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Summary

Performance Improvement with Non-Uniform Loads on SMT Processors

1st Adnan
Department of Informatics
Hasanuddin University
Makassar
adnan@unhas.ac.id

2nd Dwi Khairil Oktahidayat
Department of Electrical Engineering
Hasanuddin University
Makassar
dwikh.oktahidayat@gmail.com

3rd Andani Achmad
Department of Electrical Engineering
Hasanuddin University
Makassar
andani60@yahoo.com

Previously, the researcher conducted a study to improve processor performance focusing on uniform workloads. We suspect that the processor does not work optimally because there are several units that are inactive when working on a task. In this study, we want to show the performance of a computer if it is given a non-uniform load on the Intel Core i7-4790 and AMD Ryzen 5 1500X, so we can see the maximum performance of the processor because of the non-uniform workload. We use C and OpenMP to create a program code which is a matrix multiplication program m x n. Then, the researcher gives a different workload (integer and floating-point workload) into the program structure. We also provide additional workloads with rounds 5, 10, 15, 20 and 25 times. Finally, after each workload looped, we add para-loop to repeat both workloads 24 times simultaneously. The researcher executes the program 8 times per thread to get the best execution time. We found that in Intel Core i7 4790, the best speedup of the processor was 4.67 using 8 threads. Then, in AMD Ryzen 5 1500X, the best speedup of the processor was 5.21 using 8 threads. Just like speedup, the best IPC from the processor Intel Core i7 4790 is 7.00 when using 8 threads. In AMD Ryzen 5 1500X, the best IPC is 7.20 when using 8 threads. That means the speedup and IPC are directly proportional.

Keywords — Non-Uniform Workloads, Performance, Parallel Computing

I. INTRODUCTION

Most computer vendors are competing to introduce new products that combine several cores on a processor chip, the addition of simultaneous multithreading features, and other features used to improve the performance of a processor. With increasingly rapid development, in the future, we will see a processor chip that can work several tens or hundreds of threads simultaneously. Thus, almost all future platforms will directly support parallel applications[1].

In processing a large amount of data requires a processor with good performance. A processor that uses a single thread takes a longer time to process data than the processor that maximizes the thread it has[2]. Because, the processor that maximizes the thread divides data into threads and processes it at the same time, and it is known as simultaneous multithreading. Simultaneous multithreading can retrieve and execute several instructions to increase system utilization and speed up the process of executing programs[3]. SMT processor uses resources more efficiently. It can exploit all types of parallelism, thread and instruction levels parallelism, so get a better speed up[4].

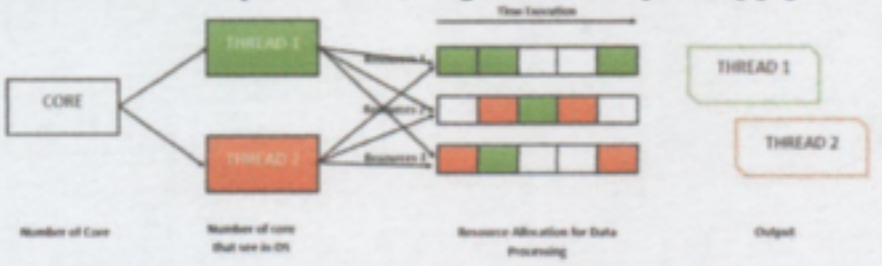

Fig 1. Data Processing Using Simultaneous Multithreading

Figure 1 shows the process of SMT. Each logical core executes each incoming thread, thus requiring a short execution time.

In the architecture of a processor, there are several units used in processing data, namely the Arithmetic Logical Unit (ALU)[5] and the Floating-Point Unit (FPU)[6]. In the previous study[2], the researcher got a speedup that was not maximal. This is because researcher uses a uniform workload in the program that he developed. When processing data, there is another unit that in idle condition. We offer a non-uniform workload on programs that will run on the processor so that it can provide maximum performance improvements to the processor.

In this research wants to show the performance of computer if given non-uniform workloads on an Intel Core i7-4790 and AMD Ryzen 5 1500X, so we can see the maximum performance of the processor due to non-uniform workloads. The hypothesis in this study is speedup which better than previous researches[2]. This is related to the non-uniform workload given to the program. Because both integer and floating-point units are not idle.

In this paper, there are 5 sections. Section II introduces related work and shows the current research. Section III describes hardware architecture of Intel Haswell. Section IV describes the result of this research. There are 3 results in this research, they are speedup, instruction per cycle, and analytical results. Section V describes the conclusion from this research.

II. RELATED WORK

There have been many previous related studies on parallel computing. Radojkovic[7] does research on thread

scheduling. In this study, the researcher has proposed a scheduling method, BlackBox Scheduler. We can see for 6 threads, the result of the naive process is 5-15% and the worst case is more than 55%. For 24 threads, the result of the naive process is 6-19% and the worst case is above 45%.

