MPI 异步通信小作业 实验报告

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任务一

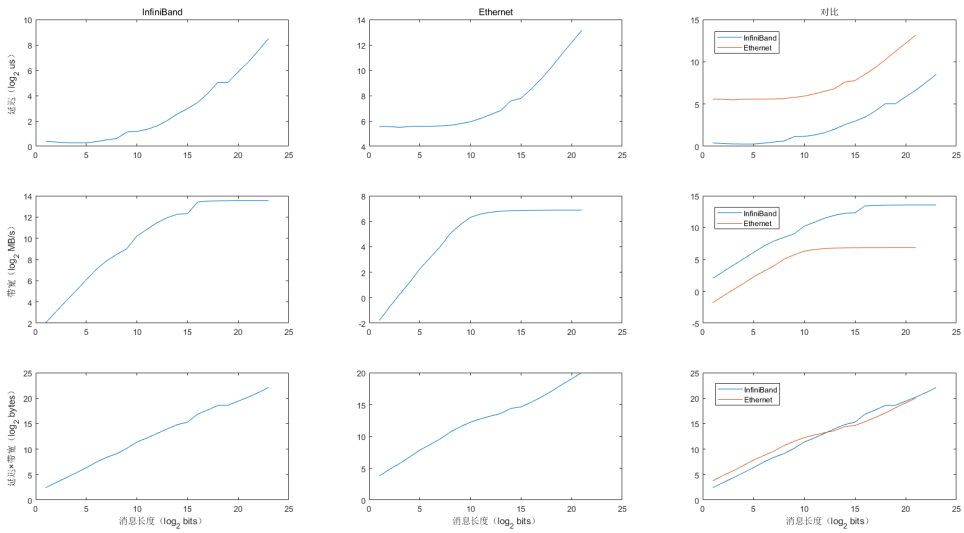
InfiniBand:

编号	消息长度	延迟（us）	带宽(MB/s)
1	1	1.31	4.14
2	2	1.26	8.42
3	4	1.22	17.00
4	8	1.21	33.67
5	16	1.21	67.97
6	32	1.29	134.75
7	64	1.42	235.52
8	128	1.53	356.32
9	256	2.19	516.09
10	512	2.25	1189.39
11	1024	2.53	1840.10
12	2048	3.05	2844.54
13	4096	4.09	3924.90
14	8192	5.88	4902.90
15	16384	7.82	5105.94
16	32768	10.93	10900.69
17	65536	18.05	11568.74
18	131072	33.04	11795.97
19	262144	33.13	11925.50
20	524288	58.21	12010.54
21	1048576	100.02	12039.19
22	2097152	187.22	12047.85
23	4194304	363.16	12055.85

以太网：

编号	消息长度	延迟（us）	带宽(MB/s)
1	1	47.47	0.29
2	2	47.04	0.60
3	4	45.03	1.19
4	8	47.24	2.31
5	16	47.79	4.80
6	32	47.80	8.75
7	64	48.77	15.85
8	128	50.34	32.72
9	256	55.25	53.22
10	512	61.20	79.27
11	1024	73.26	94.86
12	2048	90.77	104.54
13	4096	113.30	110.50
14	8192	192.49	113.96
15	16384	220.64	115.95
16	32768	366.06	116.63
17	65536	639.77	117.09
18	131072	1203.12	117.36
19	262144	2424.31	117.51
20	524288	4655.50	117.56
21	1048576	9100.34	117.60

（为了更好地读出趋势，作图如下）



- 请描述当消息长度增加时，带宽和延迟分别呈现出什么样的趋势?

答：当消息长度增加时，延迟先稳定在某一值附近、后随消息长度加速增加；带宽先随消息长度近线性增加，后稳定在某一值附近。

- 该趋势在两种网络下有何不同?

答：（1）两种网络的性能指标绝对值有差异（2）以太网较InfiniBand在延迟上更晚开始增加，在带宽上更早达到饱和。

- 为什么会有这样的趋势?

