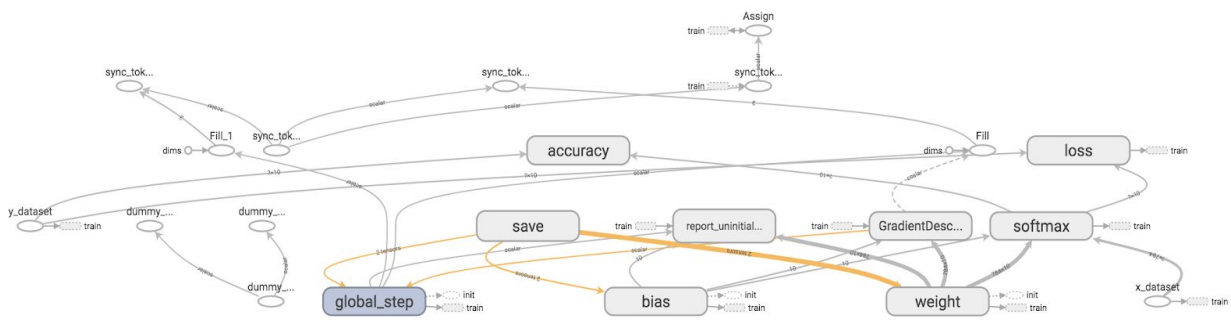
```

Task 1 - Statistics

Tensorflow graph



Training Graph



Overall Graph

Worker data

Accuracy	92.63
Time Taken	121.079723 s
CPU Usage	23% - 24%
Memory Usage	500 - 600 MB
Deploy Mode	single
Network Usage	Not Available

Task - 2

TensorFlow provides two ways to distribute training across multiple GPUs, multiple machines or TPUs. Tensorflow supports two modes of executions. In sync training, all workers train over different slices of input data in sync, and aggregating gradients at each step. In async training, all workers are independently training over the input data and updating variables asynchronously. Typically sync training is supported via all-reduce and async through parameter server architecture.

Synchronous SGD Observations:

Parameter Server

Accuracy	NA
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Time Taken	NA
CPU Usage	26% - 28%
Memory Usage	498M
Deploy Mode	cluster2
Network Usage	25-26 Mb (Megabits)

Worker 1:

Accuracy	92.02
Time Taken	103.238086 s
CPU Usage	25% - 26%
Memory Usage	568M
Deploy Mode	cluster2
Network Usage	22-25 Mb (Megabits)

Worker 2:

Accuracy	92.02
Time Taken	104.189216 s
CPU Usage	25% - 26%
Memory Usage	689M
Deploy Mode	cluster2
Network Usage	22-25 Mb (Megabits)

Worker 3:

Accuracy	92.02
Time Taken	104.099682 s
CPU Usage	25% - 26%
Memory Usage	564M
Deploy Mode	cluster2
Network Usage	22-25 Mb (Megabits)

Asynchronous SGD Observations:

Parameter Server:

Accuracy	NA
Time Taken	NA
CPU Usage	0.0% - 0.5%
Memory Usage	0.0% - 0.5%
Deploy Mode	cluster2
Network Usage	0 Mb (Megabits)

Worker 1:

Accuracy	92.02%
Time Taken	48.173872 s
CPU Usage	22% - 25%
Memory Usage	516M
Deploy Mode	cluster2
Network Usage	0 Mb (Megabits)

Worker 2:

Accuracy	91.78%
Time Taken	47.673071 s
CPU Usage	22% - 24%
Memory Usage	516M
Deploy Mode	cluster2
Network Usage	0 Mb (Megabits)

Worker 3:

Accuracy	92.27%
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Time Taken	51.172161 s
CPU Usage	22% - 24%
Memory Usage	572M
Deploy Mode	cluster2
Network Usage	0 Mb (Megabits)

Similarities/ Differences

- 1) Accuracy is the same on all nodes in case of synchronous distributed training whereas in the case asynchronous training the accuracy is different across all worker nodes.

Explanation: In sync training, all workers train over different slices of input data in sync, and aggregating gradients at each step, hence, the shared parameters are the same across all the worker nodes. Therefore, the accuracy is same across all worker nodes.

- 2) There is negligible network activity in case of asynchronous distributed training whereas there is a heavy network activity in the case of synchronous training.