Peternier[8] does a study to optimize the performance of the processor. The researcher proposes a method to prevent inefficient scheduling and bind threads that perform Floating Point calculation to the processor unit. This method was tested using 2 different processors, AMD Bulldozer and IBM Power 7. The researcher uses WorkOver integrated with Low-level Java monitoring library. In this research, the researcher uses 2 benchmarks, they are Spec CPU and SciMark 2.0. We can see in this research, for AMD-Bull used Spec CPU, the speedup reach 1,14 times (for hmmer+povray) with L2 misses cache rate 0,85%. Then, for IBM P7 used Spec CPU with SMT2, the speedup reaches 1,47 times (for h264ref+povray) with L2 misses cache rate 0,68% and if using SMT4 reach 1,4 times for speedup with L2 misses cache rate 0,6%. With the other benchmark, the researcher has found the result, for AMD-Bull reach 1,08 times (for full SciMark). And for IBM P7 reach the speedup 1,05 times with SMT 2 and 1,11 times with SMT 4.

Adnan[2] proposes a concept to improve the performance of the processor with a uniform workload. In this study, we can see that using 1 thread can be completed in 1 second and using 4 threads in 1.9 seconds. It means, the speed up from 1 to 4 threads increase less than 50%.

III. HARDWARE ARCHITECTURE

A. Intel Haswell Core i7-4790

This section describes the internal architecture of the Intel Haswell processor family.

Intel Haswell is a product from Intel corporation 4th generation. In the architecture of this processor, Intel maintains most of the architectural design from Sandy Bridge and Ivy Bridge, including hyperthreading, Intel turbo boost, and interconnection ring. In Intel, there are three pillars to be handled such as performance, modularity, and power innovations. Each pillar has the main purpose including to improve performance and ability to extract parallelism with a little coding[9].

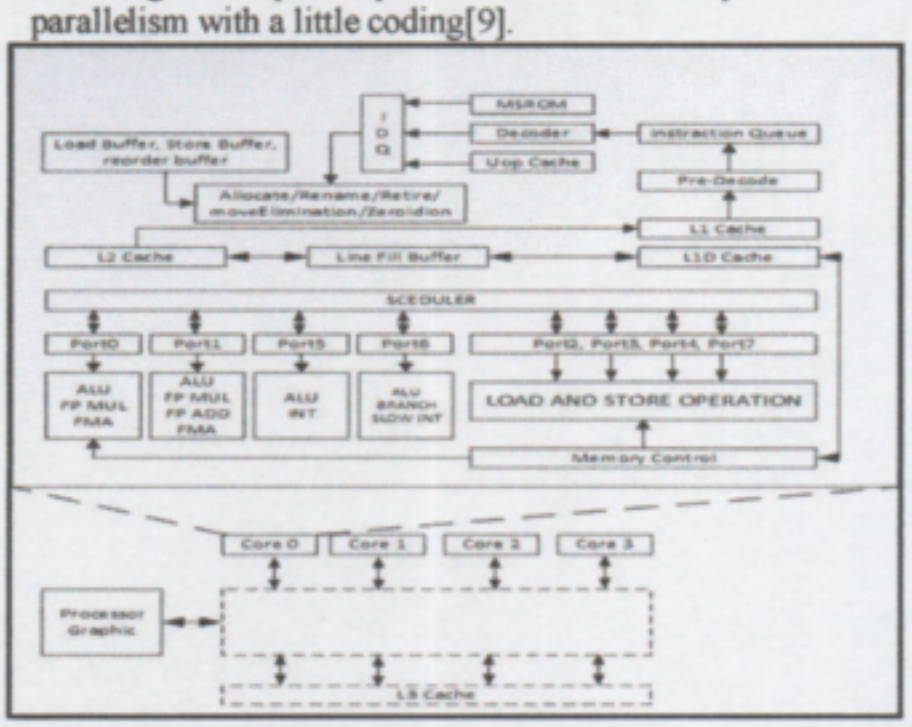

Fig 1. Intel Haswell Architecture

Figure 2 shows that Intel Haswell has 4 cores. Each core has an architecture consisting of cache memory with 2 levels (L1 and L2 caches), scheduler and the other unit such as Arithmetic Logical Unit (ALU), Floating Point Unit (FPU), etc.

The specification of processor use Intel Haswell Core i7-4790 list on Table 1.