答：在传输小信息时，延迟主要体现在网络的固有通信时延、带宽不是限制因素；在传输大信息时，带宽使用饱和，信息的有限传输速度贡献了延迟。

- 对比InfiniBand和以太网络下的带宽和延迟，它们之间的差距是多少?

答：以太网的延迟为InfiniBand的30倍左右，InfiniBand的带宽约为以太网的100倍。

任务二

编号	消息长度	计算量	mpi_sync 总耗时	mpi_async 总耗时
1	100000000	10	968.685	705.08
2	100000000	20	1072.49	867.214
3	100000000	40	1276.34	865.51
4	100000000	80	1514.44	800.227
5	100000000	160	2483.75	1600.38

- 通信时间和计算时间满足什么关系时，非阻塞通信程序能完美掩盖通信时间?

答：当计算时间大于通信时间时。

- 简述两份代码的不同之处。

答：`mpi_async.cpp` 用到了 `MPI_Isend` 和 `MPI_Wait` 这两个非阻塞通信函数来替代 `mpi_sync.cpp` 中的 `MPI_Send` 。

附录（助教批阅时不用管，仅作记录用）

附：作图的 `Matlab` 代码

```
inf_id = 1:23;
inf_delay = [1.31, 1.26, 1.22, 1.21, 1.21, 1.29, 1.42, 1.53, 2.19, 2.25, 2.53,
3.05, 4.09, 5.88, 7.82, 10.93, 18.05, 33.04, 33.13, 58.21, 100.02, 187.22,
363.16];
inf_band = [4.14, 8.42, 17.00, 33.67, 67.97, 134.75, 235.52, 356.32, 516.09,
1189.39, 1840.10, 2844.54, 3924.90, 4902.90, 5105.94, 10900.69, 11568.74,
11795.97, 11925.50, 12010.54, 12039.19, 12047.85, 12055.85];
ether_id = 1:21;
ether_delay = [47.47, 47.04, 45.03, 47.24, 47.79, 47.80, 48.77, 50.34, 55.25,
61.20, 73.26, 90.77, 113.30, 192.49, 220.64, 366.06, 639.77, 1203.12, 2424.31,
4655.50, 9100.34];
```

```
ether_band = [0.29, 0.60, 1.19, 2.31, 4.80, 8.75, 15.85, 32.72, 53.22, 79.27,
94.86, 104.54, 110.50, 113.96, 115.95, 116.63, 117.09, 117.36, 117.51, 117.56,
117.60];
figure;
subplot(3,3,1),
plot(inf_id, log2(inf_delay)),
ylabel("延迟 (log_2 us) ");
title("InfiniBand");
subplot(3,3,4),
plot(inf_id, log2(inf_band)),
ylabel("带宽 (log_2 MB/s) ");
subplot(3,3,7),
plot(inf_id, log2(inf_band .* inf_delay)),
ylabel("延迟×带宽 (log_2 bytes) ");
xlabel("消息长度 (log_2 bits) ");
subplot(3,3,2),
plot(ether_id, log2(ether_delay)),
title("Ethernet");
subplot(3,3,5),
plot(ether_id, log2(ether_band)),
subplot(3,3,8),
plot(ether_id, log2(ether_delay .* ether_band)),
xlabel("消息长度 (log_2 bits) ");
subplot(3,3,3),
plot(inf_id, log2(inf_delay), ether_id, log2(ether_delay)),
legend("InfiniBand","Ethernet");
title("对比");
subplot(3,3,6),
plot(inf_id, log2(inf_band), ether_id, log2(ether_band)),
legend("InfiniBand","Ethernet");
subplot(3,3,9),
plot(inf_id, log2(inf_band .* inf_delay), ether_id, log2(ether_delay .*
ether_band)),
legend("InfiniBand","Ethernet");
xlabel("消息长度 (log_2 bits) ");
```

