Georgia Tech School of Electrical and Computer Engineering
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SYNERGY

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ASTRA-SIM

# 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

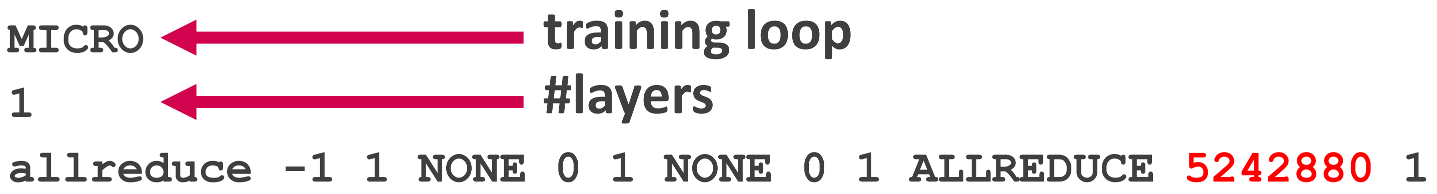
# Objective

- 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
1
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" \
        --total-stat-rows=3 \
        --stat-row=0
```

**1MB** All-Reduce

**3** total configurations

**index 0**

```
"${BINARY}" \
        --comm-scale="5" \
        --total-stat-rows=3 \
        --stat-row=1
```

**5MB** All-Reduce

**index 1**

```
"${BINARY}" \
        --comm-scale="10" \
        --total-stat-rows=3 \
        --stat-row=2
```

**10MB** All-Reduce

**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**$^{\mathbf{th}}$ 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
```

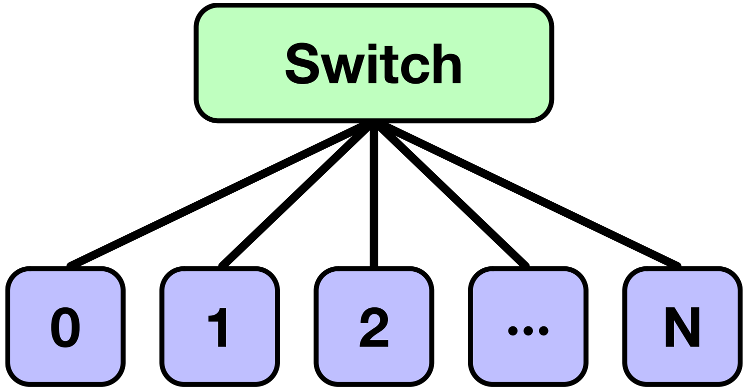
# Understanding Results

`result_1/tutorial_result.csv`

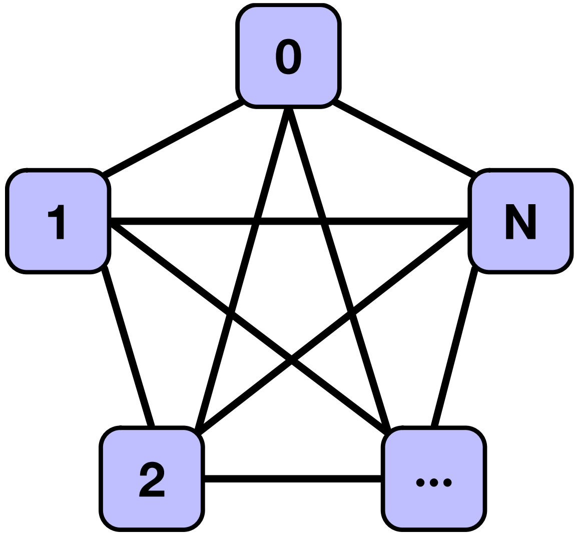
| Name | Total Time (us) | Compute Time (us) | Exposed Communication Time (us) | Total Message Size (MB) |
|---|---|---|---|---|
| 1 | 45.681 | 0 | 45.681 | 1.75 |
| 2 | 62.761 | 0 | 62.761 | 3.5 |
| 4 | 96.921 | 0 | 96.921 | 7 |
| 8 | 165.297 | 0 | 165.297 | 14 |
| 16 | 302.077 | 0 | 302.077 | 28 |
| 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 |

**TODO: Add graph here**

# Switch and FullyConnected Topology



Switch(N)



FullyConnected(N)

- **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 |