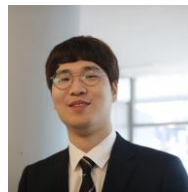


Exercise 2: Comparing Collectives



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Agenda

Time (CET)	Time (ET)	Topic	Presenter
15:00 – 16:00	9:00 – 10:00	Introduction to Distributed Deep Learning Training Platforms	Tushar Krishna
16:00 – 17:00	10:00 – 11:00	ASTRA-sim	Saeed Rashidi
17:00 – 17:10	11:00 – 11:10	Break	
17:10 – 17:50	11:10 – 11:50	Demo and Exercises	William Won and Taekyung Heo
17:50 – 18:00	11:50 – 12:00	Extensions and Future Development	Tushar Krishna and Saeed Rashidi

Tutorial Website

includes agenda, slides, ASTRA-sim installation instructions (via source + docker image)

<https://astra-sim.github.io/tutorials/asplos-2022>

Attention: Tutorial is being recorded

Objective

- Familiarizing yourself more with ASTRA-sim scripts
 - Changing communication size
 - Executing multiple runs
- Comparing ASTRA-sim results
 - Different-sized All-Reduce collective
- Implementing different topologies
 - Running HalvingDoubling All-Reduce on Switch
 - Running Direct All-Reduce on FullyConnected

Changing Communication Size

- Running **5 MB** All-Reduce collective

Method 1: Change Workload Configuration

MICRO ← **training loop**

1 ← **#layers**

allreduce -1 1 NONE 0 1 NONE 0 1 ALLREDUCE 5242880 1

Metadata		Forward			Input grad			Weight grad			Layer
Layer Name	(rsvd.)	Compute Time	Comm. Type	Comm. size	Compute Time	Comm. Type	Comm. Size	Compute Time	Comm. Type	Comm. Size	Delay
allreduce	-1	1	NONE	0	1	NONE	0	1	ALLREDUCE	5242880	1

5 MB

Changing Communication Size

- Running **5 MB** All-Reduce collective

Method 2: Change ASTRA-sim **Run Script**

```
"${BINARY}" \  
  --run-name="Exercise 2" \  
  --network-configuration="${NETWORK}" \  
  --system-configuration="${SYSTEM}" \  
  --workload-configuration="${WORKLOAD}" \  
  --comm-scale="5" \  
  --path="${RESULT_DIR}/"
```

← Run ASTRA-sim with **5x communication size**

Executing Multiple Configurations

Run [1, 5, 10] MB All-Reduce (**total 3 configurations**) concurrently

```
"${BINARY}" \
```

```
--comm-scale="1" \ ← 1MB All-Reduce  
--total-stat-rows=3 \ ← 3 total configurations  
--stat-row=0 ← index 0
```

```
"${BINARY}" \
```

```
--comm-scale="5" \ ← 5MB All-Reduce  
--total-stat-rows=3 \  
--stat-row=1 ← index 1
```

```
"${BINARY}" \
```

```
--comm-scale="10" \ ← 10MB All-Reduce  
--total-stat-rows=3 \  
--stat-row=2 ← index 2
```

Executing Multiple Configurations

- Objective: All-Reduce of size [1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024] MB (total 11 configurations)

```

SIZES=(1 2 4 8 16 32 64 128 256 512 1024)
for i in {0..10}; do
    size=${SIZES[$i]}
    "${BINARY}" \
        --run-name="${size}" \
        --network-configuration="${NETWORK}" \
        --system-configuration="${SYSTEM}" \
        --workload-configuration="${WORKLOAD}" \
        --comm-scale="${size}" \
        --path="${RESULT_DIR}/" \
        --total-stat-rows=11 \
        --stat-row=$i
done

```

Size: 1 - 1024 MB

For-loop

Run name: Size

All-Reduce Size

11 Total configs

i^{th} config

Running Experiment

- All-Reduce of size [1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024] MB (total 11 configurations)

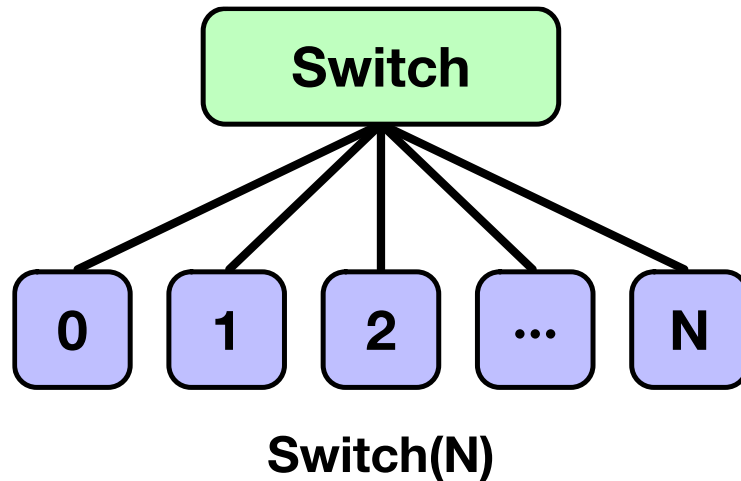
```
$ cd exercise_2/  
$ ./build.sh  
$ ./exercise_2_1.sh
```


