Assignment 0 – Chen-Yu Chang U93093024

Part 1.

1a.

- CPU: Intel(R) Core(TM) i7-9700 CPU @ 3.00GHz
- Operating Frequency: 799.987 MHz
- 8 Cores

1b.

- L1d Cache: 32K
  L1i Cache: 32K
  L2 Cache: 256K
  L3 Cache: 12288K
- Microarchitecture: Coffee Lake-S
- There are 8 cores and 8 siblings, so there is one virtual processor per core.
- Max Memory Bandwidth: 41.6GB/s

Part 2.

2a.

Accuracy is determined by the degree to which certain values are close to a correct value or standard. The method to determine the accuracy of the timer is to do repetitive operation many times. On older multi-cored processors, the rate could change differently on different cores, as they scaled their clock speeds according to different loads. On more recent processors, the rate remains constant while the clock speed changes, so that timings on a lightly-loaded core may seem slower than they are. Out-of-order execution may mean that the register isn't read when you think it is. For resolution, we can find that it should be within milliseconds range.

2b.

There are problems for RDTSC-based method. When using multiple new CPU chips, there will be some difference on time counters on different CPUs. With different frequency depending on the load, it displays a non-exact time elapsed. Therefore, when measuring time, we will get different time on distinct CPUs. However, the timers can still be useful. The time counter can be synchronized before RDTSC is run. Also, we can keep track on the instructions run and eliminate those instructions skewed. Overall, we can still know the approximate.

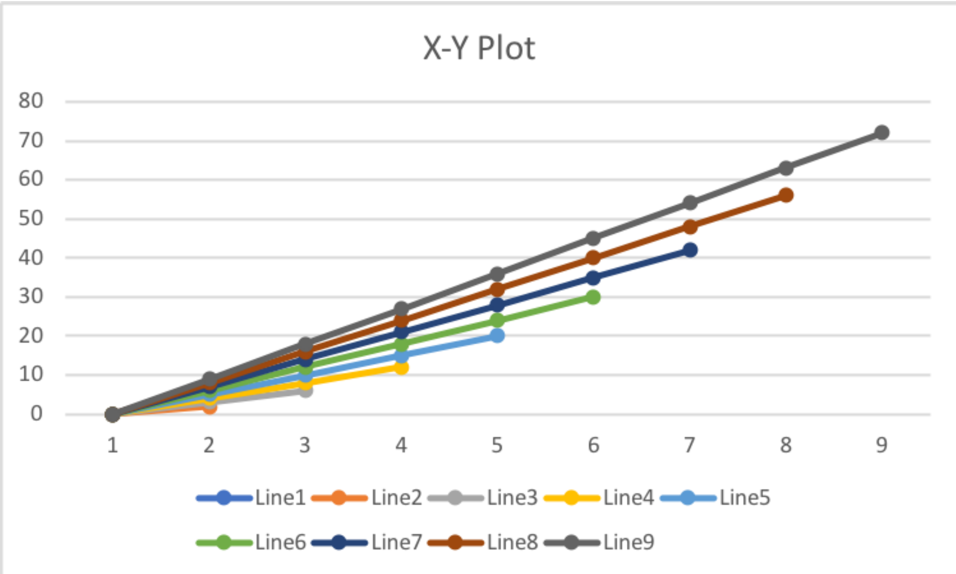
2c.

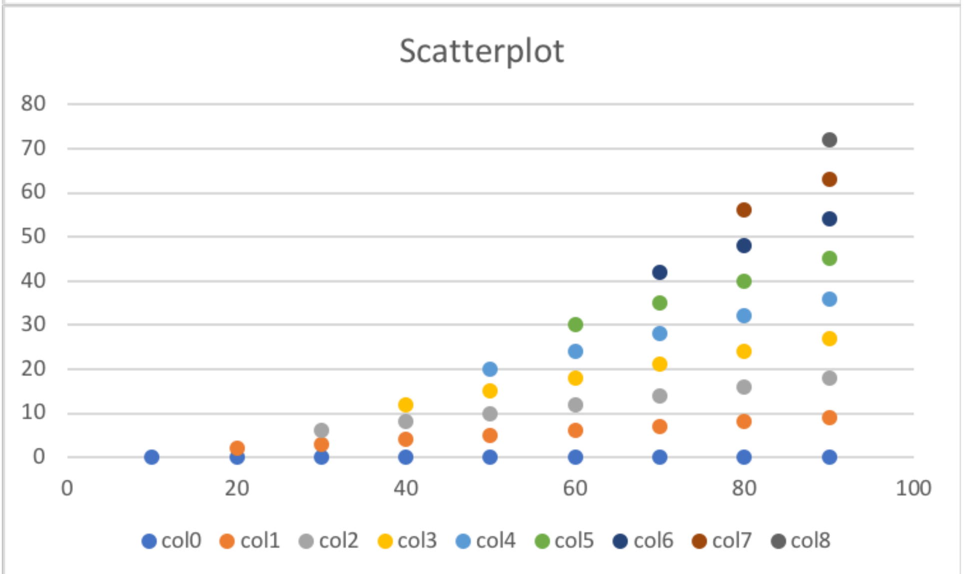
- We do not have to change for gettimeofday
- For RDTSC, we will change the clock rate (CLK_RATE) to 3.0e9
- For times, we will change the typical second ticks of 100 to a system configuration (sysconf(_SC_CLK_TCK))