Explanation: In async training, all workers are independently training over the input data and updating shared variables asynchronously whereas in the case of synchronous distributed training the updates are sent to all the workers in a burst resulting in heavy network after every single epoch.

- 3) The time taken by the synchronous distributed training is almost double the time taken by the asynchronous training.

Explanation: In the case of synchronous distributed training the worker needs to wait until all the workers update their shared parameters in the parameter server whereas in the case of asynchronous servers there is no waiting time involved. Hence the asynchronous distributed training is faster than the distributed training.

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- 4) The parameter server has negligible CPU usage and memory usage in the case of asynchronous training.

Explanation: In the case of synchronous distributed training, the updates made to the parameter servers are synchronized using locks and all the subsequent reads are blocked till gradient updates are received from all the workers. In the case of asynchronous servers, all the reads and writes are concurrent without any blocking and waiting time, therefore, the CPU usage and memory usage is negligible in the case of asynchronous training at any point of time.

- 5) In the case of asynchronous distributed training, the time taken by the workers is different.

Explanation: In the case of asynchronous distributed training, all the workers are functioning independently, therefore, they have taken different time to complete the job.

Bottleneck

As of now, the cloud lab infra is way more than we need to run SGD on the MNIST database using TensorFlow. But if the load becomes multifold, we might observe bottleneck in some of the system components

Network: If the number of workers increases multifold, then in the synchronous mode when the parameter server updates workers of the updated shared variable, we might see a burst of heavy traffic which might become a bottleneck.

CPU: We don't foresee any case where CPU becomes a bottleneck unless heavy computations are involved on top of a large graph.

Memory: If the dataset/model is so huge that it can't be put in the memory at once, we will experience a lot of thrashing and IO activity which will slow down the model execution.

Part 2: LeNet

Task - 1

In this task, we implemented the LeNet Architecture using the Keras API. The observed accuracies for the same using one, two, and three machines have been noted below:

Base Batch Sz = 64 Epochs = 6		
Mode of deployment	Accuracy	Time elapsed (sec)
Single Node	0.9800000191	178.83
Two nodes	0.9721000195	162.34
Three nodes	0.9678000212	169.67

For batch size 64 and 6 epochs, the CPU/Memory/Network usage stats were observed as follows for different cluster deployment modes:

Single node

