HPC-Homework2

Name: Zelin Gong
NetID: zg2104

Q1.

(a) Memory leak because of inappropriate free().

Before

```
==6029== Invalid write of size 4
==6029==    at 0x1093C9: f(int) (val_test01.cpp:82)
==6029==    by 0x109251: main (val_test01.cpp:40)
==6029==  Address 0x4db20e8 is 0 bytes after a block of size 40 alloc'd
==6029==    at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_memcheck-amd64-linux.so)
==6029==    by 0x1092B1: f(int) (val_test01.cpp:72)
==6029==    by 0x109251: main (val_test01.cpp:40)
==6029==
==6029== Invalid read of size 4
==6029==    at 0x109414: f(int) (val_test01.cpp:83)
==6029==    by 0x109251: main (val_test01.cpp:40)
==6029==  Address 0x4db20e8 is 0 bytes after a block of size 40 alloc'd
==6029==    at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_memcheck-amd64-linux.so)
==6029==    by 0x1092B1: f(int) (val_test01.cpp:72)
==6029==    by 0x109251: main (val_test01.cpp:40)
==6029==
  10  89
==6029== Mismatched free() / delete / delete []
==6029==    at 0x483D74F: operator delete[](void*) (in /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_memcheck-amd64-linux.so
==6029==    by 0x10944A: f(int) (val_test01.cpp:86)
==6029==    by 0x109251: main (val_test01.cpp:40)
==6029==  Address 0x4db20c0 is 0 bytes inside a block of size 40 alloc'd
==6029==    at 0x483B7F3: malloc (in /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_memcheck-amd64-linux.so)
==6029==    by 0x1092B1: f(int) (val_test01.cpp:72)
==6029==    by 0x109251: main (val_test01.cpp:40)
```

After

```
(base) zelin@MAGI:~/HPC_Homework2/hpc_homework2_code/build$ valgrind ./val_test01
==7305== Memcheck, a memory error detector
==7305== Copyright (C) 2002-2017, and GNU GPL'd, by Julian Seward et al.
==7305== Using Valgrind-3.15.0 and LibVEX; rerun with -h for copyright info
==7305== Command: ./val_test01
==7305==

TEST01
  C++ version.
  A sample code for analysis by VALGRIND.
  0  1
  1  1
  2  2
  3  3
  4  5
  5  8
  6  13
  7  21
  8  34
  9  55
  10  89

TEST01
  Normal end of execution.
==7305==
==7305== HEAP SUMMARY:
==7305==     in use at exit: 0 bytes in 0 blocks
==7305==   total heap usage: 3 allocs, 3 frees, 73,772 bytes allocated
==7305==
==7305== All heap blocks were freed -- no leaks are possible
==7305==
==7305== For lists of detected and suppressed errors, rerun with: -s
==7305== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

(b) Uninitialized variable

Before:

```
==8264== Conditional jump or move depends on uninitialised value(s)
==8264==    at 0x4982402: std::ostreambuf_iterator<char, std::char_trai
ar_traits<char> > >::_M_insert_int<long>(std::ostreambuf_iterator<char,
r/lib/x86_64-linux-gnu/libstdc++.so.6.0.28)
==8264==    by 0x4990D5E: std::ostream& std::ostream::_M_insert<long>(l
==8264==    by 0x10938C: junk_data() (val_test02.cpp:104)
==8264==    by 0x109241: main (val_test02.cpp:37)
==8264==
==8264== Use of uninitialised value of size 8
==8264==    at 0x498210B: ??? (in /usr/lib/x86_64-linux-gnu/libstdc++.s
==8264==    by 0x498242C: std::ostreambuf_iterator<char, std::char_trai
ar_traits<char> > >::_M_insert_int<long>(std::ostreambuf_iterator<char,
r/lib/x86_64-linux-gnu/libstdc++.so.6.0.28)
==8264==    by 0x4990D5E: std::ostream& std::ostream::_M_insert<long>(l
==8264==    by 0x10938C: junk_data() (val_test02.cpp:104)
==8264==    by 0x109241: main (val_test02.cpp:37)
==8264==
```

After:

