

# Linux OpenMP Benchmark Results

## Introduction

The purpose is to test 2 benchmarks to compare performance in terms of MFLOPS (Million Floating Point Operations Per Second) by executing them with and without OpenMP on both 32 bit as well as 64 bit Linux architectures. The 2 benchmarks used are MemSpeed and Original OpenMP.

### MemSpeed-

It consists of three different sequences of operations on 64 bit double precision floating point numbers, 32 bit single precision floating point numbers and 32 bit integers via 2 data arrays. The types of operations are-

$x[i] = x[i] + c * y[i]$

$x[i] = x[i] + y[i]$

$x[i] = y[i]$

The MFLOPS performance measure is calculated by dividing the MB/s for double and single precision floating point numbers by 8 and 4 respectively. On the other hand, the same measure is obtained for integers by multiplying the MB/s with 11 / 8 since both 64 and 32 bit versions are translated to 11 integer instructions per 8 data words.

### Original OpenMP-

It consists of arithmetic operations of the form  $x[i] = (x[i] + a) * b - (x[i] + c) * d + (x[i] + e) * f$  with 2, 8 or 32 operations per input data word. Array sizes used are 0.1, 1 or 10 million 4 byte single precision floating point words.

2 operations-

$x[i] = (x[i] + a) * b$

8 operations-

$x[i] = (x[i] + a) * b - (x[i] + c) * d + (x[i] + e) * f$

32 operations-

$x[i] = (x[i] + a) * b - (x[i] + c) * d + (x[i] + e) * f - (x[i] + g) * h + (x[i] + j) * k - (x[i] + l) * m + (x[i] + o) * p - (x[i] + q) * r + (x[i] + s) * t - (x[i] + u) * v + (x[i] + w) * y$

Without OpenMP, both the benchmarks run on a single CPU, with OpenMP, both the benchmarks' workloads get distributed over all the cores of all configured CPUs.

## Setting up the environment

### Requirements-

Linux system

OpenMP support

GCC compiler

Python3 with matplotlib module (for plotting the performance comparison graphs)

System monitor (for observing CPU usage)

### System specifications-

Linux 4.15.0-88-generic

16.04.1-Ubuntu x86\_64

AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G

CPU's 4, Configured CPU's 4  
RAM Size 11.13 GB, Page Size 4096 Bytes

```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp sudo lshw -C memory
[sudo] password for niranay:
*-cache:0
  description: L1 cache
  physical id: 22
  slot: L1 Cache
  size: 320KiB
  capacity: 320KiB
  clock: 1GHz (1.0ns)
  capabilities: pipeline-burst internal write-back unified
  configuration: level=1
*-cache:1
  description: L2 cache
  physical id: 23
  slot: L2 Cache
  size: 2MiB
  capacity: 2MiB
  clock: 1GHz (1.0ns)
  capabilities: pipeline-burst internal write-back unified
  configuration: level=2
```

```
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp lscpu
Architecture:          x86_64
CPU op-mode(s):        32-bit, 64-bit
Byte Order:            Little Endian
CPU(s):                4
On-line CPU(s) list:   0-3
Thread(s) per core:    2
Core(s) per socket:    2
Socket(s):             1
NUMA node(s):         1
Vendor ID:             AuthenticAMD
CPU family:            21
Model:                 101
Model name:            AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Stepping:              1
CPU MHz:               1191.890
CPU max MHz:           2400.0000
CPU min MHz:           1200.0000
BogoMIPS:              4790.98
Virtualization:        AMD-V
L1d cache:             32K
L1l cache:             96K
L2 cache:              1024K
NUMA node0 CPU(s):    0-3
Flags:                 fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ht syscall nx mmxext fxsr_opt pdpe1gb rdtscp lm
                        constant_tsc rep_good acc_power nopl nonstop_tsc cpuid extd_apicid aperfmperf pni pclmulqdq monitor ssse3 fma cx16 sse4_1 sse4_2 movbe popcnt aes xsave avx f16c lahf_l
                        m cmp_legacy svm extapic cr8_legacy abm sse4a misalignsse 3dnowprefetch osvw ibs xop skinit wdt lwp fma4 tce nodeid_msr tbnm topoext perfctr_core perfctr_nb bpext ptsc m
                        waitx cpb hw_pstate ssbd vmmcall fsgsbase bmi1 avx2 smep bmi2 xsaveopt arat npt lbrv svm_lock nrip_save tsc_scale vmcb_clean flushbyasid decodeassists pausefilter pfthr
                        eshold avic v_vmsave vmload vgif overflow recov
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp
```

## Problem statement

Measuring performance of Linux OpenMP benchmarks in terms of MFLOPS upon execution with and without use of OpenMP, and comparing performance in both these scenarios by plotting comparison graphs.

## Program

Refer the following tree to locate program files in the submission.

```
Assignment_3 : zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment_3 tree 111605075_code_and_results_files
111605075_code_and_results_files
├── 32_bit
│   ├── memspeed
│   │   ├── code
│   │   │   ├── cpuid.a.o
│   │   │   ├── cpuidc.o
│   │   │   ├── cpuidh.h
│   │   │   ├── memory_speed32
│   │   │   ├── memory_speed32OMP
│   │   │   ├── memory_speed.c
│   │   │   └── plot_memspeed_32.py
│   │   └── results
│   │       ├── double_32_bit.png
│   │       ├── int_32_bit.png
│   │       ├── memSpeed_normal.txt
│   │       ├── memSpeed_openmp.txt
│   │       └── single_32_bit.png
│   └── openmp
│       ├── code
│       │   ├── cpuid.a.o
│       │   ├── cpuidc.o
│       │   ├── cpuidh.h
│       │   ├── notOMPmFlops32
│       │   ├── openMPmFlops32
│       │   ├── OpenMPmFLOPS.c
│       │   └── plot_openmp_32.py
│       └── results
│           ├── OpenMPLog_normal.txt
│           ├── OpenMPLog_openmp.txt
│           └── triad_3_types_32.png
└── 64_bit
    ├── memspeed
    │   ├── code
    │   │   ├── cpuid.a64.o
    │   │   ├── cpuidc64.o
    │   │   ├── cpuidh.h
    │   │   ├── memory_speed64
    │   │   ├── memory_speed64OMP
    │   │   ├── memory_speed.c
    │   │   └── plot_memspeed_64.py
    │   └── results
    │       ├── double_64_bit.png
    │       ├── int_64_bit.png
    │       ├── memSpeed_normal.txt
    │       ├── memSpeed_openmp.txt
    │       └── single_64_bit.png
    └── openmp
        ├── code
        │   ├── cpuid.a64.o
        │   ├── cpuidc64.o
        │   ├── cpuidh.h
        │   ├── notOMPmFlops64
        │   ├── openMPmFlops64
        │   ├── OpenMPmFLOPS.c
        │   └── plot_openmp_64.py
        └── results
            ├── OpenMPLog_normal.txt
            ├── OpenMPLog_openmp.txt
            └── triad_3_types_64.png

14 directories, 44 files
niranay@niranay: ~/Documents/sem8/MT/Assignment_3
```

```
Assignment_3 : zsh — Konsole
File Edit View Bookmarks Settings Help
├── openMPmFlops32
│   ├── OpenMPmFLOPS.c
│   └── plot_openmp_32.py
└── results
    ├── OpenMPLog_normal.txt
    ├── OpenMPLog_openmp.txt
    └── triad_3_types_32.png
64_bit
├── memspeed
│   ├── code
│   │   ├── cpuid.a64.o
│   │   ├── cpuidc64.o
│   │   ├── cpuidh.h
│   │   ├── memory_speed64
│   │   ├── memory_speed64OMP
│   │   ├── memory_speed.c
│   │   └── plot_memspeed_64.py
│   └── results
│       ├── double_64_bit.png
│       ├── int_64_bit.png
│       ├── memSpeed_normal.txt
│       ├── memSpeed_openmp.txt
│       └── single_64_bit.png
└── openmp
    ├── code
    │   ├── cpuid.a64.o
    │   ├── cpuidc64.o
    │   ├── cpuidh.h
    │   ├── notOMPmFlops64
    │   ├── openMPmFlops64
    │   ├── OpenMPmFLOPS.c
    │   └── plot_openmp_64.py
    └── results
        ├── OpenMPLog_normal.txt
        ├── OpenMPLog_openmp.txt
        └── triad_3_types_64.png

14 directories, 44 files
niranay@niranay: ~/Documents/sem8/MT/Assignment_3
```

