Assignment 1 : MPI Programming and Benchmarking MPI Cluster in the Cloud

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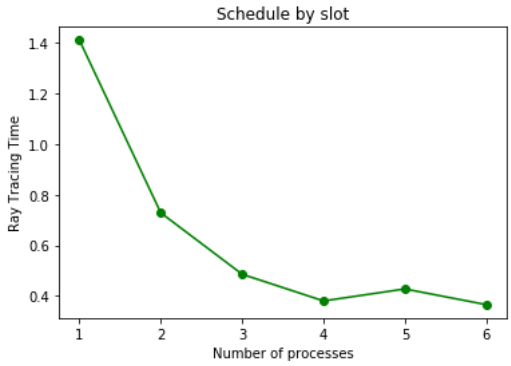
Ray Tracing Engine Performance

1 By Slots

For the first experiment we ran the ray tracing program using two, four, and six processes. In each case we were able to see faster ray tracing times. We noticed as the number of processes went up, the change in times became smaller. Increasing processes produced diminishing returns. The time difference between two and four nodes was 0.3565 seconds. The difference in time to complete between four and six nodes was 0.0114 seconds.

Slots	Time to Complete	Difference
2	0.7350	0
4	0.3785	0.3565
6	0.3671	0.0114



By slot graph.

```
 Data for JOB [3154,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3154,1] App: 0 Process rank: 0
        Process OMPI jobid: [3154,1] App: 0 Process rank: 1

 =============================================================
Tachyon Parallel/Multiprocessor Ray Tracer   Version 0.99
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-------------------------------------------------------------
Scene Parsing Time:     0.0199 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0042 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.7350 seconds
    Image I/O Time:     0.0114 seconds
```

Output of two processes by slot.

```
 Data for JOB [3182,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3182,1] App: 0 Process rank: 0
        Process OMPI jobid: [3182,1] App: 0 Process rank: 1

 Data for node: 129.115.30.95   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3182,1] App: 0 Process rank: 2
        Process OMPI jobid: [3182,1] App: 0 Process rank: 3

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-------------------------------------------------------------
Scene Parsing Time:     0.0199 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0040 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.3785 seconds
    Image I/O Time:     0.0105 seconds
```

Output of four processes by slot.

```
 Data for JOB [3178,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3178,1] App: 0 Process rank: 0
        Process OMPI jobid: [3178,1] App: 0 Process rank: 1

 Data for node: 129.115.30.95   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3178,1] App: 0 Process rank: 2
        Process OMPI jobid: [3178,1] App: 0 Process rank: 3

 Data for node: 129.115.30.78   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3178,1] App: 0 Process rank: 4
        Process OMPI jobid: [3178,1] App: 0 Process rank: 5

 =============================================================
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-------------------------------------------------------------
Scene Parsing Time:     0.0194 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0042 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.3671 seconds
    Image I/O Time:     0.0122 seconds
```
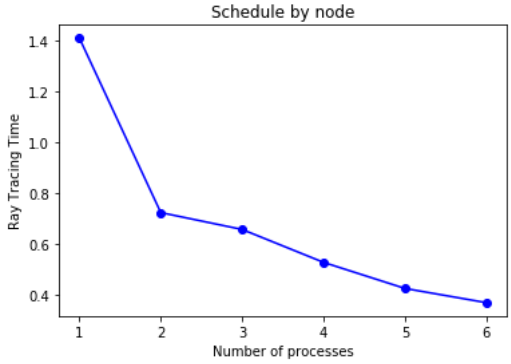

Output of six processes by slot.

2 By Node

The ray tracing experiment with the by-node option led to greater changes between the number of processes, but overall took longer to complete. From two to four nodes, the ray tracing time difference was 0.1987 seconds. And the difference between four and six nodes was 0.1683 seconds. Similar to the by-slot experiment, there is a trend of diminishing returns.

Slots	Time to Complete	Difference
2	0.7218	0
4	0.5231	0.1987
6	0.3639	0.1683



By node graph.

```
Data for JOB [3198,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 1
        Process OMPI jobid: [3198,1] App: 0 Process rank: 0

 Data for node: 129.115.30.95   Num slots: 2    Max slots: 0    Num procs: 1
        Process OMPI jobid: [3198,1] App: 0 Process rank: 1

 ============================================================
Tachyon Parallel/Multiprocessor Ray Tracer   Version 0.99
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------------------------------------------------------------
Scene Parsing Time:     0.0189 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0034 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.7218 seconds
    Image I/O Time:     0.0112 seconds
```