```
node0.arpit-asgn-2.uwmadison744-f19-pg0.wisc.cloudlab.us (Ubuntu 16.04 64bit / Linux 4.4.0-154-generic) Uptime: 10 days, 8:12:25

CPU    85.3%  nice:    0.0%      LOAD   5-core          MEM    5.7%  active:  2.51G      SWAP    0.0%
user:   83.0%  irq:     0.0%      1 min:  3.45      total:  31.2G  inactive: 1.17G   total:  1024M
system: 1.9%   iowait:  0.1%      5 min:  1.24      used:    1.78G  buffers:  192M   used:    0
idle:   14.7%  steal:   0.2%      15 min:  0.56     free:   29.4G  cached:   2.19G   free:   1024M

NETWORK Rx/s Tx/s  TASKS 133 (251 thr), 1 run, 131 slp, 1 oth sorted automatically by cpu_percent, flat view
eth0    126Kb 32Kb
eth1     0b  0b
lo      52.1Mb 52.1Mb

DISK I/O R/s W/s  CPU% MEM% VIRT RES  PID USER  NI S  TIME+ IOR/s IOW/s Command
loop0    0  0    0.3  0.0  0  0  7 root  -20 S  0:54.59 0  0 python3 MNIST-LeNet-cluster.py --deploy_mode=sin
loop1    0  0    0.0  0.0  0  0 176 root -20 S  0:00.00 0  0 /usr/bin/python3 /usr/bin/glances
loop2    0  0    0.0  0.0  0  0 283 root -20 S  0:00.00 0  0 1K ssh node0 cd ~/tf ; python3 MNIST-LeNet-cluster.
loop3    0  0    0.0  0.0  0  0 191 root -20 S  0:00.30 0  0 rcu_sched
loop4    0  0    0.0  0.0  0  0 277 root -20 S  0:00.00 0  0 ext4-rsv-conver
loop5    0  0    0.0  0.0 107M 5.40M 1111 ntp -20 S  0:00.00 0  0 ib_nl_sa_wq
loop6    0  0    0.0  0.0  0  0 26 root  -20 S  0:06.79 0  0 kworker/0:1H
loop7    0  0    0.0  0.0  0  0 3 root  -20 S  0:01.26 0  0 iscsi_ah
xvda     0 12K    0.0  0.0 36.8M 5.58M 1 root  -20 S  1:14.80 0  0 /usr/sbin/ntpd -n -u ntp:ntp -g
xvda1    0 12K    0.0  0.0 90.6M 6.54M 30737 root  -20 S  0:06.79 0  0 watchdog/4
xvda2    0  0    0.0  0.0  0  0 78 root  -20 S  0:01.26 0  0 ksoftirqd/0
xvda3    0  0    0.0  0.0  0  0 24018 root -20 S  37:59.37 0  0 /sbin/init
xvda4    0  0    0.0  0.0  0  0 76 root  -20 S  0:00.18 0  0 sshd: ajain [priv]
FILE SYS Used Total  0.0  0.0  0  0 42 root  -20 S  0:00.00 0  0 bioset
/ (xvda1) 3.82G 15.6G 0.0  0.0  0  0 199 root  -20 S  0:00.12 0  0 kworker/u10:0
Warning or critical alerts (lasts 6 entries)
2019-10-11 19:41:22 (ongoing) - CPU_SYSTEM (85.3)
2019-10-11 19:41:12 (0:00:04) - WARNING on CPU_SYSTEM (85.0)
2019-10-11 19:40:47 (0:00:04) - WARNING on CPU_SYSTEM (85.4)
2019-10-11 19:40:19 (0:00:04) - WARNING on CPU_SYSTEM (85.3)
2019-10-11 19:39:54 (0:00:04) - WARNING on CPU_SYSTEM (85.1)
2019-10-11 19:39:45 (ongoing) - CPU_USER (Min:74.5 Mean:82.6 Max:83.7)
2019-10-11 19:41:22
```

Two nodes


```
node0.arpit-asgn-2.uwmadison744-f19-pg0.wisc.cloudlab.us (Ubuntu 16.04 64bit / Linux 4.4.0-154-generic) Uptime: 10 days, 8:27:15

CPU 88.6% nice: 0.0% LOAD 5-core MEM 5.9% active: 2.57G SWAP 0.0%
user: 86.9% irq: 0.0% 1 min: 3.54 total: 31.2G inactive: 1.17G total: 1024M
system: 1.5% iowait: 0.1% 5 min: 2.79 used: 1.85G buffers: 193M used: 0
idle: 11.3% steal: 0.1% 15 min: 1.91 free: 29.4G cached: 2.19G free: 1024M

NETWORK Rx/s Tx/s TASKS 132 (250 thr), 1 run, 130 slp, 1 oth sorted automatically by cpu_percent, flat view
eth0 286Kb 31Kb
eth1 25Kb 9Kb
lo 54.8Mb 54.8Mb

DISK I/O R/s W/s
loop0 0 0
loop1 0 0
loop2 0 0
loop3 0 0
loop4 0 0
loop5 0 0
loop6 0 0
loop7 0 0
xvda 0 17K
xvda1 0 17K
xvda2 0 0
xvda3 0 0
xvda4 0 0

Warning or critical alerts (lasts 10 entries)
FILE SYS Used Total 2019-10-11 19:56:12 (ongoing) - CPU_SYSTEM (88.6)
/ (xvda1) 3.82G 15.6G 2019-10-11 19:55:47 (0:00:04) - WARNING on CPU_SYSTEM (88.6)
2019-10-11 19:55:22 (0:00:04) - WARNING on CPU_SYSTEM (88.3)
2019-10-11 19:54:54 (0:00:04) - WARNING on CPU_SYSTEM (88.7)
2019-10-11 19:54:51 (ongoing) - CPU_USER (86.7)
2019-10-11 19:52:30 (0:00:04) - CRITICAL on CPU_SYSTEM (90.9)
2019-10-11 19:52:05 (0:00:04) - CRITICAL on CPU_SYSTEM (91.2)
2019-10-11 19:51:40 (0:00:04) - CRITICAL on CPU_SYSTEM (90.6)
2019-10-11 19:51:18 (0:00:04) - WARNING on CPU_SYSTEM (89.9)
2019-10-11 19:50:56 (0:00:04) - CRITICAL on CPU_SYSTEM (90.4)
```

Three nodes