## Results

32 bit MemSpeed-

Normal (without OpenMP)

```
d_32_bit: zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit 11 10028 13:27:05
total 40
drwxrwxr-x 2 niranay niranay 4096 Apr 9 13:27 ./
drwxrwxr-x 3 niranay niranay 4096 Apr 9 13:10 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.o
-rw-r--r-- 1 niranay niranay 4916 Dec 2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 13:17 cpuidh.h
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 13:27 memory_speed.c
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit gcc memory_speed.c cpuidc.o cpuid.o -lrt -lc -lm -O3 -m32 -o memo
ry_speed32
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit ./memory_speed32 10030 13:27:24

#####
getDetails and MHz

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

#####

Memory Reading Speed Test 32 Bit Version 4.1 Thu Apr 9 13:27:35 2020

Memory x[m]=x[m]+s*y[n] Int x[m]=x[m]+y[n] x[m]=y[n]
KBytes Dble Sngl Int32 Dble Sngl Int32 Dble Sngl Int32
Used MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S

4 17768 8903 21430 23095 11839 19672 17313 9134 10935
8 17930 8574 21990 23574 11439 19675 18179 9365 11282
16 15957 8225 17399 18573 10162 16976 16280 8252 9336
32 15953 8614 15300 18267 10191 15271 13161 7779 8867
64 16887 8770 19292 22268 11491 18994 13858 8713 9850

source_code: zsh d_32_bit: zsh
```

```
d_32_bit: zsh — Konsole
File Edit View Bookmarks Settings Help
KBytes Dble Sngl Int32 Dble Sngl Int32 Dble Sngl Int32
Used MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S MB/S

4 17768 8903 21430 23095 11839 19672 17313 9134 10935
8 17930 8574 21990 23574 11439 19675 18179 9365 11282
16 15957 8225 17399 18573 10162 16976 16280 8252 9336
32 15953 8614 15300 18267 10191 15271 13161 7779 8867
64 16887 8770 19292 22268 11491 18994 13858 8713 9850
128 16791 8666 18878 22172 11380 18685 13560 8429 10016
256 16616 8268 19134 22224 11524 18910 13731 8552 10178
512 16543 8596 18494 21102 11297 18538 13605 8425 10115
1024 6847 5942 7456 7652 6943 7551 3552 3784 3864
2048 4436 4743 5011 5094 4935 5058 2581 2502 2533
4096 4760 4290 4978 5132 4931 4943 2581 2522 2524
8192 4864 4668 4944 5086 4902 5003 2347 2507 2518
16384 4873 4626 4956 5056 4891 4983 2584 2476 2512
32768 4623 4340 4981 5060 4782 4957 2572 2489 2530
65536 5010 4591 4991 5087 4563 4968 2597 2512 2550
131072 5116 4768 5060 5154 4983 4856 2580 2504 2553
262144 5137 4813 5106 4814 5056 5151 2611 2576 2621
524288 4693 4890 5205 5185 5152 5207 2522 2609 2631
1048576 5231 4685 5168 5271 5159 5181 2675 2613 2638
2097152 5166 4953 5067 5009 5133 5221 2669 2635 2664

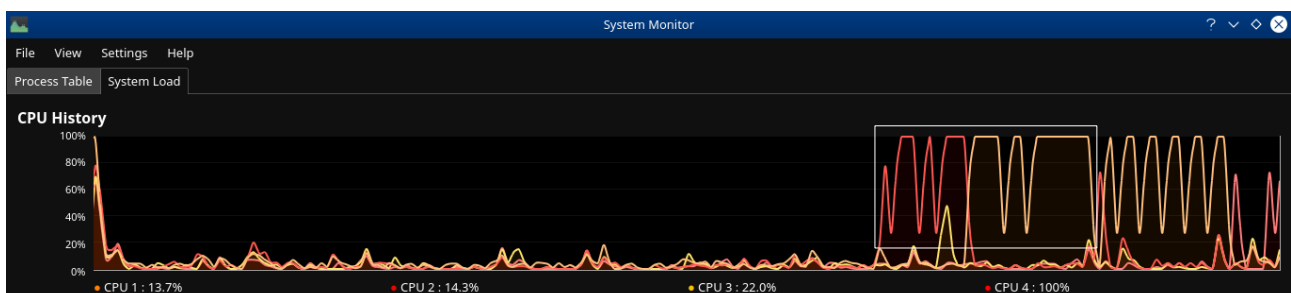
End of test Thu Apr 9 13:28:18 2020

Press Enter

niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit 11 10031 13:28:20
total 64
drwxrwxr-x 2 niranay niranay 4096 Apr 9 13:27 ./
drwxrwxr-x 3 niranay niranay 4096 Apr 9 13:10 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.o
-rw-r--r-- 1 niranay niranay 4916 Dec 2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 13:17 cpuidh.h
-rwxrwxr-x 1 niranay niranay 18136 Apr 9 13:27 memory_speed32*
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 13:27 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr 9 13:28 memSpeed.txt
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit 10032 13:28:35

source_code: zsh d_32_bit: zsh
```

System monitor (single CPU usage, highlighted using a white box)



## With OpenMP

```
d_32_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit ll
total 316
drwxrwxr-x 2 niranay niranay 4096 Apr  9 14:39 ./
drwxrwxr-x 3 niranay niranay 4096 Apr  9 13:10 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.a.o
-rw-r--r-- 1 niranay niranay 4916 Dec  2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 13:17 cpuidh.h
-rwxrwxr-x 1 niranay niranay 18136 Apr  9 13:27 memory_speed32*
-rw-rw-r-- 1 niranay niranay 15174 Apr  9 14:39 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr  9 13:28 memSpeed_normal.txt
-rw-rw-r-- 1 niranay niranay 127739 Apr  9 13:28 Screenshot_20200409_132845.png
-rw-rw-r-- 1 niranay niranay 124874 Apr  9 13:29 Screenshot_20200409_132957.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit gcc memory_speed.c cpuidc.o cpuid.a.o -lrt -lc -lm -O3 -fopenmp -m
32 -o memory_speed32OMP
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit ./memory_speed32OMP
#####
getDetails and MHz

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 3311 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

#####

Memory Reading Speed Test 32 Bit OpenMP v4.1 Thu Apr  9 14:40:19 2020

Memory  x[n]=x[n]+s*y[n] Int  x[n]=x[n]+y[n]      x[n]=y[n]
KBytes  Dble  Sngl  Int32  Dble  Sngl  Int32  Dble  Sngl  Int32
Used    MB/S  MB/S  MB/S  MB/S  MB/S  MB/S  MB/S  MB/S  MB/S

4       1197  1492  1540  1466  1563  1303  793   810   808

#####
source_code : zsh
d_32_bit : zsh
```