附：任务二计算的输出

```
+ srun -N 2 -n 2 ./mpi_sync 10 100000000 10
Iter 0 MPI_Send: 86.5957 ms
Iter 0 Compute: 10.0001 ms
Iter 1 MPI_Send: 86.8895 ms
Iter 1 Compute: 10.0001 ms
Iter 2 MPI_Send: 86.9107 ms
Iter 2 Compute: 10.0001 ms
Iter 3 MPI_Send: 86.8681 ms
Iter 3 Compute: 10.0001 ms
Iter 4 MPI_Send: 86.8424 ms
Iter 4 Compute: 10.0001 ms
Iter 5 MPI_Send: 86.923 ms
Iter 5 Compute: 10.0001 ms
Iter 6 MPI_Send: 86.8462 ms
Iter 6 Compute: 10.0001 ms
Iter 7 MPI_Send: 86.8845 ms
```

```
Iter 7 Compute: 10.0001 ms
Iter 8 MPI_Send: 86.9047 ms
Iter 8 Compute: 10.0001 ms
Iter 9 MPI_Send: 86.842 ms
Iter 9 Compute: 10.0001 ms
Total: 968.685 ms
+ srun -N 2 -n 2 ./mpi_async 10 100000000 10
Iter 0 MPI_Isend: 0.050595 ms
Iter 0 Compute: 10.0651 ms
Iter 1 MPI_Isend: 0.001297 ms
Iter 1 Compute: 10.0024 ms
Iter 2 MPI_Isend: 0.000398 ms
Iter 2 Compute: 10.0016 ms
Iter 3 MPI_Isend: 0.000392 ms
Iter 3 Compute: 10.0016 ms
Iter 4 MPI_Isend: 0.000426 ms
Iter 4 Compute: 10.0013 ms
Iter 5 MPI_Isend: 0.000435 ms
Iter 5 Compute: 10.0013 ms
Iter 6 MPI_Isend: 0.000412 ms
Iter 6 Compute: 10.0014 ms
Iter 7 MPI_Isend: 0.000402 ms
Iter 7 Compute: 10.0013 ms
Iter 8 MPI_Isend: 0.000419 ms
Iter 8 Compute: 10.0013 ms
Iter 9 MPI_Isend: 0.000413 ms
Iter 9 Compute: 10.0013 ms
Wait Request: 604.909 ms
Total: 705.08 ms
+ srun -N 2 -n 2 ./mpi_sync 10 100000000 20
Iter 0 MPI_Send: 86.8646 ms
Iter 0 Compute: 20.0002 ms
Iter 1 MPI_Send: 87.2777 ms
Iter 1 Compute: 20.0001 ms
Iter 2 MPI_Send: 87.2967 ms
Iter 2 Compute: 20.0001 ms
Iter 3 MPI_Send: 87.2407 ms
Iter 3 Compute: 20.0001 ms
Iter 4 MPI_Send: 87.3093 ms
Iter 4 Compute: 20.0001 ms
Iter 5 MPI_Send: 87.2538 ms
Iter 5 Compute: 20.0001 ms
Iter 6 MPI_Send: 87.2833 ms
Iter 6 Compute: 20.0001 ms
Iter 7 MPI_Send: 87.2531 ms
Iter 7 Compute: 20.0001 ms
Iter 8 MPI_Send: 87.2439 ms
Iter 8 Compute: 20.0001 ms
Iter 9 MPI_Send: 87.2944 ms
Iter 9 Compute: 20.0001 ms
Total: 1072.49 ms
+ srun -N 2 -n 2 ./mpi_async 10 100000000 20
Iter 0 MPI_Isend: 0.057923 ms
Iter 0 Compute: 20.0708 ms
```

```
Iter 1 MPI_Isend: 0.001453 ms
Iter 1 Compute: 20.0023 ms
Iter 2 MPI_Isend: 0.000417 ms
Iter 2 Compute: 20.0017 ms