Understanding Results

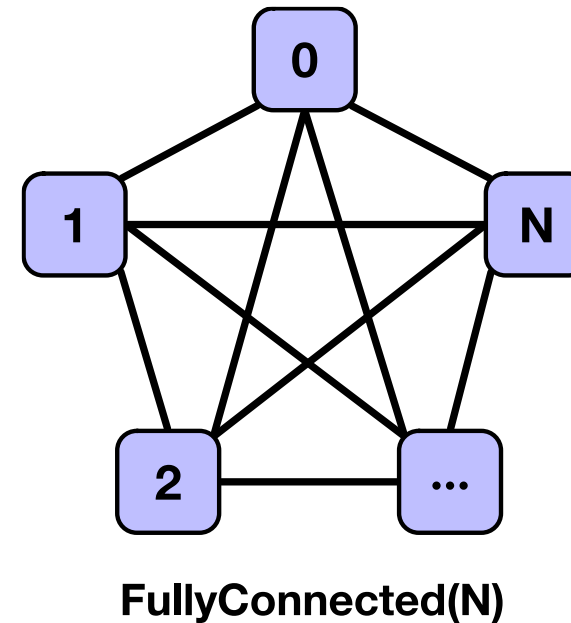
result_1/tutorial_result.csv

Name	Total Time (us)	Compute Time (us)	Exposed Communication Time (us)	Total Message Size (MB)
1	45.681	0	45.681	1.75
2	62.761	0	62.761	3.5
4	96.921	0	96.921	7
8	165.297	0	165.297	14
16	302.077	0	302.077	28
32	575.609	0	575.609	56
64	1122.673	0	1122.673	112
128	2216.745	0	2216.745	224
256	4404.945	0	4404.945	448
512	8781.373	0	8781.373	896
1024	17534.229	0	17534.229	1792

Switch and FullyConnected Topology



- **Switch** topology
- **HalvingDoubling** All-Reduce
- **1** Link / NPU



- **FullyConnected** topology
- **Direct** All-Reduce
- **(N-1)** Links / NPU

Switch/FullyConnected Network

inputs/switch.json

```
{
  "dimensions-count": 1,
  "topologies-per-dim": ["Switch"],
  "units-count": [8],
  "links-count": [1],
  "link-latency": [500],
  "link-bandwidth": [50]
}
```

Switch topology

1 link/NPU

inputs/fullyconnected.json

```
{
  "dimensions-count": 1,
  "topologies-per-dim": ["FullyConnected"],
  "units-count": [8],
  "links-count": [7],
  "link-latency": [500],
  "link-bandwidth": [50]
}
```

FullyConnected topology

7 link/NPU

Configurations: System

inputs/switch.txt

```
scheduling-policy: LIFO
endpoint-delay: 10
active-chunks-per-dimension: 1
preferred-dataset-splits: 4
boost-mode: 1
all-reduce-implementation: halvingDoubling
all-gather-implementation: halvingDoubling
reduce-scatter-implementation: halvingDoubling
all-to-all-implementation: direct
collective-optimization: localBWAware
```



HalvingDoubling
collective algorithm

inputs/fullyconnected.txt

```
scheduling-policy: LIFO
endpoint-delay: 10
active-chunks-per-dimension: 1
preferred-dataset-splits: 4
boost-mode: 1
all-reduce-implementation: direct
all-gather-implementation: direct
reduce-scatter-implementation: direct
all-to-all-implementation: direct
collective-optimization: localBWAware
```



Direct
collective algorithm

Running Experiment

- Objective: Running
 - 1GB All-Reduce
 - On 8-NPU Ring, Switch, FullyConnected

exercise_2_2.txt

```
"${BINARY}" \  
  --run-name="Switch" \  
  --network-configuration="${INPUT_DIR}/switch.json" \  
  --system-configuration="${INPUT_DIR}/switch.txt" \  
  --workload-configuration="${WORKLOAD}" \  
  --comm-scale="1024" \  
  --path="${RESULT_DIR}/" \  
  --total-stat-rows=3 \  
  --stat-row=1
```

← Switch topology

← Switch system

← 1GB All-Reduce

← 3 Total configs

Running Experiment

- Objective: Running
 - 1GB All-Reduce
 - On 8-NPU Ring, Switch, FullyConnected

```
$ ./build.sh
```

```
$ ./exercise_2_2.sh
```

Understanding Results

result_2/tutorial_result.csv

Name	Total Time (us)	Compute Time (us)	Exposed Communication Time (us)	Total Message Size (MB)
Ring	17534.229	0	17534.229	1792
Switch	35026.693	0	35026.693	1792
FullyConnected	5004.925	0	5004.925	1792