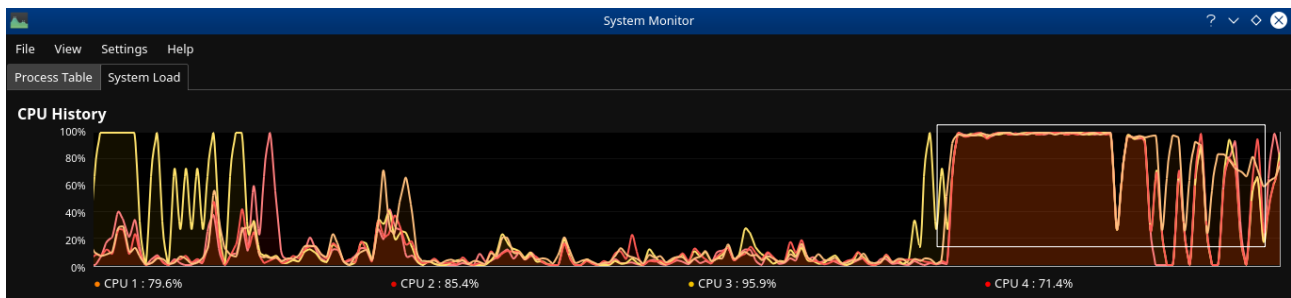
```
d_32_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
8      2942  3025  3066  2814  2863  2986  1569  1309  1566
16     6191  4927  5472  6131  4937  5798  3046  2844  2960
32     9563  6289  9456  9793  8390  10635  5801  5030  5321
64     9172  8403  12295  12899  10602  16960  9732  7396  8755
128    16507  10273  16776  15602  11594  23235  13281  9317  12031
256    21217  11848  19373  25646  15077  29624  17405  11168  17361
512    22859  12367  23240  30511  16839  36791  21797  10066  21275
1024   24247  12735  26187  29328  17122  39661  23341  7082  12353
2048   11275  9827  11769  10162  10097  11317  5389  5367  5466
4096   4710  5271  5289  5325  4648  5193  2603  2646  2669
8192   5319  5199  5083  4946  4479  5313  2658  2624  2660
16384  5237  5237  5244  4769  5223  5313  2643  2290  2129
32768  5371  5287  5330  4923  5294  5377  2654  2663  2673
65536  5160  5502  5515  5507  5171  5393  2745  2752  2752
131072 5553  5416  5038  5518  5485  5507  2746  2755  2753
262144 5568  5292  5641  5556  5569  5593  2767  2782  2806
524288 5717  5673  4904  5733  5719  5720  2858  2808  2838
1048576 5712  5843  5833  5817  5820  5816  2861  2924  2867
2097152 5848  5869  5884  5914  5868  5878  2946  2960  2949

End of test Thu Apr  9 14:41:07 2020

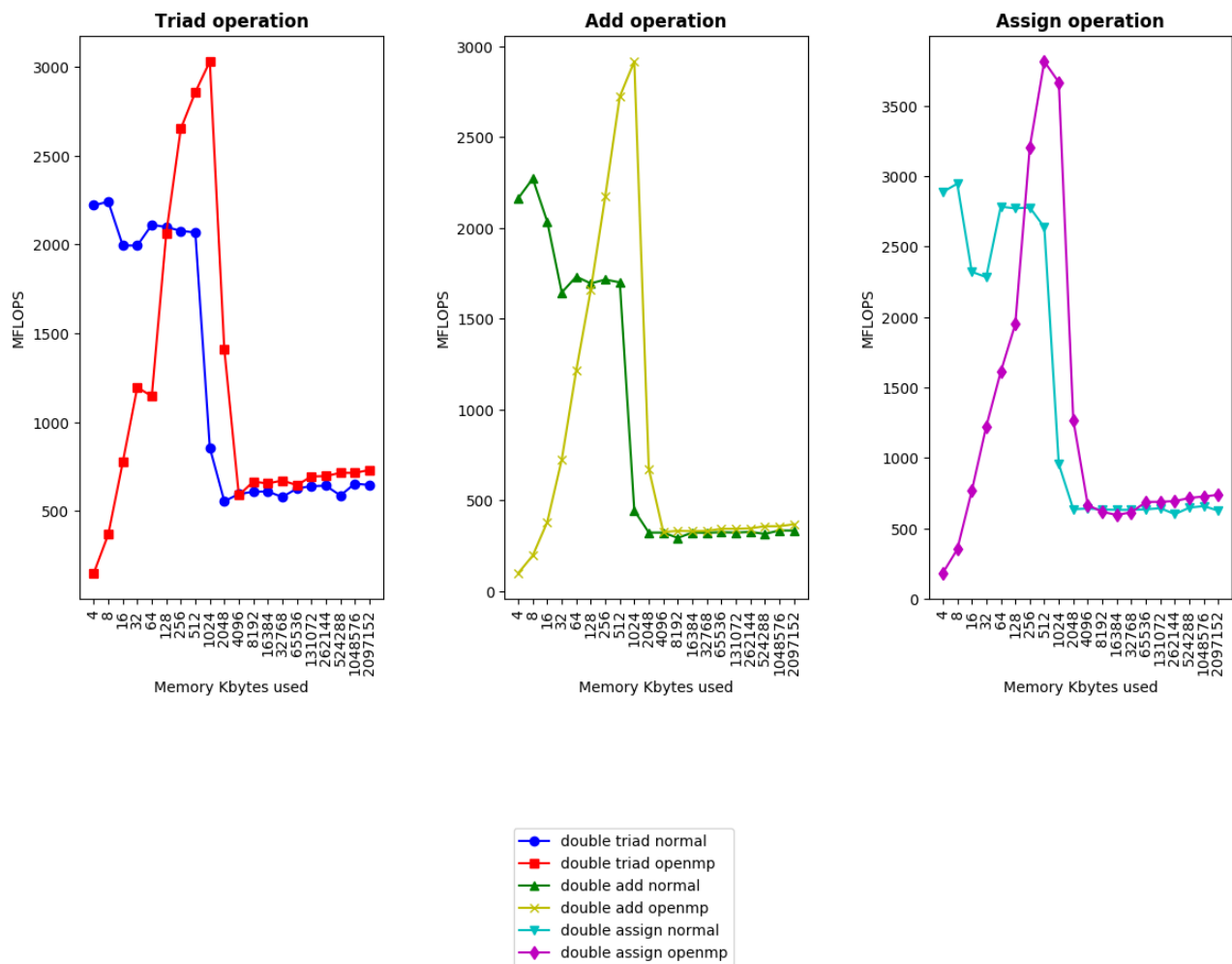
Press Enter

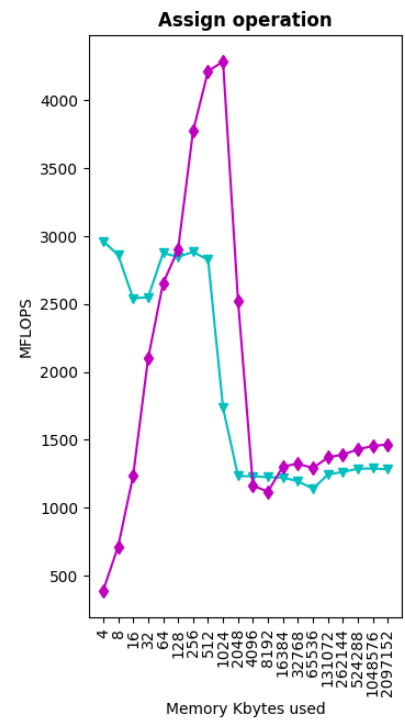
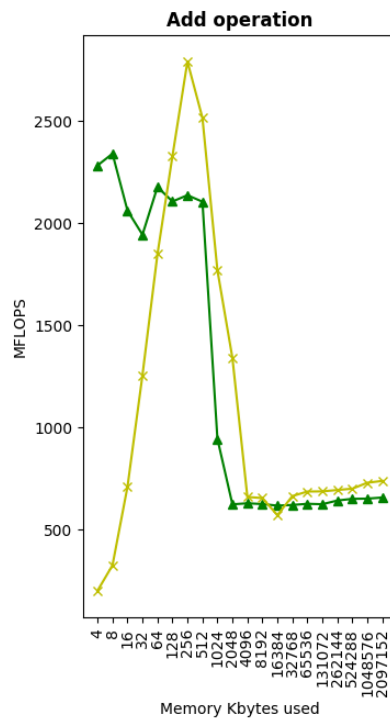
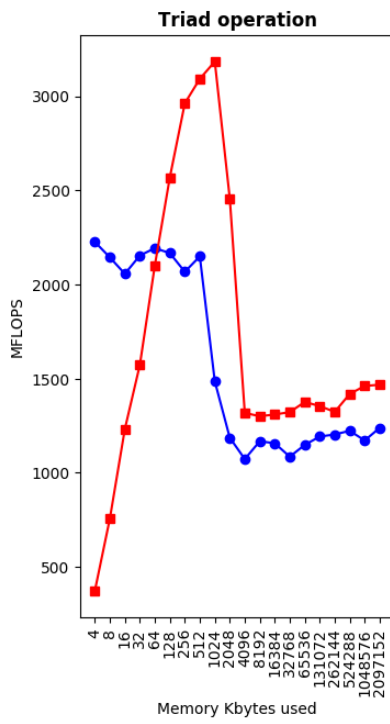
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit ll
total 344
drwxrwxr-x 2 niranay niranay 4096 Apr  9 14:40 ./
drwxrwxr-x 3 niranay niranay 4096 Apr  9 13:10 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.a.o
-rw-r--r-- 1 niranay niranay 4916 Dec  2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 13:17 cpuidh.h
-rwxrwxr-x 1 niranay niranay 18136 Apr  9 13:27 memory_speed32*
-rwxrwxr-x 1 niranay niranay 22604 Apr  9 14:40 memory_speed32OMP*
-rw-rw-r-- 1 niranay niranay 15174 Apr  9 14:39 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr  9 13:28 memSpeed_normal.txt
-rw-rw-r-- 1 niranay niranay 2397 Apr  9 14:41 memSpeed.txt
-rw-rw-r-- 1 niranay niranay 127739 Apr  9 13:28 Screenshot_20200409_132845.png
-rw-rw-r-- 1 niranay niranay 124874 Apr  9 13:29 Screenshot_20200409_132957.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/d_32_bit
source_code : zsh
d_32_bit : zsh
```

System monitor (usage of all i.e. 4 CPUs, highlighted using a white box)

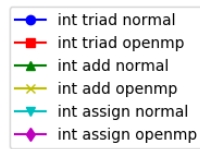
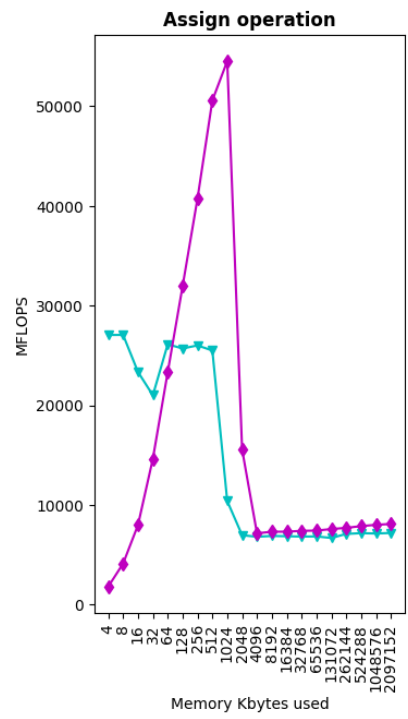
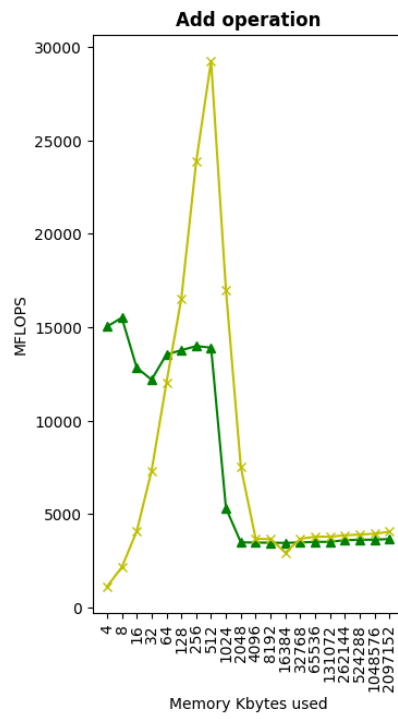
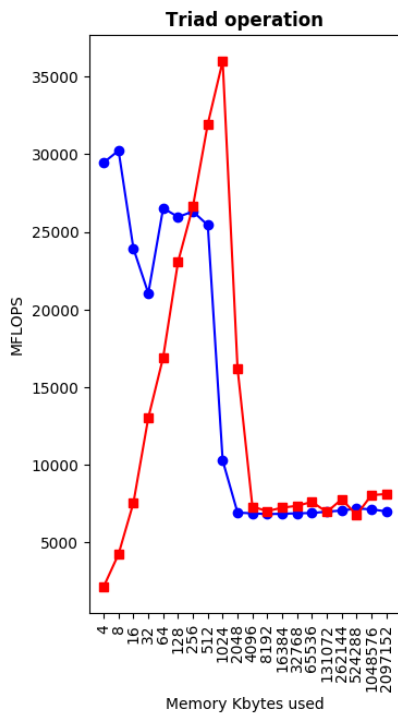