```
(base) zelin@MAGI:~/HPC_Homework2/hpc_homework2_code/build$ valgrind ./val_test02
==8513== Memcheck, a memory error detector
==8513== Copyright (C) 2002-2017, and GNU GPL'd, by Julian Seward et al.
==8513== Using Valgrind-3.15.0 and LibVEX; rerun with -h for copyright info
==8513== Command: ./val_test02
==8513==

TEST02:
  C++ version
  A sample code for analysis by VALGRIND.
  0  0
  1  2
  2  0
  3  6
  4  8
  5  0
  6  0
  7  0
  8  0
  9  0

TEST02
  Normal end of execution.
==8513==
==8513== HEAP SUMMARY:
==8513==     in use at exit: 0 bytes in 0 blocks
==8513==   total heap usage: 3 allocs, 3 frees, 73,768 bytes allocated
==8513==
==8513== All heap blocks were freed -- no leaks are possible
==8513==
==8513== For lists of detected and suppressed errors, rerun with: -s
==8513== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

Q2.

The Processor: Intel Core I7 8570H

6 Core, 12 Thread, 2.20 GHz-4.40GHz, 9MB Intel Smart Cache (L3)

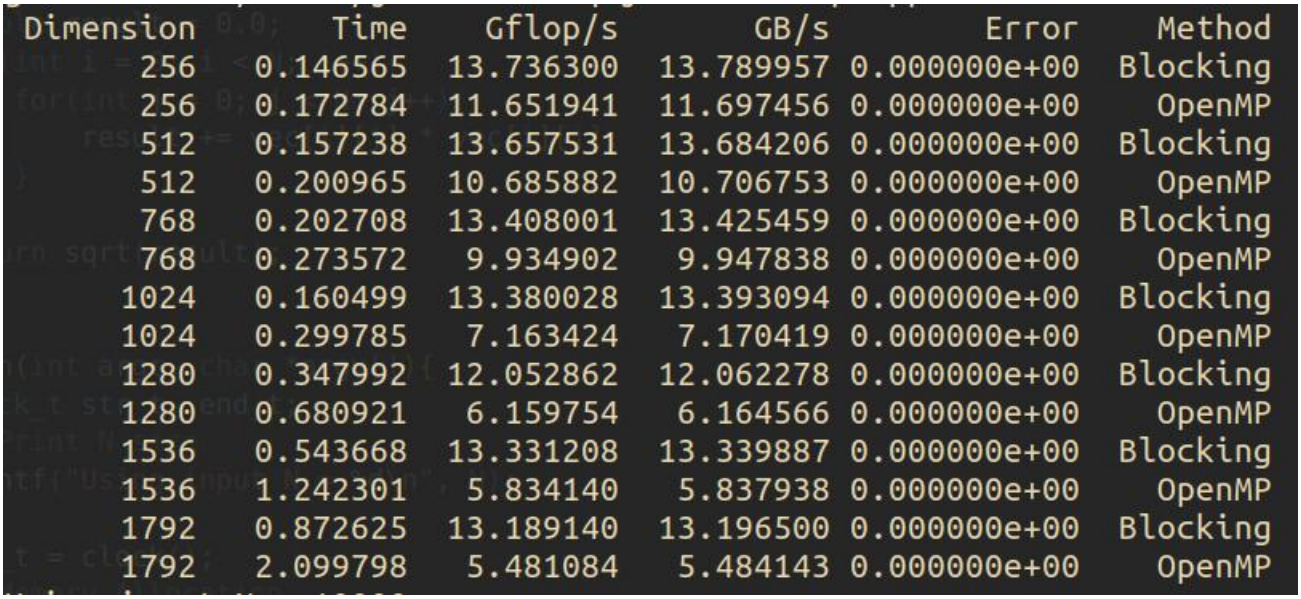
Coffee Lake Architecture, support AVX2 SSE4.2 extended instruction set, with 32 GFLOPs/cycle maximum.