```
node0.arpit-asgn-2.uwmadison744-f19-pg0.wisc.cloudlab.us (Ubuntu 16.04 64bit / Linux 4.4.0-154-generic) Uptime: 10 days, 8:23:05

CPU 91.5% nice: 0.0% LOAD 5-core MEM 6.2% active: 2.65G SWAP 0.0%
user: 89.4% irq: 0.0% 1 min: 4.46 total: 31.2G inactive: 1.17G total: 1024M
system: 1.8% iowait: 0.0% 5 min: 3.16 used: 1.92G buffers: 193M used: 0
idle: 8.5% steal: 0.1% 15 min: 1.77 free: 29.3G cached: 2.19G free: 1024M

NETWORK Rx/s Tx/s TASKS 133 (251 thr), 1 run, 131 slp, 1 oth sorted automatically by cpu_percent, flat view
eth0 254Kb 22Kb
eth1 29Kb 11Kb
lo 55.2Mb 55.2Mb

DISK I/O R/s W/s
loop0 0 0
loop1 0 0
loop2 0 0
loop3 0 0
loop4 0 0
loop5 0 0
loop6 0 0
loop7 0 0
xvda 0 1K
xvda1 0 1K
xvda2 0 0
xvda3 0 0
xvda4 0 0

Warning or critical alerts (lasts 10 entries)
FILE SYS Used Total 2019-10-11 19:52:02 (ongoing) - CPU_SYSTEM (91.5)
/ (xvda1) 3.82G 15.6G 2019-10-11 19:51:40 (0:00:04) - CRITICAL on CPU_SYSTEM (90.6)
2019-10-11 19:51:18 (0:00:04) - WARNING on CPU_SYSTEM (89.9)
2019-10-11 19:50:56 (0:00:04) - CRITICAL on CPU_SYSTEM (90.4)
2019-10-11 19:50:31 (0:00:04) - WARNING on CPU_SYSTEM (88.5)
2019-10-11 19:50:06 (0:00:04) - WARNING on CPU_SYSTEM (90.0)
2019-10-11 19:50:00 (ongoing) - CPU_USER (87.3)
2019-10-11 19:49:16 (0:00:04) - WARNING on CPU_SYSTEM (88.2)
2019-10-11 19:48:51 (0:00:04) - WARNING on CPU_SYSTEM (88.7)
2019-10-11 19:48:23 (0:00:04) - WARNING on CPU_SYSTEM (88.5)
```

Task - 2

In this task, we vary the batch size in the algorithm and observe how the performance changes. The experiments are run for 6 epochs. The batch size is varied as 64,128,256,512 and the results were noted:

Base Batch Sz = 64 | Epochs = 6

Mode of deployment	Accuracy	Time elapsed (sec)
Single Node	0.9800000191	178.83
Two nodes	0.9721000195	162.34
Three nodes	0.9678000212	169.67

Base Batch Sz = 128 | Epochs = 6

Mode of deployment	Accuracy	Time elapsed (sec)
Single Node	0.9763000011	162.00
Two nodes	0.948300004	175.59
Three nodes	0.923699975	171.38

Base Batch Sz = 256 | Epochs = 6

Mode of deployment	Accuracy	Time elapsed (sec)
Single Node	0.9574000239	192.23
Two nodes	0.9338999987	191.58
Three nodes	0.911499977111816	181.40

Base Batch Sz = 512 | Epochs = 6

Mode of deployment	Accuracy	Time elapsed (sec)
Single Node	0.9268000126	195.99
Two nodes	0.8734999895	191.60
Three nodes	0.8400999904	212.09

The CPU/Memory/Network usage is shown below for single node:

Batch size 64:

```
node0.arpit-asgn-2.ummadison744-f19-pg0.wisc.cloudlab.us (Ubuntu 16.04 64bit / Linux 4.4.0-154-generic) Uptime: 10 days, 8:12:25

CPU 85.3% nice: 0.0% LOAD 5-core MEM 5.7% active: 2.51G SWAP 0.0%
user: 83.0% irq: 0.0% 1 min: 3.45 total: 31.2G inactive: 1.17G total: 1024M
system: 1.9% iowait: 0.1% 5 min: 1.24 used: 1.78G buffers: 192M used: 0
idle: 14.7% steal: 0.2% 15 min: 0.56 free: 29.4G cached: 2.19G free: 1024M

