1. Develop a simple MPI program using C/C++ and OpenMPI that uses at least 2 nodes on Discovery and utilizes at least 16 processes on each node (a minimum of 32 processes in total). You are suggested to use the sample batch script provided on Canvas for specifying your OpenMPI configuration and running your program.

a) Start with an integer variable that you will pass to each process, where process 1 prints the value, increments the value by 1, and sends it to process 2. Process 2 prints the value, then increments the value by 1 and sends it to process 3. Repeat this for all 32 processes. When performing printing, print both the integer value, as well as identify which process is printing, and on which node this process is running on.

```
process 0 read value 0
process 0 send value 1 to process 1
process 1 receive value 1 from 0
process 1 send value 2 to process 2
process 2 receive value 2 from 1
process 2 send value 3 to process 3
process 3 receive value 3 from 2
process 3 send value 4 to process 4
process 4 receive value 4 from 3
process 4 send value 5 to process 5
process 5 receive value 5 from 4
process 5 send value 6 to process 6
process 6 receive value 6 from 5
process 6 send value 7 to process 7
process 7 receive value 7 from 6
process 7 send value 8 to process 8
process 8 receive value 8 from 7
process 8 send value 9 to process 9
process 9 receive value 9 from 8
process 9 send value 10 to process 10
process 10 receive value 10 from 9
process 10 send value 11 to process 11
process 11 receive value 11 from 10
process 11 send value 12 to process 12
process 12 receive value 12 from 11
process 12 send value 13 to process 13
process 13 receive value 13 from 12
process 13 send value 14 to process 14
process 14 receive value 14 from 13
process 14 send value 15 to process 15
process 15 receive value 15 from 14
process 15 send value 16 to process 16
process 16 receive value 16 from 15
process 16 send value 17 to process 17
process 17 receive value 17 from 16
process 17 send value 18 to process 18
process 18 receive value 18 from 17
process 18 send value 19 to process 19
process 19 receive value 19 from 18
process 19 send value 20 to process 20
process 20 receive value 20 from 19
process 20 send value 21 to process 21
process 21 receive value 21 from 20
process 21 send value 22 to process 22
process 22 receive value 22 from 21
process 22 send value 23 to process 23
process 23 receive value 23 from 22
process 23 send value 24 to process 24
process 24 receive value 24 from 23
process 24 send value 25 to process 25
process 25 receive value 25 from 24
process 25 send value 26 to process 26
process 26 receive value 26 from 25
process 26 send value 27 to process 27
process 27 receive value 27 from 26
process 27 send value 28 to process 28
process 28 receive value 28 from 27
process 28 send value 29 to process 29
process 29 receive value 29 from 28
process 29 send value 30 to process 30
process 30 receive value 30 from 29
process 30 send value 31 to process 31
process 31 receive value 31 from 30
```

b) Next, continuing the printing, but once the value gets to 32, decrement the value, and continue to print out the value until the decremented value is zero.

```
process 0 read value 0
process 0 send value 1 to process 1
process 1 receive value 1 from 0
process 1 send value 2 to process 2
process 2 receive value 2 from 1
process 2 send value 3 to process 3
process 3 receive value 3 from 2
process 3 send value 4 to process 4
process 4 receive value 4 from 3
process 4 send value 5 to process 5
process 5 receive value 5 from 4
process 5 send value 6 to process 6
process 6 receive value 6 from 5
process 6 send value 7 to process 7
process 7 receive value 7 from 6
process 7 send value 8 to process 8
process 8 receive value 8 from 7
process 8 send value 9 to process 9
process 9 receive value 9 from 8
process 9 send value 10 to process 10
process 10 receive value 10 from 9
process 10 send value 11 to process 11
process 11 receive value 11 from 10
process 11 send value 12 to process 12
process 12 receive value 12 from 11
process 12 send value 13 to process 13
process 13 receive value 13 from 12
process 13 send value 14 to process 14
process 14 receive value 14 from 13
process 14 send value 15 to process 15
process 15 receive value 15 from 14
process 15 send value 16 to process 16
process 16 receive value 16 from 15
process 16 send value 17 to process 17
process 17 receive value 17 from 16
process 17 send value 18 to process 18
process 18 receive value 18 from 17
process 18 send value 19 to process 19
process 19 receive value 19 from 18
process 19 send value 20 to process 20
process 20 receive value 20 from 19
process 20 send value 21 to process 21
process 21 receive value 21 from 20
process 21 send value 22 to process 22
process 22 receive value 22 from 21
process 22 send value 23 to process 23
process 23 receive value 23 from 22
process 23 send value 24 to process 24
process 24 receive value 24 from 23
process 24 send value 25 to process 25
process 25 receive value 25 from 24
process 25 send value 26 to process 26
process 26 receive value 26 from 25
process 26 send value 27 to process 27
process 27 receive value 27 from 26
process 27 send value 28 to process 28
process 28 receive value 28 from 27
```

```
process 28 send value 29 to process 29
process 29 receive value 29 from 28
process 29 send value 30 to process 30
process 30 receive value 30 from 29
process 30 send value 31 to process 31
process 31 receive value 31 from 30
process 29 receive value 29 from 30
process 29 send value 28 to process 28
process 30 receive value 30 from 31
process 30 send value 29 to process 29
process 31 read value 31
process 31 send value 30 to process 30
process 22 receive value 22 from 23
process 22 send value 21 to process 21
process 23 receive value 23 from 24
process 23 send value 22 to process 22
process 24 receive value 24 from 25
process 24 send value 23 to process 23
process 25 receive value 25 from 26
process 25 send value 24 to process 24
process 14 receive value 14 from 15
process 14 send value 13 to process 13
process 26 receive value 26 from 27
process 26 send value 25 to process 25
process 27 receive value 27 from 28
process 27 send value 26 to process 26
process 28 receive value 28 from 29
process 28 send value 27 to process 27
process 15 receive value 15 from 16
process 15 send value 14 to process 14
process 17 receive value 17 from 18
process 17 send value 16 to process 16
process 12 receive value 12 from 13
process 12 send value 11 to process 11
process 18 receive value 18 from 19
process 18 send value 17 to process 17
process 19 receive value 19 from 20
process 19 send value 18 to process 18
process 13 receive value 13 from 14
process 13 send value 12 to process 12
process 20 receive value 20 from 21
process 20 send value 19 to process 19
process 9 receive value 9 from 10
process 9 send value 8 to process 8
process 21 receive value 21 from 22
process 21 send value 20 to process 20
```

```
process 10 receive value 10 from 11
process 10 send value 9 to process 9
process 16 receive value 16 from 17
process 11 receive value 11 from 12
process 11 send value 10 to process 10
process 16 send value 15 to process 15
process 6 receive value 6 from 7
process 6 send value 5 to process 5
process 7 receive value 7 from 8
process 7 send value 6 to process 6
process 8 receive value 8 from 9
process 8 send value 7 to process 7
process 4 receive value 4 from 5
process 4 send value 3 to process 3
process 5 receive value 5 from 6
process 5 send value 4 to process 4
process 2 receive value 2 from 3
process 2 send value 1 to process 1
process 3 receive value 3 from 4
process 3 send value 2 to process 2
process 1 receive value 1 from 2
process 1 send value 0 to process 0
process 0 receive value 0 from 1
```