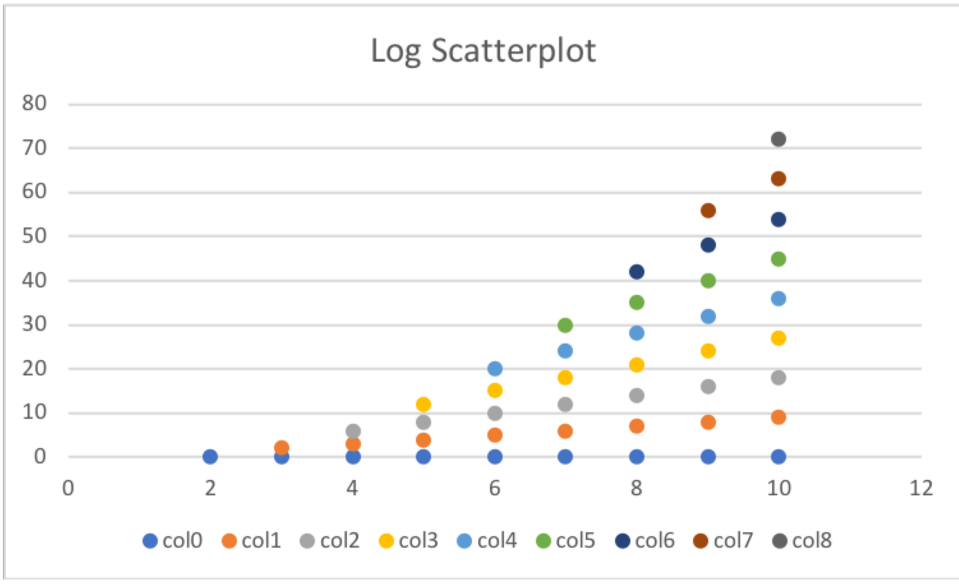
2f.

- The closest I can get is 0.999217708 seconds. The resolution is to its nanoseconds and the standard deviation is about 0.042 seconds.

Part 3.

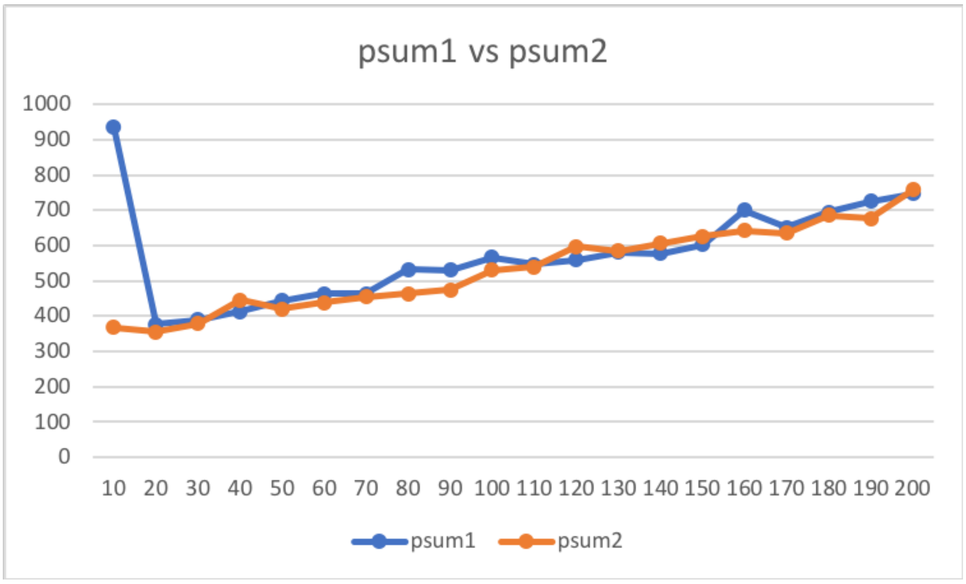






Part 4.

4b.



4c.

A good way to get rid of anomalies could be removing redundant data from database or reducing the need to restructure the database every time new fields are added.

4d.

We can get that the CPE for psum1 is about 6.34 and 4.82 for psum2, which is not the same written in the material. The reason might be the gettime function with non-fixed frequency makes the calculation have some flaws.

Part 5.