Iter 3 MPI_Isend: 0.000625 ms
Iter 3 Compute: 20.0014 ms
Iter 4 MPI_Isend: 0.00054 ms
Iter 4 Compute: 20.0015 ms
Iter 5 MPI_Isend: 0.000475 ms
Iter 5 Compute: 20.0014 ms
Iter 6 MPI_Isend: 0.000455 ms
Iter 6 Compute: 20.0015 ms
Iter 7 MPI_Isend: 0.000425 ms
Iter 7 Compute: 20.0013 ms
Iter 8 MPI_Isend: 0.000446 ms
Iter 8 Compute: 20.0014 ms
Iter 9 MPI_Isend: 0.023495 ms
Iter 9 Compute: 20.0025 ms
Wait Request: 666.993 ms
Total: 867.214 ms
+ srun -N 2 -n 2 ./mpi_sync 10 100000000 40
Iter 0 MPI_Send: 86.8358 ms
Iter 0 Compute: 40.0001 ms
Iter 1 MPI_Send: 87.7685 ms
Iter 1 Compute: 40.0001 ms
Iter 2 MPI_Send: 87.7255 ms
Iter 2 Compute: 40.0001 ms
Iter 3 MPI_Send: 87.7404 ms
Iter 3 Compute: 40.0001 ms
Iter 4 MPI_Send: 87.4848 ms
Iter 4 Compute: 40.0001 ms
Iter 5 MPI_Send: 87.7293 ms
Iter 5 Compute: 40.0001 ms
Iter 6 MPI_Send: 87.7373 ms
Iter 6 Compute: 40.0001 ms
Iter 7 MPI_Send: 87.665 ms
Iter 7 Compute: 40.0001 ms
Iter 8 MPI_Send: 87.7774 ms
Iter 8 Compute: 40.0001 ms
Iter 9 MPI_Send: 87.7026 ms
Iter 9 Compute: 40.0001 ms
Total: 1276.34 ms
+ srun -N 2 -n 2 ./mpi_async 10 100000000 40
Iter 0 MPI_Isend: 0.048409 ms
Iter 0 Compute: 40.073 ms
Iter 1 MPI_Isend: 0.00127 ms
Iter 1 Compute: 40.0023 ms
Iter 2 MPI_Isend: 0.000382 ms
Iter 2 Compute: 40.0018 ms
Iter 3 MPI_Isend: 0.000441 ms
Iter 3 Compute: 40.0015 ms
Iter 4 MPI_Isend: 0.000477 ms
Iter 4 Compute: 40.0014 ms
Iter 5 MPI_Isend: 0.034657 ms
```

```
Iter 5 Compute: 40.0024 ms
Iter 6 MPI_Isend: 0.000672 ms
Iter 6 Compute: 40.0015 ms
Iter 7 MPI_Isend: 0.000412 ms
Iter 7 Compute: 40.0014 ms
Iter 8 MPI_Isend: 0.000433 ms
Iter 8 Compute: 40.0014 ms
Iter 9 MPI_Isend: 0.000435 ms
Iter 9 Compute: 40.0014 ms
Wait Request: 465.296 ms
Total: 865.51 ms
+ srun -N 2 -n 2 ./mpi_sync 10 100000000 80
Iter 0 MPI_Send: 70.5019 ms
Iter 0 Compute: 80.0001 ms
Iter 1 MPI_Send: 71.4719 ms
Iter 1 Compute: 80.0001 ms
Iter 2 MPI_Send: 71.5578 ms
Iter 2 Compute: 80.0001 ms
Iter 3 MPI_Send: 71.5754 ms
Iter 3 Compute: 80.0001 ms
Iter 4 MPI_Send: 71.5798 ms
Iter 4 Compute: 80.0001 ms
Iter 5 MPI_Send: 71.5219 ms
Iter 5 Compute: 80.0001 ms
Iter 6 MPI_Send: 71.5318 ms