## Performance comparison in MFLOPS





- single triad normal
- single triad openmp
- ▲ single add normal
- ✕ single add openmp
- ▼ single assign normal
- ◆ single assign openmp



64 bit MemSpeed-

Normal



```
64_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ll
total 44
drwxrwxr-x 2 niranay niranay 4096 Apr 9 14:45 ./
drwxrwxr-x 4 niranay niranay 4096 Apr 9 14:42 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec 2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 14:44 cpuidh.h
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 14:45 memory_speed.c
niranay@niranay ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit gcc memory_speed.c cpuidc64.o cpuid64.o -lrt -lc -lm -O3 -o memory_speed64
niranay@niranay ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ./memory_speed64

#####
getDetails and MHz

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

#####

Memory Reading Speed Test 64 Bit Version 4.1 Thu Apr 9 14:47:54 2020

Memory  x[m]=x[m]+s*y[m] Int  x[m]=x[m]+y[m]      x[m]=y[m]
KBytes  Dble  Sngl  Int32  Dble  Sngl  Int32  Dble  Sngl  Int32
Used    MB/S  MB/S  MB/S   MB/S  MB/S  MB/S   MB/S  MB/S  MB/S

  4    37002  32795  32801  43126  33065  20770  7735  6588  8491
  8    19871  35257  33897  46382  34848  33852  19157  16651  23570
 16    18567  11269  30021  34265  29842  29855  17992  18243  8433
 32    31135  24506  29229  30181  24750  26674  5956  6530  18700
 64    23974  22893  27505  26846  24311  24104  9271  14232  15099

source_code : zsh
64_bit : zsh
```

```
64_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
KBytes  Dble  Sngl  Int32  Dble  Sngl  Int32  Dble  Sngl  Int32
Used    MB/S  MB/S  MB/S   MB/S  MB/S  MB/S   MB/S  MB/S  MB/S

  4    37002  32795  32801  43126  33065  20770  7735  6588  8491
  8    19871  35257  33897  46382  34848  33852  19157  16651  23570
 16    18567  11269  30021  34265  29842  29855  17992  18243  8433
 32    31135  24506  29229  30181  24750  26674  5956  6530  18700
 64    23974  22893  27505  26846  24311  24104  9271  14232  15099
128    25008  22899  24007  25515  22117  23116  12542  10455  12231
256    15118  17385  15168  22231  25191  19772  9076  10527  11014
512    22759  19113  18857  20410  18305  25511  12354  13219  12671
1024   8353  4130  5217  5575  5176  5334  2497  2885  2901
2048   3702  3675  3597  3451  4708  4709  2435  2277  2072
4096   4452  4711  4534  4368  4246  4413  2140  2528  2700
8192   5190  5350  5272  3451  3317  3298  1761  1705  2216
16384  5044  5250  5178  5330  5251  5277  2622  2633  2601
32768  4359  5205  5253  5282  5218  5241  2610  2622  2677
65536  5349  5327  4840  5264  5290  5286  2642  2656  2700
131072 5308  5313  5255  4884  5309  5330  2661  2675  2723
262144 5353  5369  5338  5409  5348  5347  2689  2553  2717
524288 5349  5336  5157  5418  5317  5364  2672  2710  2753
1048576 5065  5333  5297  5335  5333  5279  2673  2694  2756
2097152 5384  5363  5366  5378  5338  5348  2627  2385  2650

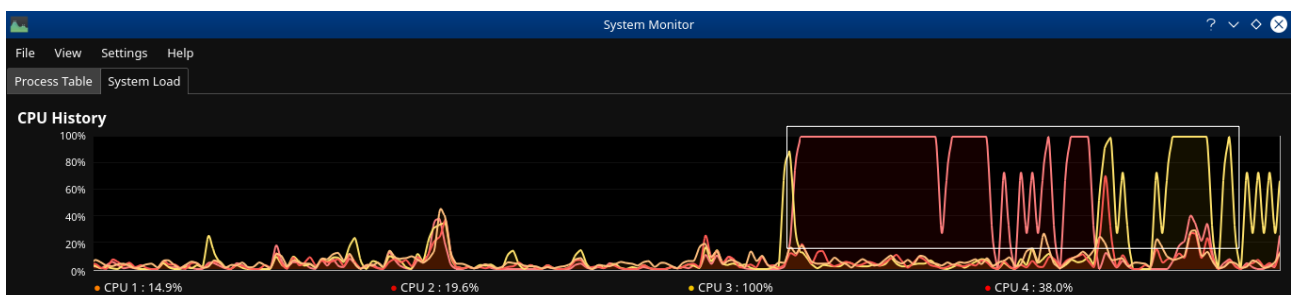
End of test Thu Apr 9 14:48:41 2020

Press Enter

niranay@niranay ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ll
total 76
drwxrwxr-x 2 niranay niranay 4096 Apr 9 14:47 ./
drwxrwxr-x 4 niranay niranay 4096 Apr 9 14:42 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec 2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 25776 Apr 9 14:47 memory_speed64*
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 14:45 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr 9 14:48 memSpeed.txt
niranay@niranay ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit

source_code : zsh
64_bit : zsh
```

## System monitor



## With OpenMP

```
64_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ll
total 328
drwxrwxr-x 2 niranay niranay 4096 Apr 9 14:51 ./
drwxrwxr-x 4 niranay niranay 4096 Apr 9 14:42 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec 2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 25776 Apr 9 14:50 memory_speed64*
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 14:51 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr 9 14:48 memSpeed_normal.txt
-rw-rw-r-- 1 niranay niranay 127563 Apr 9 14:48 Screenshot_20200409_144856.png
-rw-rw-r-- 1 niranay niranay 124697 Apr 9 14:49 Screenshot_20200409_144901.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit gcc memory_speed.c cpuidc64.o cpuid64.o -lrt -lc -lm -O3 -fopenmp
-o memory_speed64OMP
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ./memory_speed64OMP
#####
getDetails and MHz

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

#####

Memory Reading Speed Test 64 Bit OpenMP v4.1 Thu Apr 9 14:51:53 2020

Memory      x[n]=x[n]+s*y[n] Int  x[n]=x[n]+y[n]      x[n]=y[n]
KBytes      Dble  Sngl  Int32  Dble  Sngl  Int32  Dble  Sngl  Int32
Used        MB/S   MB/S   MB/S   MB/S   MB/S   MB/S   MB/S   MB/S   MB/S

4          1553   1399   1517   1517   1531   1605   829    814    811

64_bit : zsh
```