NETWORK Rx/s Tx/s TASKS 133 (251 thr), 1 run, 131 slp, 1 oth sorted automatically by cpu_percent, flat view
eth0 126Kb 32Kb
eth1 0b 0b
lo 52.1Mb 52.1Mb

DISK I/O R/s W/s CPU% MEM% VIRT RES PID USER NI S TIME+ IOR/s IOW/s Command
loop0 0 0 0.3 0.0 0 0 7 root 0 S 6:54.17 0 0 python3 MNIST-LeNet-cluster.py --deploy_mode=sin
loop1 0 0 0.0 0.0 0 0 176 root 0 R 0:30.27 0 0 /usr/bin/python3 /usr/bin/glances
loop2 0 0 0.0 0.0 0 0 283 root 0 S 0:54.59 0 0 rcu_sched
loop3 0 0 0.0 0.0 0 0 191 root 0 S 0:00.22 0 1K ssh node0 cd ~/tf ; python3 MNIST-LeNet-cluster.
loop4 0 0 0.0 0.0 0 0 277 root 0 S 0:00.00 0 0 ext4-rsv-conver
loop5 0 0 0.0 0.0 107M 5.40M 1111 ntp 0 S 0:00.00 0 0 ib_nl_sa_wq
loop6 0 0 0.0 0.0 0 0 26 root -20 S 0:00.00 0 0 kworker/0:1H
loop7 0 0 0.0 0.0 0 0 3 root -20 S 0:00.30 0 0 iscsi_ah
xvda 0 12K 0.0 0.0 36.8M 5.58M 1 root 0 S 1:14.80 0 0 /usr/sbin/ntpd -n -u ntp:ntp -g
xvda1 0 12K 0.0 0.0 90.6M 6.54M 30737 root 0 S 0:06.79 0 0 watchdog/4
xvda2 0 0 0.0 0.0 0 0 78 root 0 S 0:01.26 0 0 ksoftirqd/0
xvda3 0 0 0.0 0.0 0 0 24018 root 0 S 37:59.37 0 0 /sbin/init
xvda4 0 0 0.0 0.0 0 0 76 root 0 S 0:00.18 0 0 sshd: ajain [priv]
0 0 0.0 0.0 0 0 42 root -20 S 0:00.00 0 0 bioset
/ (xvda1) 3.82G 15.6G 0 0 199 root -20 S 0:00.12 0 0 kworker/u10:0
0 0 0.0 0.0 0 0 3 root -20 S 0:00.00 0 0 bioset
0 0 0.0 0.0 0 0 42 root -20 S 0:00.00 0 0 kblockd
0 0 0.0 0.0 0 0 199 root -20 S 0:00.69 0 0 kworker/2:1H

Warning or critical alerts (lasts 6 entries)
2019-10-11 19:41:22 (ongoing) - CPU_SYSTEM (85.3)
2019-10-11 19:41:12 (0:00:04) - WARNING on CPU_SYSTEM (85.0)
2019-10-11 19:40:47 (0:00:04) - WARNING on CPU_SYSTEM (85.4)
2019-10-11 19:40:19 (0:00:04) - WARNING on CPU_SYSTEM (85.3)
2019-10-11 19:39:54 (0:00:04) - WARNING on CPU_SYSTEM (85.1)
2019-10-11 19:39:45 (ongoing) - CPU_USER (Min:74.5 Mean:82.6 Max:83.7)
```

Batch size 512:

```
node0.arpit-asgn-2.ummadison744-f19-pg0.wisc.cloudlab.us (Ubuntu 16.04 64bit / Linux 4.4.0-154-generic) Uptime: 10 days, 9:48:21

CPU 81.3% nice: 0.0% LOAD 5-core MEM 6.1% active: 2.67G SWAP 0.0%
user: 68.8% irq: 0.0% 1 min: 4.21 total: 31.2G inactive: 1.12G total: 1024M
system: 12.4% iowait: 0.1% 5 min: 2.44 used: 1.90G buffers: 194M used: 0
idle: 18.6% steal: 0.1% 15 min: 2.07 free: 29.3G cached: 2.19G free: 1024M