Iter 6 Compute: 80.0001 ms
Iter 7 MPI_Send: 71.5097 ms
Iter 7 Compute: 80.0001 ms
Iter 8 MPI_Send: 71.4408 ms
Iter 8 Compute: 80.0001 ms
Iter 9 MPI_Send: 71.5486 ms
Iter 9 Compute: 80.0001 ms
Total: 1514.44 ms
+ srun -N 2 -n 2 ./mpi_async 10 100000000 80
Iter 0 MPI_Isend: 0.04745 ms
Iter 0 Compute: 80.0604 ms
Iter 1 MPI_Isend: 0.001303 ms
Iter 1 Compute: 80.0027 ms
Iter 2 MPI_Isend: 0.000509 ms
Iter 2 Compute: 80.0017 ms
Iter 3 MPI_Isend: 0.023062 ms
Iter 3 Compute: 80.0023 ms
Iter 4 MPI_Isend: 0.000567 ms
Iter 4 Compute: 80.0015 ms
Iter 5 MPI_Isend: 0.00039 ms
Iter 5 Compute: 80.0015 ms
Iter 6 MPI_Isend: 0.001035 ms
Iter 6 Compute: 80.0016 ms
Iter 7 MPI_Isend: 0.000465 ms
Iter 7 Compute: 80.0016 ms
Iter 8 MPI_Isend: 0.000507 ms
Iter 8 Compute: 80.0014 ms
Iter 9 MPI_Isend: 0.00056 ms
Iter 9 Compute: 80.0015 ms
```

```
Wait Request: 0.027979 ms
Total: 800.227 ms
+ srun -N 2 -n 2 ./mpi_sync 10 100000000 160
Iter 0 MPI_Send: 87.0127 ms
Iter 0 Compute: 160 ms
Iter 1 MPI_Send: 88.5872 ms
Iter 1 Compute: 160 ms
Iter 2 MPI_Send: 88.5053 ms
Iter 2 Compute: 160 ms
Iter 3 MPI_Send: 88.5757 ms
Iter 3 Compute: 160 ms
Iter 4 MPI_Send: 88.5961 ms
Iter 4 Compute: 160 ms
Iter 5 MPI_Send: 88.5934 ms
Iter 5 Compute: 160 ms
Iter 6 MPI_Send: 88.5779 ms
Iter 6 Compute: 160 ms
Iter 7 MPI_Send: 88.0209 ms
Iter 7 Compute: 160 ms
Iter 8 MPI_Send: 88.5612 ms
Iter 8 Compute: 160 ms
Iter 9 MPI_Send: 88.5188 ms
Iter 9 Compute: 160 ms
Total: 2483.75 ms
+ srun -N 2 -n 2 ./mpi_async 10 100000000 160
Iter 0 MPI_Isend: 0.048072 ms
Iter 0 Compute: 160.068 ms
Iter 1 MPI_Isend: 0.001393 ms
Iter 1 Compute: 160.002 ms
Iter 2 MPI_Isend: 0.034128 ms
Iter 2 Compute: 160.002 ms
Iter 3 MPI_Isend: 0.001235 ms
Iter 3 Compute: 160.002 ms
Iter 4 MPI_Isend: 0.000547 ms
Iter 4 Compute: 160.002 ms
Iter 5 MPI_Isend: 0.001065 ms
Iter 5 Compute: 160.002 ms
Iter 6 MPI_Isend: 0.000494 ms
Iter 6 Compute: 160.001 ms
Iter 7 MPI_Isend: 0.070827 ms
Iter 7 Compute: 160.002 ms
Iter 8 MPI_Isend: 0.000655 ms
Iter 8 Compute: 160.001 ms
Iter 9 MPI_Isend: 0.021875 ms
Iter 9 Compute: 160.002 ms
Wait Request: 0.04847 ms
Total: 1600.38 ms
```