Output of two processes by node.

```
 Data for JOB [3170,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3170,1] App: 0 Process rank: 0
        Process OMPI jobid: [3170,1] App: 0 Process rank: 3

 Data for node: 129.115.30.95   Num slots: 2    Max slots: 0    Num procs: 1
        Process OMPI jobid: [3170,1] App: 0 Process rank: 1

 Data for node: 129.115.30.78   Num slots: 2    Max slots: 0    Num procs: 1
        Process OMPI jobid: [3170,1] App: 0 Process rank: 2

 ============================================================
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------------------------------------------------------------
Scene Parsing Time:     0.0199 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0041 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.5231 seconds
    Image I/O Time:     0.0109 seconds
```

Output of four processes by node.

```
Data for JOB [3174,1] offset 0

 ========================   JOB MAP   ========================

 Data for node: 129.115.30.81   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3174,1] App: 0 Process rank: 0
        Process OMPI jobid: [3174,1] App: 0 Process rank: 3

 Data for node: 129.115.30.95   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3174,1] App: 0 Process rank: 1
        Process OMPI jobid: [3174,1] App: 0 Process rank: 4

 Data for node: 129.115.30.78   Num slots: 2    Max slots: 0    Num procs: 2
        Process OMPI jobid: [3174,1] App: 0 Process rank: 2
        Process OMPI jobid: [3174,1] App: 0 Process rank: 5

 ============================================================
Tachyon Parallel/Multiprocessor Ray Tracer   Version 0.99
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------------------------------------------------------------
Scene Parsing Time:     0.0194 seconds
Scene contains 2330 objects.
Preprocessing Time:     0.0042 seconds
Rendering Progress:       100% complete
  Ray Tracing Time:     0.3639 seconds
    Image I/O Time:     0.0118 seconds
```

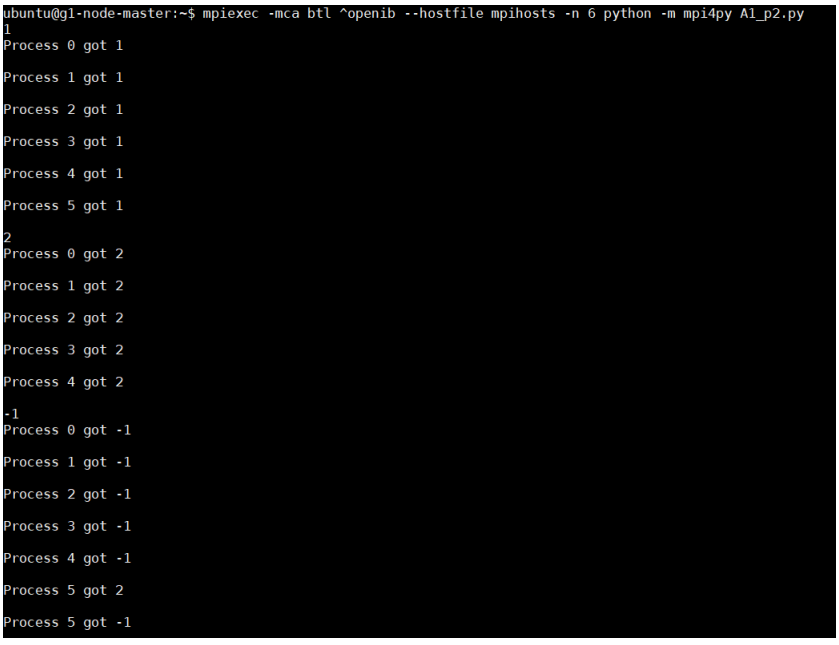
Output of two processes by node.

3 Question 1 Conclusion

We believe the reason by-slot is much faster is due to less overhead for the context switch between processes in each VM. In contrast, the by-node experiment required more overhead to complete the context switches between VM's. Locality played a big part in the faster times we saw with the by-slot experiment.

MPI4PY Ring

For this experiment we created a program that takes input from user and sends the input to the next node. If the node is not the master node, then, the node will take input from the preceding node. Each node will print out the input before passing the input to the next node. We noticed that the last node would sometimes print out all its inputs, after the negative value was passed in to all the other nodes. We initially thought that the last process was not being spawned until the other processes were shutdown. But that would mean that when the node prior to the last node sent out its input, then, there would be no node to receive. So the last node is spawned but it is not executing until all other nodes have shutdown. We believe this to be an internal characteristic that we currently do not understand.



Mpi4py output.

Team Contribution

- Amatullah Yousuf: Volunteered her computer and school account to setup and run the experiments. Created the graphs and output screenshots for the report. Contributed to the python code needed to complete question 2 of the assignment.
- David J.: Contributed to the python code creation and helped debug issues we had with setting up the first part of the assignment.
- Hector Herrera: Wrote up the report, contributed to the python code and kept spirits up whenever we ran into a problem.
- Seth Louis Allen Greco: Contributed to the python code and helped debug issues we had with setting up the first part of the assignment and the python code.