The result are shown as follow:

With Block_Size 128:

Dimension	Time	Gflop/s	GB/s	Error	Method
128	0.143777	13.915213	14.023925	0.000000e+00	Blocking
128	0.159135	12.572231	12.670451	0.000000e+00	OpenMP
256	0.143882	13.992481	14.047139	0.000000e+00	Blocking
256	0.202183	9.957645	9.996542	0.000000e+00	OpenMP
384	0.144331	14.123279	14.160058	0.000000e+00	Blocking
384	0.223943	9.102449	9.126153	0.000000e+00	OpenMP
512	0.151476	14.177069	14.204759	0.000000e+00	Blocking
512	0.230121	9.331977	9.350204	0.000000e+00	OpenMP
640	0.148752	14.098335	14.120363	0.000000e+00	Blocking
640	0.226011	9.279001	9.293500	0.000000e+00	OpenMP
768	0.194114	14.001579	14.019810	0.000000e+00	Blocking
768	0.303344	8.959812	8.971478	0.000000e+00	OpenMP
896	0.206785	13.914406	13.929936	0.000000e+00	Blocking
896	0.352531	8.161807	8.170916	0.000000e+00	OpenMP
1024	0.156264	13.742681	13.756102	0.000000e+00	Blocking
1024	0.308494	6.961191	6.967989	0.000000e+00	OpenMP
1152	0.220411	13.872457	13.884499	0.000000e+00	Blocking
1152	0.484406	6.312154	6.317633	0.000000e+00	OpenMP
1280	0.305244	13.740822	13.751557	0.000000e+00	Blocking
1280	0.681398	6.155442	6.160251	0.000000e+00	OpenMP
1408	0.401188	13.915210	13.925093	0.000000e+00	Blocking
1408	0.973727	5.733249	5.737321	0.000000e+00	OpenMP
1536	0.534597	13.557411	13.566237	0.000000e+00	Blocking
1536	1.342812	5.397446	5.400960	0.000000e+00	OpenMP
1664	0.671194	13.729102	13.737353	0.000000e+00	Blocking
1664	1.730415	5.325245	5.328445	0.000000e+00	OpenMP
1792	0.860604	13.373356	13.380819	0.000000e+00	Blocking
1792	2.241270	5.135111	5.137976	0.000000e+00	OpenMP
1920	1.030471	13.737187	13.744342	0.000000e+00	Blocking
1920	2.715406	5.213135	5.215850	0.000000e+00	OpenMP

With Block_Size 256:



Dimension	Time	Gflop/s	GB/s	Error	Method
256	0.146565	13.736300	13.789957	0.000000e+00	Blocking
256	0.172784	11.651941	11.697456	0.000000e+00	OpenMP
512	0.157238	13.657531	13.684206	0.000000e+00	Blocking
512	0.200965	10.685882	10.706753	0.000000e+00	OpenMP
768	0.202708	13.408001	13.425459	0.000000e+00	Blocking
768	0.273572	9.934902	9.947838	0.000000e+00	OpenMP
1024	0.160499	13.380028	13.393094	0.000000e+00	Blocking
1024	0.299785	7.163424	7.170419	0.000000e+00	OpenMP
1280	0.347992	12.052862	12.062278	0.000000e+00	Blocking
1280	0.680921	6.159754	6.164566	0.000000e+00	OpenMP
1536	0.543668	13.331208	13.339887	0.000000e+00	Blocking
1536	1.242301	5.834140	5.837938	0.000000e+00	OpenMP
1792	0.872625	13.189140	13.196500	0.000000e+00	Blocking
1792	2.099798	5.481084	5.484143	0.000000e+00	OpenMP

Reaches 43.73% of peak FLOPS.

Q3.

See code in the Github Repo. https://github.com/11610309GZL/HPC_ZelinGong

Q4.

(1)(2).

The Processor: Intel Core I7 8570H

6 Core, 12 Thread, 2.20 GHz-4.40GHz, 9MB Intel Smart Cache (L3)

Coffee Lake Architecture, support AVX2 SSE4.2 extended instruction set, with 32 GFLOPs/cycle maximum.

Max iteration k = 100.

N-size t =12	Gauss-Seidel OMP	Jacobi OMP
N=1000	6.75	5.81
N=10000	554.57	508.58

Max iteration k = 100.

N-size & thread num	Gauss-Seidel OMP	Jacobi OMP
N=1000 thread = 12	6.75	5.81
N=1000 thread = 8	3.77	3.35
N=1000 thread = 4	1.80	1.58