5a.

```
Starting a loop

  done

real  0m0.152s
user 0m0.148s
sys   0m0.002s
```

5b.

```
Starting a loop

  done

real  0m0.029s
user 0m0.026s
sys   0m0.002s
```

5c.

```
.LFB0:
	.cfi_startproc
	pushq	%rbp
	.cfi_def_cfa_offset 16
	.cfi_offset 6, -16
	movq	%rsp, %rbp
	.cfi_def_cfa_register 6
	subq$32, %rsp
	movl	%edi, -20(%rbp)
	movq	%rsi, -32(%rbp)
	movq	$0, -16(%rbp)
	movl	$.LC0, %edi
	call	puts
	movq	$0, -8(%rbp)
	jmp	.L2
```

```
.L3:
	addq	$3, -16(%rbp)
	addq	$1, -8(%rbp)
.L2:
	cmpq	$100000000, -8(%rbp)
	jle	.L3
	movl	$.LC1, %edi
	call	puts
	leave
	.cfi_def_cfa 7, 8
	ret
	.cfi_endproc
```

5d.

```
	.file	"test_O_level.c"
	.section	.rodata.str1.1,"aMS",@progbits,1
.LC0:
	.string	"\n Starting a loop "
.LC1:
	.string	"\n done "
	.text
	.globl	main
	.type	main, @function
main:
.LFB11:
	.cfi_startproc
	subq$8, %rsp
	.cfi_def_cfa_offset 16
	movl	$.LC0, %edi
	call	puts
	movl	$100000001, %eax
.L3:
	subq$1, %rax
	jne	.L3
	movl	$.LC1, %edi
	call	puts
	addq	$8, %rsp
	.cfi_def_cfa_offset 8
```

```
        ret
        .cfi_endproc
.LFE11:
        .size main, .-main
        .ident      "GCC: (GNU) 4.8.5 20150623 (Red Hat 4.8.5-44)"
        .section    .note.GNU-stack,"",@progbits
```

--- There is no ‘steps’ and ‘i’ variables anymore.

5e.

Starting a loop
steps: 300000003

done

real: 0.065s
user:0.041s
sys: 0.002s

The code was optimized to calculate steps. Movl $300000003, %esi was printed.

Part 6.

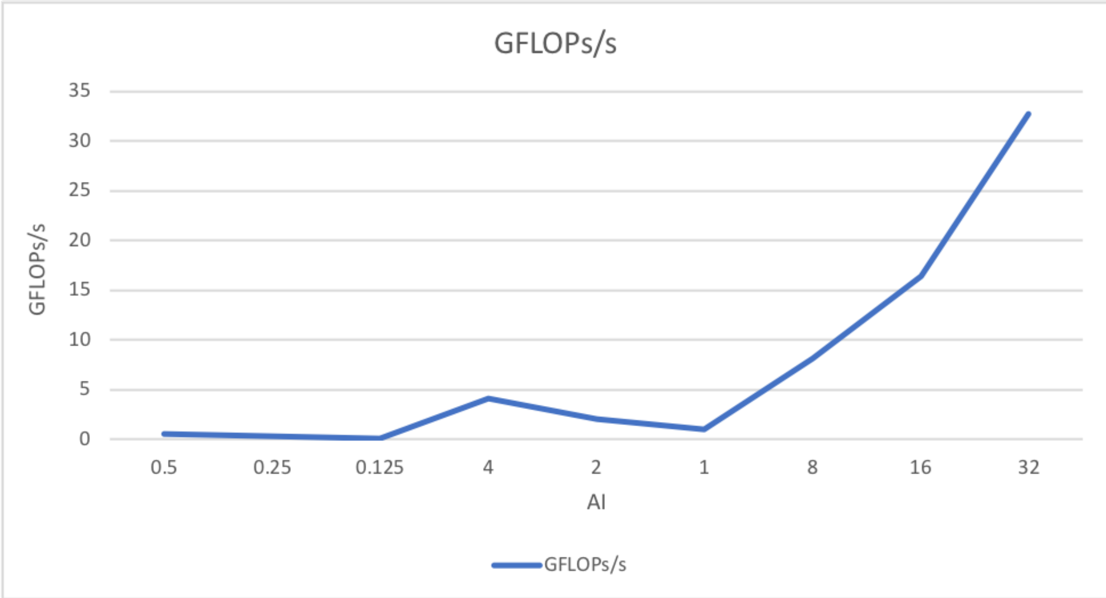
6c.

The memory bandwidth is 11508.9742MB/s. This is less than the maximum bandwidth of the processor (41.6GB/s)

6d.

FLOPs_per_Loop	Unique_Reads_per_Loop	AI	GFLOPs/s
1	2	0.5	0.510728
1	4	0.25	0.255424
1	8	0.125	0.127719
4	1	4	4.084547
4	2	2	2.043307
4	4	1	1.022308
8	1	8	8.176715
16	1	16	16.352851
32	1	32	32.691069

6e.



6f.

The graph shows that GFLOPs/s increases as AI increases. Within the range of [1/8,2]. We can see that it will hit to a wall and decrease a little. Before that, it has a limited bandwidth. However, when AI goes over the range, it still shoots up.

Part 7.

7a. I did not miss any of the parts.
7b. This assignment took me about 8-10 hours in total, separated in several days.
7c. I spent the most time on part 4, but not too much.
7d. Not now.