Assignment I: GPU programming enviroment

Observation

1. When the transfer size is adequately large, the device-to-device bandwidth is significantly larger than host-to-device and device-to-host bandwidth. This is reasonable since device-to-device data transfer can be done in parallel, while other data transfer cannot.
2. When transfer size reaches higher value, the bandwidth tends to converge to a limit. This is also reasonable since when the data is too much, the data bus might be more occupied, thus increasing the transfer size does not increase the bandwidth significantly.

Bandwidth test

```
!./bandwidthTest/bandwidthTest
```

```
[CUDA Bandwidth Test] - Starting...
Running on...

 Device 0: Tesla T4
 Quick Mode

 Host to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)    Bandwidth(GB/s)
   32000000         12.4

 Device to Host Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)    Bandwidth(GB/s)
   32000000         13.1

 Device to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)    Bandwidth(GB/s)
   32000000         239.4

Result = PASS

NOTE: The CUDA Samples are not meant for performance measurements. Results may
vary when GPU Boost is enabled.
```

Shmoo Mode bandwidth test

```
!./bandwidthTest/bandwidthTest --mode=shmoo
```

```
[CUDA Bandwidth Test] - Starting...
Running on...

 Device 0: Tesla T4
 Shmoo Mode

.....................................................................................
 Host to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)    Bandwidth(GB/s)
   1000             0.4
   2000             0.7
   3000             1.1
   4000             1.5
   5000             1.8
   6000             2.0
   7000             2.3
   8000             2.5
   9000             2.7
   10000            2.9
   11000            3.1
   12000            3.3
   13000            3.6
   14000            3.7
   15000            3.8
   16000            4.0
   17000            4.2
   18000            4.2
   19000            4.2
   20000            4.5
   22000            4.7
   24000            4.9
   26000            5.1
   28000            5.3
   30000            5.5
   32000            5.8
   34000            5.8
   36000            6.2
   38000            6.4
   40000            6.4
   42000            6.6
   44000            6.7
   46000            6.9
   48000            7.0
   50000            7.1
   60000            7.6
   70000            8.0
   80000            8.5
   90000            8.8
   100000           9.1
   200000           10.4
```

```
   300000           11.1
   400000           11.4
   500000           11.5
   600000           11.7
   700000           9.0
   800000           11.6
   900000           9.5
   1000000          11.8
   2000000          10.7
   3000000          11.1
   4000000          11.5
   5000000          11.6
   6000000          11.8
   7000000          11.9
   8000000          12.0
   9000000          11.9
   10000000         12.0
   11000000         12.0
   12000000         12.1
   13000000         12.1
   14000000         12.1
   15000000         12.1
   16000000         12.1
   18000000         12.2
   20000000         12.2
   22000000         12.2
   24000000         12.2
   26000000         12.2
   28000000         12.2
   30000000         12.2
   32000000         12.3
   36000000         12.3
   40000000         12.3
   44000000         12.3
   48000000         12.3
   52000000         12.3
   56000000         12.3
   60000000         12.3
   64000000         12.3
   68000000         12.3

 ..............................................................................
  Device to Host Bandwidth, 1 Device(s)
  PINNED Memory Transfers
    Transfer Size (Bytes)    Bandwidth(GB/s)
    1000             0.6
    2000             1.2
    3000             1.8
    4000             1.4
    5000             2.8
    6000             3.2
    7000             3.9
    8000             4.0
    9000             4.7
```

```
10000           5.1
11000           5.2
12000           5.6
13000           5.8
14000           6.1
15000           6.3
16000           6.5
17000           6.7
18000           6.8
19000           7.1
20000           7.3
22000           7.6
24000           7.9
26000           8.1
28000           8.4
30000           8.6
32000           8.8
34000           8.7
36000           9.1
38000           9.2
40000           9.4
42000           9.5
44000           9.6
46000           9.7
48000           9.9
50000           9.8
60000           10.3
70000           10.7
80000           10.7
90000           11.2
100000          11.3
200000          10.8
300000          9.5
400000          11.0
500000          11.5
600000          12.8
700000          12.5
800000          12.0
900000          11.6
1000000         11.1
2000000         12.9
3000000         13.0
4000000         13.0
5000000         13.1
6000000         13.0
7000000         13.1
8000000         13.1
9000000         13.1
10000000        13.1
11000000        13.1
12000000        13.1
13000000        13.1
14000000        13.1
15000000        13.1
```

```
   16000000         13.1
   18000000         13.1
   20000000         13.1
   22000000         13.1
   24000000         13.1
   26000000         13.1
   28000000         13.1
   30000000         13.1
   32000000         13.2
   36000000         13.2
   40000000         13.2
   44000000         13.2
   48000000         13.2
   52000000         13.2
   56000000         13.2
   60000000         13.2
   64000000         13.2
   68000000         13.2

.....................................................................................
 Device to Device Bandwidth, 1 Device(s)
 PINNED Memory Transfers
   Transfer Size (Bytes)    Bandwidth(GB/s)
   1000             0.6
   2000             1.2
   3000             1.6
   4000             2.3
   5000             1.9
   6000             3.5
   7000             4.1
   8000             4.7
   9000             5.4
   10000            5.7
   11000            6.6
   12000            6.7
   13000            7.7
   14000            8.0
   15000            8.8
   16000            9.5
   17000            9.5
   18000            10.6
   19000            11.0
   20000            11.6
   22000            12.3
   24000            13.9
   26000            15.8
   28000            15.8
   30000            18.0
   32000            18.1
   34000            17.1
   36000            14.2
   38000            17.8
   40000            22.8
   42000            25.6
```

```
    44000           26.9
    46000           26.3
    48000           26.9
    50000           30.3
    60000           35.3
    70000           42.7
    80000           46.7
    90000           54.0
    100000          61.2
    200000          124.2
    300000          186.9
    400000          265.4
    500000          341.0
    600000          413.5
    700000          271.0
    800000          468.6
    900000          490.4
    1000000         516.9
    2000000         580.1
    3000000         207.8
    4000000         214.7
    5000000         220.9
    6000000         223.1
    7000000         226.5
    8000000         228.4
    9000000         229.8
    10000000        231.1
    11000000        232.2
    12000000        232.8
    13000000        234.1
    14000000        234.7
    15000000        235.3
    16000000        235.5
    18000000        236.4
    20000000        237.2
    22000000        237.9
    24000000        238.0
    26000000        238.2
    28000000        238.5
    30000000        239.2
    32000000        239.4
    36000000        239.8
    40000000        240.1
    44000000        240.4
    48000000        240.5
    52000000        240.9
    56000000        241.0
    60000000        241.1
    64000000        242.2
    68000000        241.4

Result = PASS
```

```
NOTE: The CUDA Samples are not meant for performance measurements. Results may
vary when GPU Boost is enabled.
```