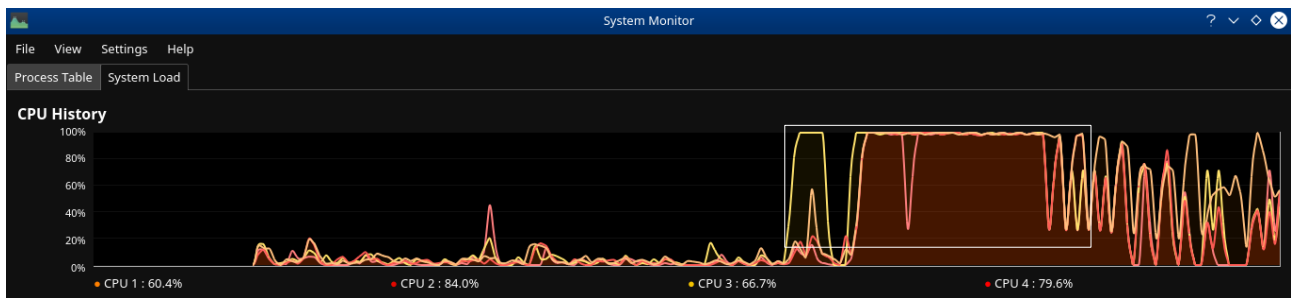
```
64_bit : zsh — Konsole
File Edit View Bookmarks Settings Help
8      2904  2861  2721  2504  3124  3253  1644  1656  1641
16     5441  5215  5434  5555  4866  6420  3832  3222  3243
32     10906 8890  9257  10166 9139  9477  5640  5008  5643
64     13029 12025 12075 18550 14750 16171 9540  8029  9213
128    21458 11887 14511 25238 18164 22202 14597 10688 12027
256    30974 18252 11761 19500 25680 32098 21585 14005 18242
512    33919 19384 27267 30557 13334 36431 22297 15736 22163
1024   36894 19998 27448 46460 17084 18604 29608 16434 24029
2048   9467  10606 10834 9441  12953 13146  6711  4752  4852
4096   5138  5158  5171  4530  5172  5244  2619  2432  2512
8192   5215  4989  5184  4558  5254  5236  2602  2636  2603
16384  5167  5131  5201  4705  5005  5176  2623  2611  2627
32768  5221  5082  5169  4894  5206  5257  2615  2355  2625
65536  5264  5301  5309  4966  5296  5196  2629  2632  2660
131072 5346  5441  5296  5467  5467  5466  2716  2736  2715
262144 5521  5554  5561  5544  5558  5591  2761  2785  2788
524288 5668  5399  5662  5661  5683  5533  2822  2802  2837
1048576 5798  5754  5785  5779  5803  5815  2879  2903  2828
2097152 5554  5312  5372  5543  4809  5351  2432  2554  2532

End of test Thu Apr 9 14:52:40 2020

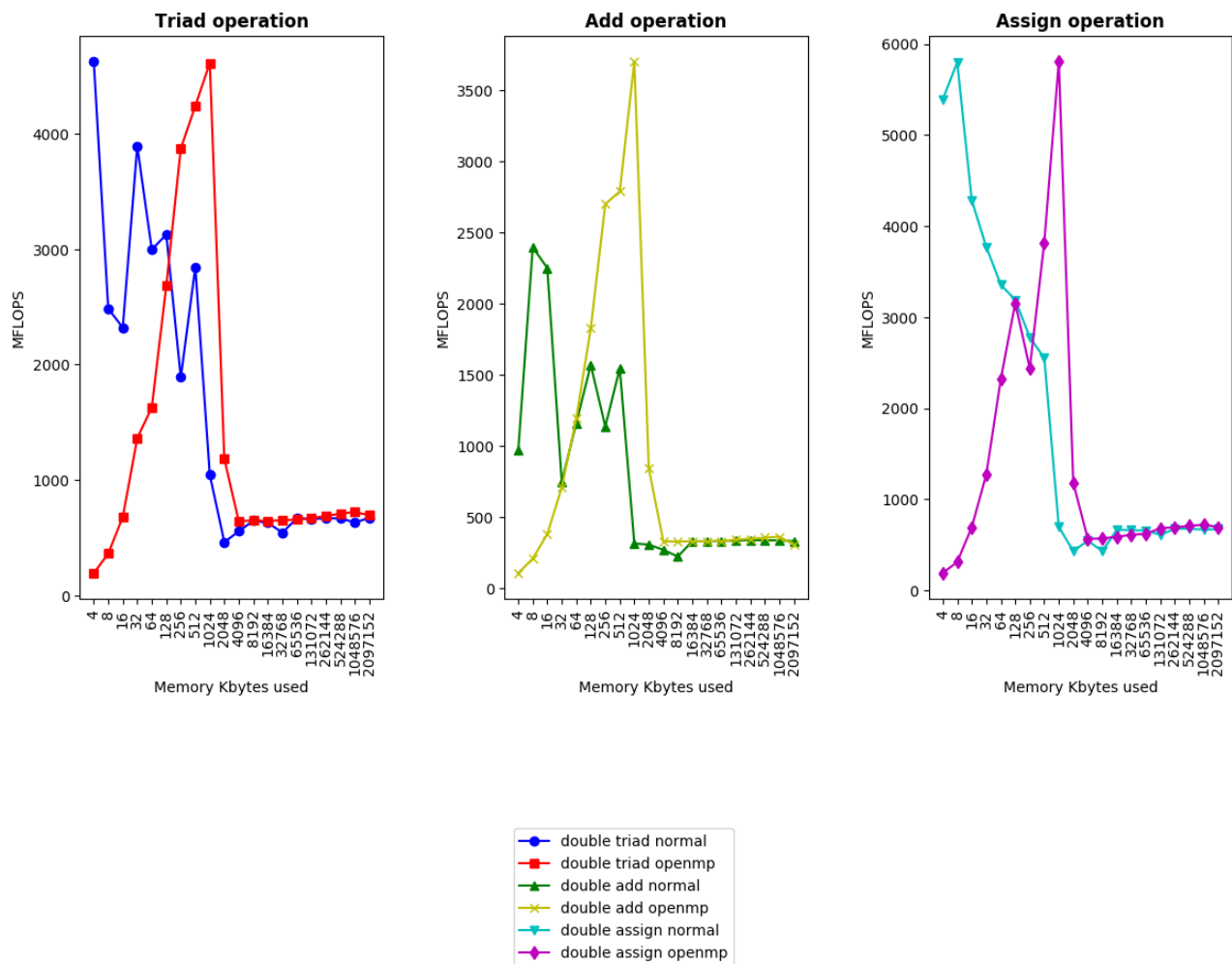
Press Enter

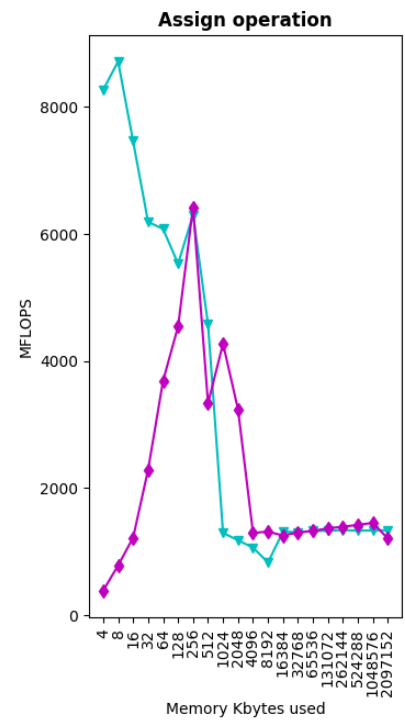
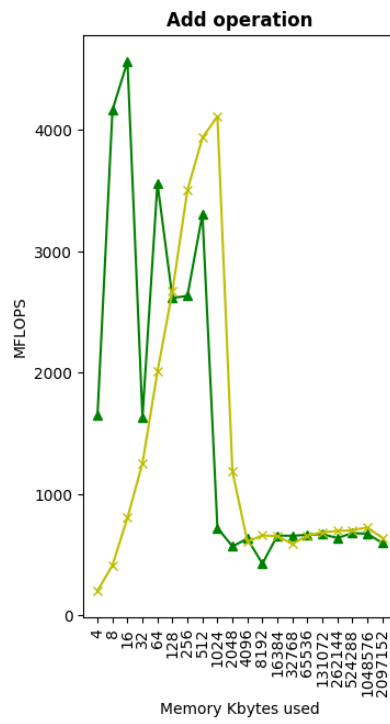
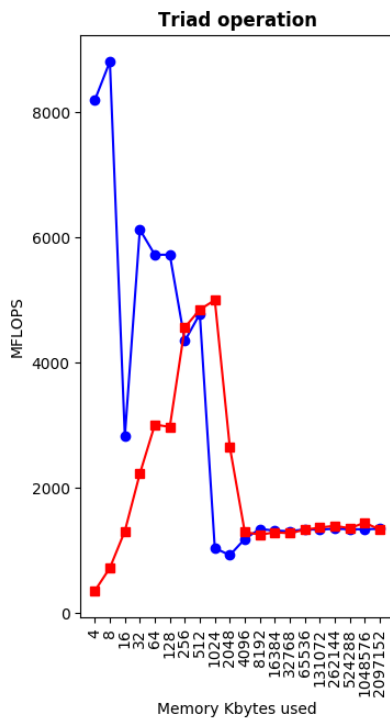
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit ll
total 364
drwxrwxr-x 2 niranay niranay 4096 Apr 9 14:51 ./
drwxrwxr-x 4 niranay niranay 4096 Apr 9 14:42 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec 2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr 9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 25776 Apr 9 14:50 memory_speed64*
-rwxrwxr-x 1 niranay niranay 30336 Apr 9 14:51 memory_speed64OMP*
-rw-rw-r-- 1 niranay niranay 15174 Apr 9 14:51 memory_speed.c
-rw-rw-r-- 1 niranay niranay 2397 Apr 9 14:48 memSpeed_normal.txt
-rw-rw-r-- 1 niranay niranay 2397 Apr 9 14:52 memSpeed.txt
-rw-rw-r-- 1 niranay niranay 127563 Apr 9 14:48 Screenshot_20200409_144856.png
-rw-rw-r-- 1 niranay niranay 124697 Apr 9 14:49 Screenshot_20200409_144901.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/memspeed/64_bit
```

## System monitor

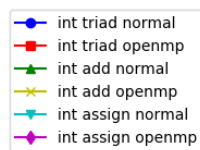
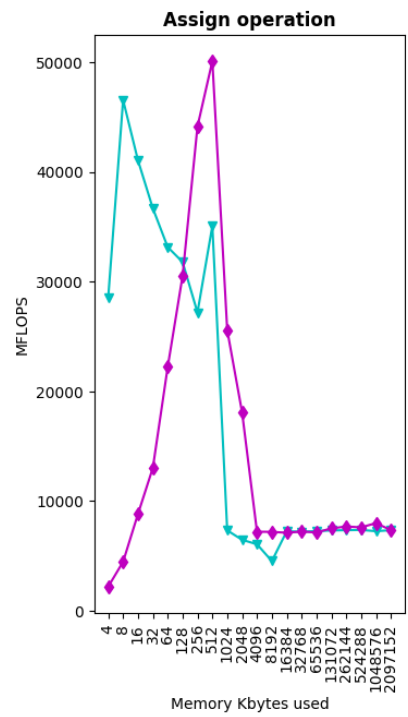
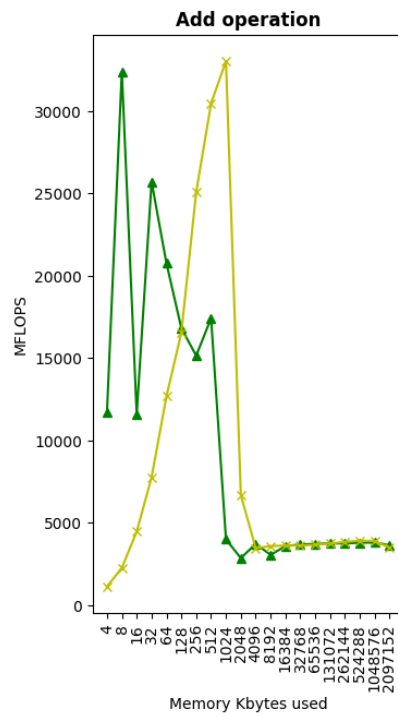
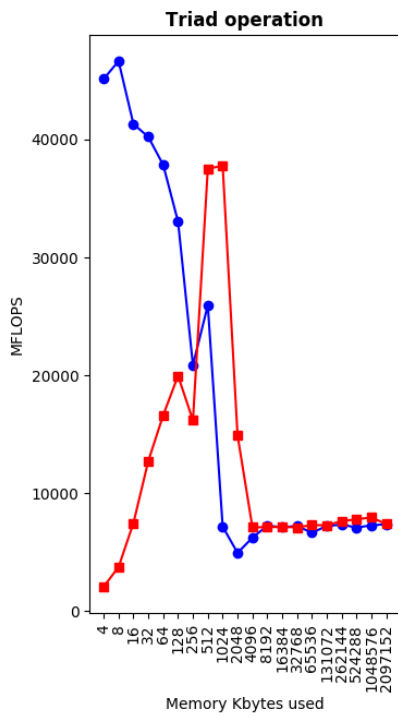