NETWORK Rx/s Tx/s TASKS 131 (249 thr), 1 run, 129 slp, 1 oth sorted automatically by cpu_percent, flat view
eth0 141Kb 9Kb
eth1 0b 0b
lo 43.3Mb 43.3Mb

DISK I/O R/s W/s CPU% MEM% VIRT RES PID USER NI S TIME+ IOR/s IOW/s Command
loop0 0 0 0.0 0.0 0 0 176 root 0 R 0:51.43 0 0 python3 MNIST-LeNet-cluster.py --deploy_mode=sin
loop1 0 0 0.0 0.0 0 0 283 root 0 S 0:07.10 0 0 /usr/bin/python3 /usr/bin/glances
loop2 0 0 0.0 0.0 0 0 191 root 0 S 0:00.10 0 0 sshd: ajain@pts/1
loop3 0 0 0.0 0.0 0 0 2411 root -20 S 0:00.00 0 0 ext4-rsv-conver
loop4 0 0 0.0 0.0 0 0 277 root 0 S 0:00.00 0 0 ib_nl_sa_wq
loop5 0 0 0.0 0.0 107M 5.40M 1111 ntp 0 S 0:00.30 0 0 kworker/0:1H
loop6 0 0 0.0 0.0 0 0 26 root 0 S 0:00.00 0 0 kworker/1:2
loop7 0 0 0.0 0.0 0 0 2388 root -20 S 0:00.00 0 0 iscsi_ah
xvda 0 10K 0.0 0.0 36.8M 5.58M 1 root 0 S 1:14.52 0 0 /usr/sbin/ntpd -n -u ntp:ntp -g
xvda1 0 10K 0.0 0.0 90.6M 6.54M 30737 root 0 S 0:06.83 0 0 watchdog/4
xvda2 0 0 0.0 0.0 0 0 78 root 0 S 0:00.10 0 0 kworker/4:2
xvda3 0 0 0.0 0.0 0 0 3 root 0 S 0:01.32 0 0 ksoftirqd/0
xvda4 0 0 0.0 0.0 0 0 78 root 0 S 28:33.63 0 0 /sbin/init
0 0 0.0 0.0 0 0 78 root 0 S 0:00.18 0 0 sshd: ajain [priv]
0 0 0.0 0.0 0 0 78 root -20 S 0:00.00 0 0 bioset

Warning or critical alerts (lasts 9 entries)
2019-10-11 21:17:18 (ongoing) - CPU_SYSTEM (81.3)
2019-10-11 21:16:53 (0:00:04) - WARNING on CPU_SYSTEM (85.4)
2019-10-11 21:16:44 (0:00:22) - WARNING on CPU_USER (72.7)
2019-10-11 21:16:32 (0:00:09) - WARNING on CPU_USER (71.5)
2019-10-11 21:16:28 (0:00:04) - WARNING on CPU_SYSTEM (81.0)
2019-10-11 21:16:22 (0:00:06) - WARNING on CPU_USER (71.8)
2019-10-11 21:16:04 (0:00:12) - WARNING on CPU_USER (73.5)
2019-10-11 21:16:00 (0:00:04) - WARNING on CPU_SYSTEM (78.3)
2019-10-11 21:15:54 (0:00:06) - WARNING on CPU_USER (72.0)
```

Observations and Inferences

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- 1) As we increase the number of nodes in the cluster deployment, the network utilization increases.

Explanation: As the nodes communicate with the parameter server to update the shared parameters, there is expected to be an increase in the network bandwidth utilization. The CPU/Memory remained roughly around the same.

- 2) As we increase the number of nodes in the cluster deployment, the accuracy reduces slightly.

Explanation: As multiple workers are updating the parameters in sync mode, the parameters are “averaging out” in the aggregation phase which leads to a slight loss in accuracy. The time to completion, however, was seen to reduce a bit due to the parallelization.

- 3) As we increase the batch size, the accuracy remains around the same.

Explanation: A larger batch size means that more training samples are used for each iteration. We did not observe a major accuracy difference in this case.

- 4) As we increase the batch size, the network utilization increases

Explanation: The batch size is essentially the number of samples to be propagated through the network. As the batch size increases, more data is sent over the network and hence a higher network utilization is observed.