## Performance comparison in MFLOPS





- single triad normal
- single triad openmp
- ▲ single add normal
- × single add openmp
- ▼ single assign normal
- ◆ single assign openmp



32 bit Original OpenMP-

Normal

```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help

niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp 11
total 36
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:01 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:00 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.o
-rw-r--r-- 1 niranay niranay 4916 Dec  2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:01 OpenMPMFLOPS.c
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp gcc OpenMPMFLOPS.c cpuidc.o cpuid.o -lrt -lc -lm -O3 -m32 -o notOMPm
flops32
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp ./notOMPmFlops32
#####
getDetails and MHz

32 Bit One CPU MFLOPS Benchmark 1 Thu Apr  9 19:01:51 2020

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2023 MHz, Maximum 2801 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte  Ops/  Repeat  Seconds  MFLOPS      First  All
              Words  Word  Passes              Results Same
Data in & out 1000000 2    2500    0.269694  1854    0.929475 Yes
Data in & out 1000000 2    250     0.320681  1559    0.992543 Yes
Data in & out 1000000 2    25      0.316601  1579    0.999249 Yes

> exec: zsh openmp: zsh
```

```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help

AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2023 MHz, Maximum 2801 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte  Ops/  Repeat  Seconds  MFLOPS      First  All
              Words  Word  Passes              Results Same
Data in & out 1000000 2    2500    0.269694  1854    0.929475 Yes
Data in & out 1000000 2    250     0.320681  1559    0.992543 Yes
Data in & out 1000000 2    25      0.316601  1579    0.999249 Yes

Data in & out 1000000 8    2500    0.745803  2682    0.957164 Yes
Data in & out 1000000 8    250     0.791915  2526    0.995525 Yes
Data in & out 1000000 8    25      0.863208  2317    0.999550 Yes

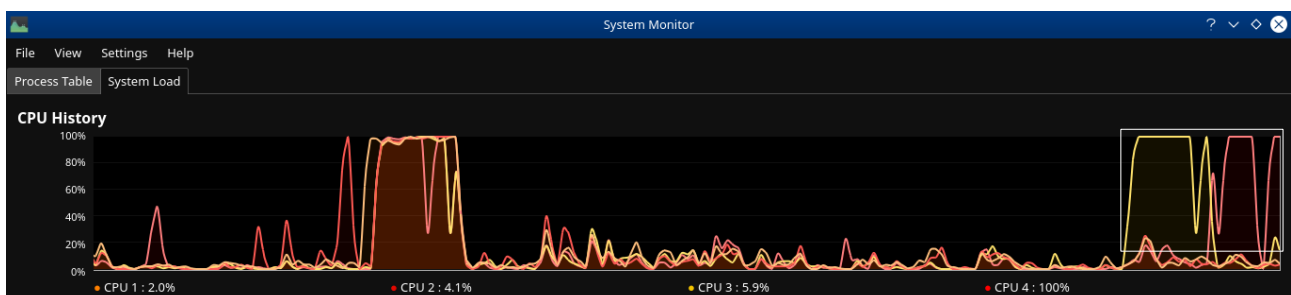
Data in & out 1000000 32   2500    2.665545  3001    0.890377 Yes
Data in & out 1000000 32   250     2.697614  2966    0.988102 Yes
Data in & out 1000000 32   25      2.915229  2744    0.998799 Yes

Press Enter

niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp 11
total 60
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:01 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:00 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.o
-rw-r--r-- 1 niranay niranay 4916 Dec  2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 19124 Apr  9 19:01 notOMPmFlops32*
-rw-rw-r-- 1 niranay niranay 1524 Apr  9 19:02 OpenMPLog.txt
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:01 OpenMPMFLOPS.c
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp 11

> exec: zsh openmp: zsh
```

## System monitor



## With OpenMP

```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp 11
total 312
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:03 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:02 ../
-rw-r--r-- 1 niranay niranay 1392 Nov 30 2010 cpuid.o
-rw-r--r-- 1 niranay niranay 4916 Dec  2 2010 cpuidc.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 19124 Apr  9 19:01 notOMPmFlops32*
-rw-rw-r-- 1 niranay niranay 1524 Apr  9 19:02 OpenMPLog_normal.txt
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:03 OpenMPMFLOPS.c
-rw-rw-r-- 1 niranay niranay 122924 Apr  9 19:02 Screenshot_20200409_190233.png
-rw-rw-r-- 1 niranay niranay 130938 Apr  9 19:02 Screenshot_20200409_190237.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp gcc OpenMPMFLOPS.c cpuidc.o cpuid.o -lrt -lc -lm -O3 -fopenmp -m32 -
o openMPmFlops32
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp ./openMPmFlops32
#####
getDetails and MHz

32 Bit OpenMP MFLOPS Benchmark 1 Thu Apr  9 19:03:48 2020

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2000 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte Ops/ Repeat Seconds MFLOPS First All
              Words Word Passes           Results Same

> exec: zsh openmp: zsh
```

```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help
#####
getDetails and MHz

32 Bit OpenMP MFLOPS Benchmark 1 Thu Apr  9 19:03:48 2020

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2000 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte Ops/ Repeat Seconds MFLOPS First All
              Words Word Passes           Results Same

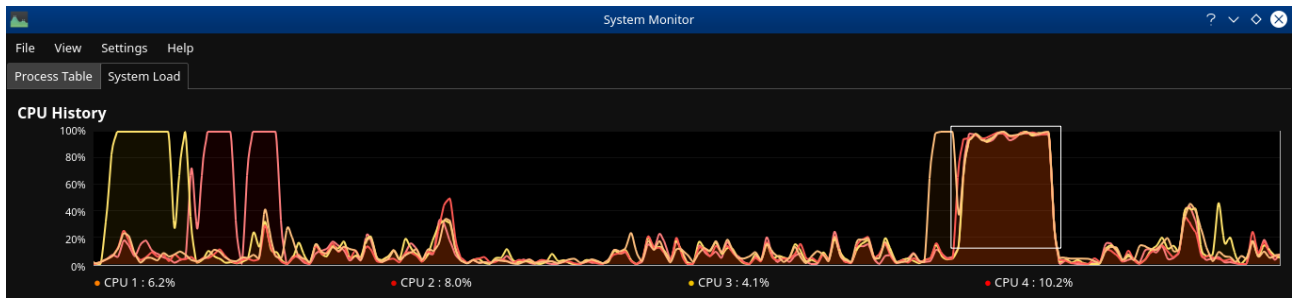
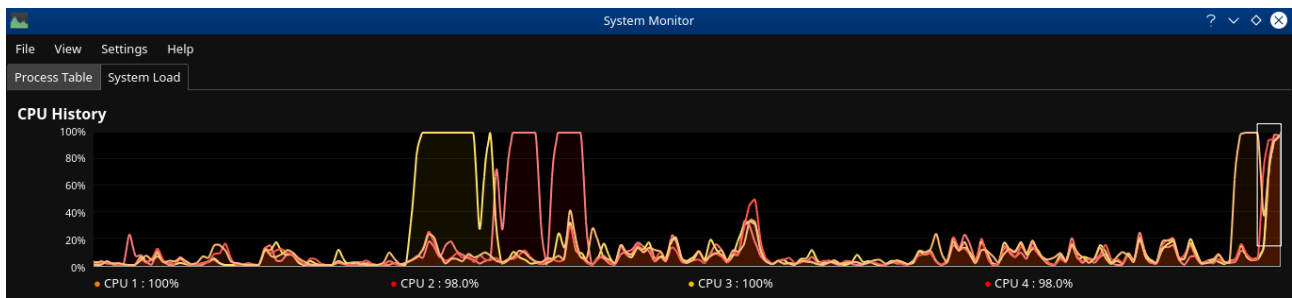
Data in & out 1000000 2 2500 0.186959 2674 0.929475 Yes
Data in & out 1000000 2 250 0.303994 1645 0.992543 Yes
Data in & out 10000000 2 25 0.305145 1639 0.999249 Yes

Data in & out 1000000 8 2500 0.532453 3756 0.957164 Yes
Data in & out 1000000 8 250 0.531872 3760 0.995525 Yes
Data in & out 10000000 8 25 0.522655 3827 0.999550 Yes

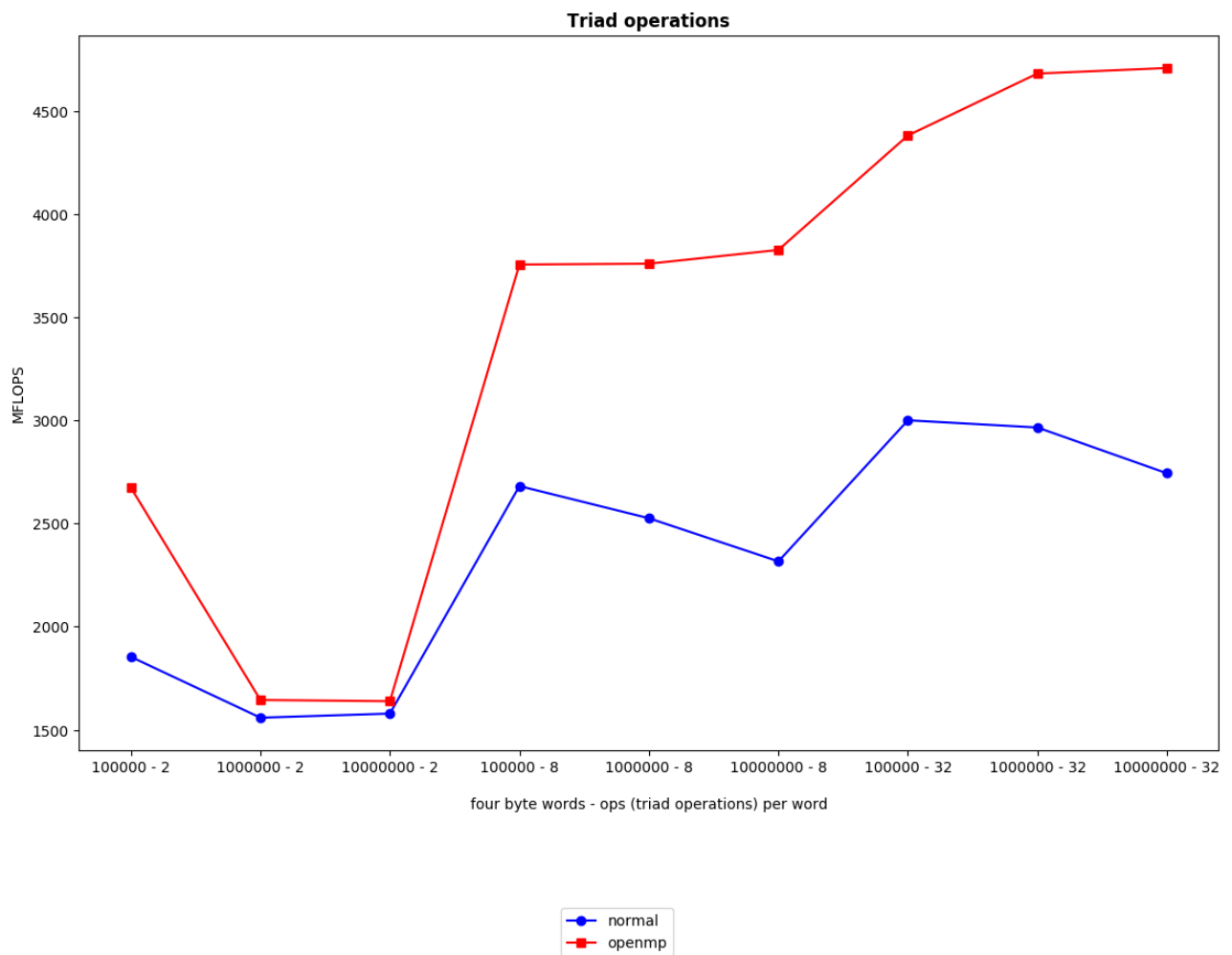
Data in & out 1000000 32 2500 1.825738 4382 0.890377 Yes
Data in & out 1000000 32 250 1.708748 4682 0.988102 Yes
Data in & out 10000000 32 25 1.698822 4709 0.998799 Yes

Press Enter
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/32_bit/openmp 11
> exec: zsh openmp: zsh
```

## System monitor



## Performance comparison in MFLOPS



64 bit Original OpenMP-

Normal



```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64_bit/openmp ll
total 40
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:16 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:11 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec  2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:16 OpenMPMFLOPS.c
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64_bit/openmp gcc OpenMPMFLOPS.c cpuidc64.o cpuid64.o -lrt -lc -lm -O3 -o notOMPmFl
ops64
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64_bit/openmp ./notOMPmFlps64
#####
getDetails and MHz

64 Bit One CPU MFLOPS Benchmark 1 Thu Apr  9 19:17:19 2020

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte  Ops/  Repeat  Seconds  MFLOPS    First  All
              Words  Word  Passes              Results Same
Data in & out  100000    2    2500  0.083235   6007  0.929538 Yes
Data in & out  1000000    2    250  0.291486   1715  0.992550 Yes
Data in & out  10000000    2    25  0.289308   1728  0.999250 Yes

exec: zsh
openmp: zsh
```

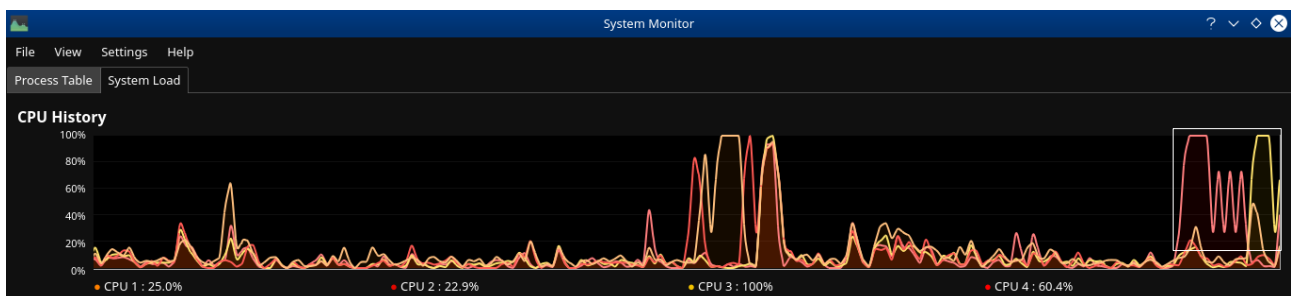
```
openmp: zsh — Konsole
File Edit View Bookmarks Settings Help
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2395 MHz, Maximum 2395 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88-16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte  Ops/  Repeat  Seconds  MFLOPS    First  All
              Words  Word  Passes              Results Same
Data in & out  100000    2    2500  0.083235   6007  0.929538 Yes
Data in & out  1000000    2    250  0.291486   1715  0.992550 Yes
Data in & out  10000000    2    25  0.289308   1728  0.999250 Yes
Data in & out  100000    8    2500  0.121816  16418  0.957117 Yes
Data in & out  1000000    8    250  0.291952  6850  0.995517 Yes
Data in & out  10000000    8    25  0.283125  7064  0.999549 Yes
Data in & out  100000   32    2500  0.606118  13199  0.890211 Yes
Data in & out  1000000   32    250  0.702463  11389  0.988082 Yes
Data in & out  10000000   32    25  0.654850  12217  0.998796 Yes

Press Enter
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64_bit/openmp ll
total 76
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:17 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:11 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec  2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rw-rwxr-x 1 niranay niranay 31096 Apr  9 19:17 notOMPmFlps64*
-rw-rw-r-- 1 niranay niranay 1524 Apr  9 19:17 notOMPLog.txt
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:16 OpenMPMFLOPS.c
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64_bit/openmp

exec: zsh
openmp: zsh
```

## System monitor



## With OpenMP

```
openmp : zsh — Konsole
File Edit View Bookmarks Settings Help
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp ll
total 332
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:18 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:11 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec  2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 31096 Apr  9 19:17 notOMPmFlops64*
-rw-rw-r-- 1 niranay niranay 1524 Apr  9 19:17 OpenMPLLog_normal.txt
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:18 OpenMPmFLOPS.c
-rw-rw-r-- 1 niranay niranay 123834 Apr  9 19:17 Screenshot_20200409_191737.png
-rw-rw-r-- 1 niranay niranay 131861 Apr  9 19:17 Screenshot_20200409_191739.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp gcc OpenMPmFLOPS.c cpuidc64.o cpuid64.o -lrt -lc -lm -O3 -fopenmp -o
openMPmFlops64
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp ./openMPmFlops64
#####
getDetails and MHz

64 Bit OpenMP MFLOPS Benchmark 1 Thu Apr  9 19:18:47 2020

Assembler CPUID and RDTSC
CPU AuthenticAMD, Features Code 178BFBFF, Model Code 00660F51
AMD A10-9600P RADEON R5, 10 COMPUTE CORES 4C+6G
Measured - Minimum 2204 MHz, Maximum 2590 MHz
Linux Functions
get_nprocs() - CPUs 4, Configured CPUs 4
get_phys_pages() and size - RAM Size 11.13 GB, Page Size 4096 Bytes
uname() - Linux, Niranay, 4.15.0-88-generic
#88~16.04.1-Ubuntu SMP Wed Feb 12 04:19:15 UTC 2020, x86_64

Test          4 Byte  Ops/  Repeat  Seconds  MFLOPS  First  All
              Words  Word  Passes                Results Same

Data in & out  1000000  2     2500   0.073513  6802    0.929538 Yes
Data in & out  1000000  2     25    0.246855  2025    0.992550 Yes
Data in & out  10000000  2     25    0.258579  1934    0.999250 Yes

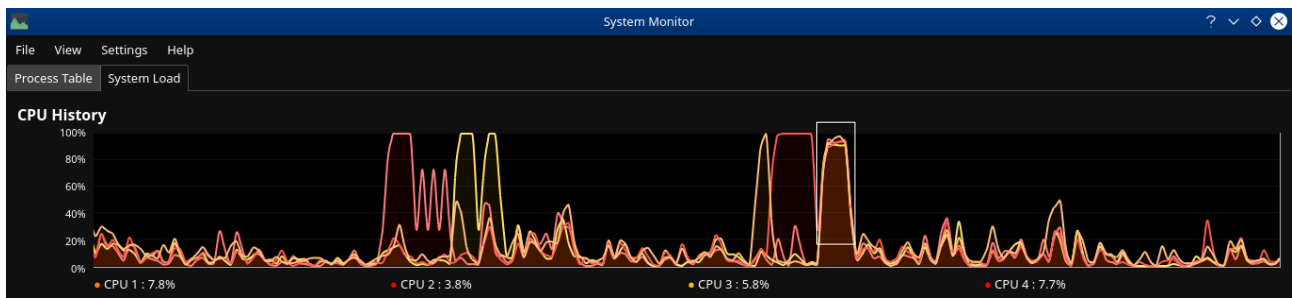
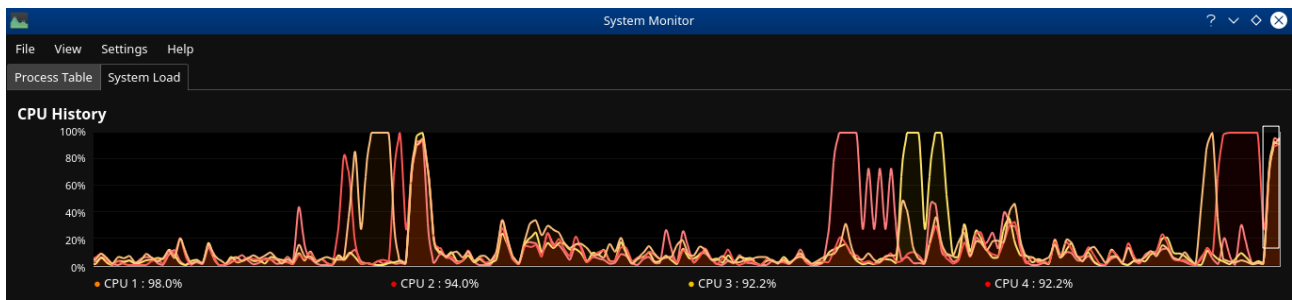
Data in & out  100000  8     2500   0.080444  24862   0.957117 Yes
Data in & out  1000000  8     250   0.273588  7310    0.995517 Yes
Data in & out  10000000  8     25    0.237623  8417    0.999549 Yes

Data in & out  100000  32    2500   0.268888  29752   0.890211 Yes
Data in & out  1000000  32    250   0.281264  28443   0.988082 Yes
Data in & out  10000000  32    25    0.293464  27261   0.998796 Yes

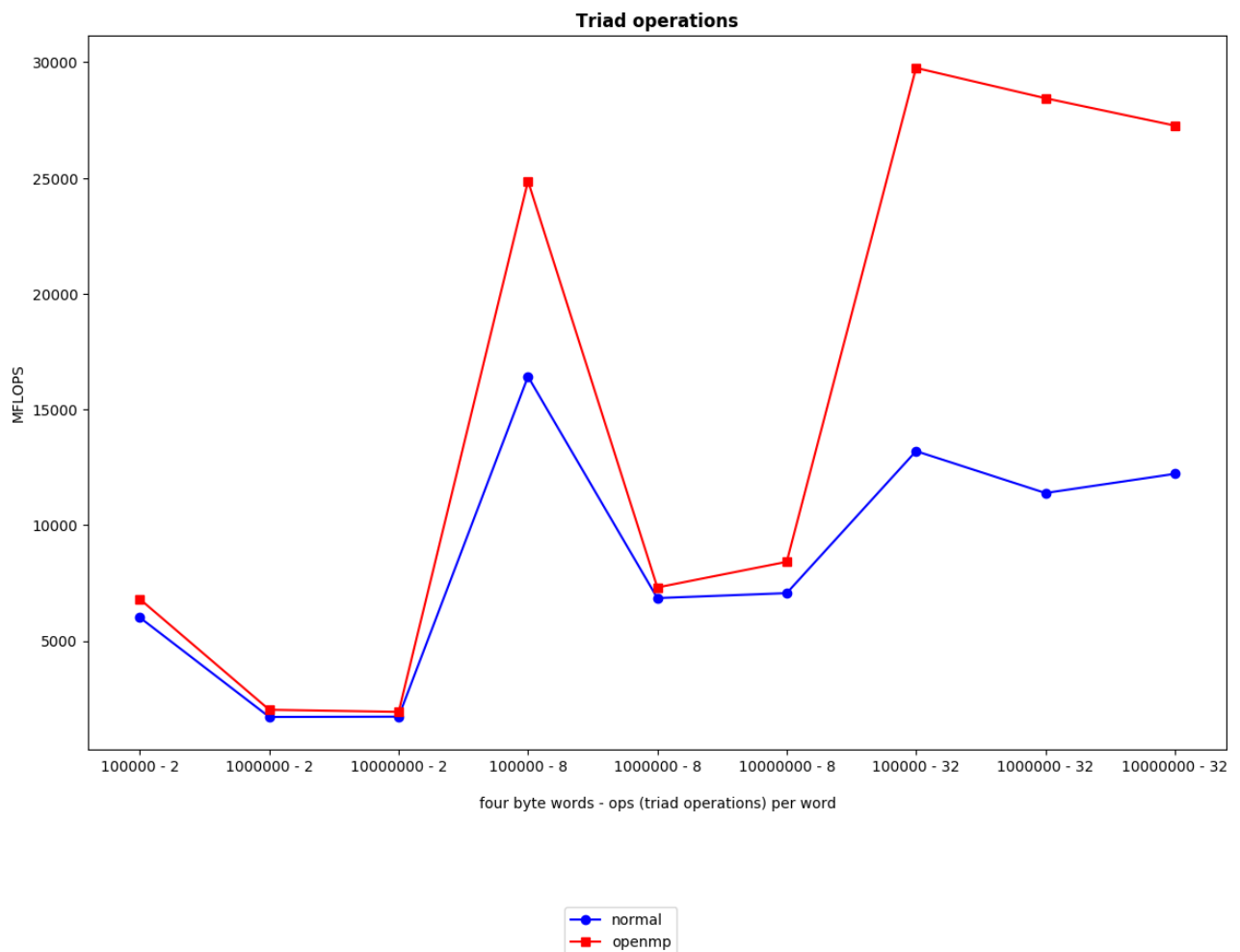
Press Enter

niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp ll
total 364
drwxrwxr-x 2 niranay niranay 4096 Apr  9 19:18 ./
drwxrwxr-x 4 niranay niranay 4096 Apr  9 19:11 ../
-rw-r--r-- 1 niranay niranay 5232 Nov 30 2010 cpuid64.o
-rw-r--r-- 1 niranay niranay 7864 Dec  2 2010 cpuidc64.o
-rw-r--r-- 1 niranay niranay 597 Apr  9 14:44 cpuidh.h
-rwxrwxr-x 1 niranay niranay 31096 Apr  9 19:17 notOMPmFlops64*
-rw-rw-r-- 1 niranay niranay 1524 Apr  9 19:17 OpenMPLLog_normal.txt
-rw-rw-r-- 1 niranay niranay 1523 Apr  9 19:18 OpenMPLLog.txt
-rwxrwxr-x 1 niranay niranay 27312 Apr  9 19:18 openMPmFLOPS64*
-rw-r--r-- 1 niranay niranay 9681 Apr  9 19:18 OpenMPmFLOPS.c
-rw-rw-r-- 1 niranay niranay 123834 Apr  9 19:17 Screenshot_20200409_191737.png
-rw-rw-r-- 1 niranay niranay 131861 Apr  9 19:17 Screenshot_20200409_191739.png
niranay@niranay: ~/Documents/sem8/MT/Assignment 3/linux_openmp/source_code/exec/64 bit/openmp
```

## System monitor



## Performance comparison in MFLOPS



## Conclusion

### MemSpeed-

The general observation in case of MemSpeed for both 32 and 64 bit is that execution of the benchmark in terms of MFLOPS performance without OpenMP fares well for low memory usage and then drastically decreases roughly at central memory usage, and then finally remains approximately within a low range with further increase in memory usage. On the other hand, with OpenMP, for low memory usage the performance is really low as compared to without OpenMP, but then it peaks for memory usage roughly in the centre of the low and high limits, and then again drops to match the range without OpenMP with further increase in memory usage.

### Original OpenMP-

The general observation in case of Original OpenMP for both 32 and 64 bit is that execution of the benchmark in terms of MFLOPS performance with OpenMP in general exceeds that without OpenMP, with a decrease in performance in both cases for an increase in the number of 4 byte words for a constant number of ops per word.

## References

- <http://www.roylongbottom.org.uk/linux%20openmp%20benchmarks.htm#anchorStart>