Table 1 The specification of Intel Haswell Core i7-4790

System	*Detail of the Spesification*
Processor	Intel Haswell Core i7-4790
Core / Thread	4 Core / 8 Thread
Frequency	3,6 GHz up to 4 GHz
RAM	16 GB
L1 Cache Size	4x32 KB 8-Way set associative instruction caches 4x32 KB 8-way set associative data caches
L2 Cache Size	4x256 KB 8-way set associative caches
L3 Cache Size	8 MB 16-way set associative shared cache

B. AMD Ryzen 5 1500X

This section describes the internal architecture of Zen's family.

Ryzen 5 1500X is the fastest AMD quad-core processor based on the latest Zen architecture. Simultaneous multithreading makes the processor has 4 cores with 8 threads, which can run at the frequency of 3.5 - 3.7 GHz, with single-thread boost reaching 3.9 GHz outside its normal frequency[10].

Figure 3 shows zen architecture of AMD Ryzen 5.

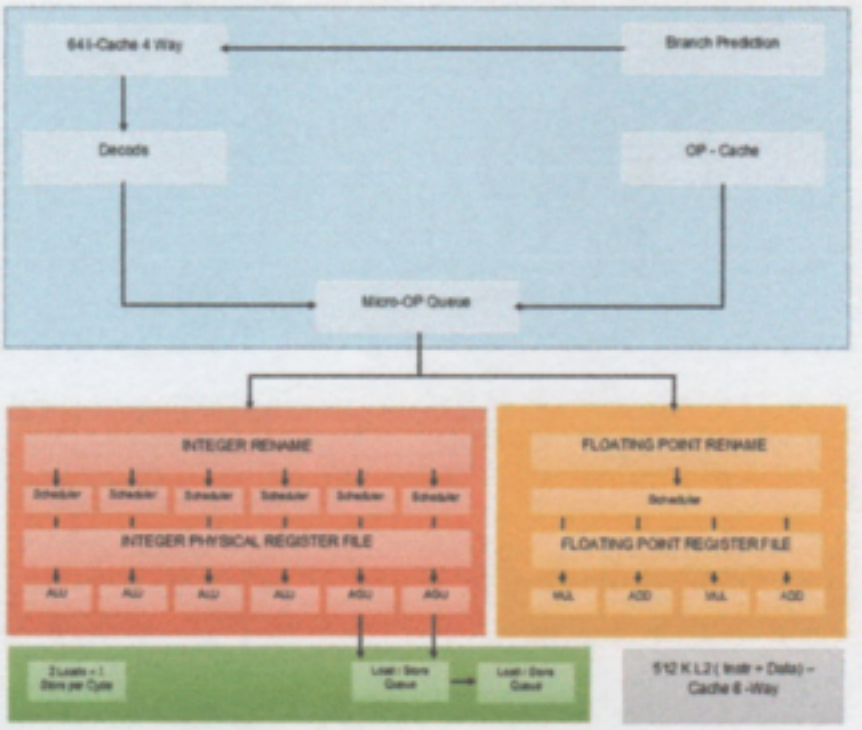

Fig 3. Zen Architecture

The specification of processor AMD Ryzen 5 1500 X list on Table 2.

Table 2. The specification of AMD Ryzen 5 1500X

System	*Detail of the Spesification*
Processor	AMD Ryzen 5 1500X
Core / Thread	4 Core / 8 Thread
Frequency	3,5 GHz up to 3,7 GHz
RAM	16 GB
L1 Cache Size	4x32 KB 4-Way set associative instruction caches 4x32 KB 8-way set associative data caches
L2 Cache Size	4x512 KB 8-way set associative unified caches
L3 Cache Size	2X8 MB 16-way set associative shared cache

C. Software Development

In this section describes a software design that we make.

This software is a matrix multiplication between matrix m and matrix n, which written in C and openMP using Ubuntu Linux as an operating system. In this research examines between parallel and serial program.

The structure of a parallel program in this research can be shown in Figure 4. In that structure, each of matrix matrix multiplication between matrix m and n loop as many as n times for integer workloads (ni) and it is for float workloads (nf). After both of workloads being looped, then it is looped again for 24 times.

In a serial program, the coding structure is the same as the parallel program. The coding structure of the serial program shows in Figure 5. The difference between serial and parallel program is the use of `#pragma omp parallel`.

```
Int main () {
    #pragma omp parallel num_threads(nthreads)
      #pragma omp for private (var)
        For(.......){
            For(........){
                Looped n integer workloads {
                        Multiplied matriks m x n
                }
            }
            For(.........){
                Looped n float workloads {
                        Multiplied matriks m x n
                }
            }
        }
}
```

Fig 2. The structure of parallel program

```
Int main () {
        For(.......){
            For(........){
                Looped n integer workloads {
                        Multiplied matriks m x n
                }
            }
            For(.........){
                Looped n float workloads {
                        Multiplied matriks m x n
                }
            }
        }
}
```

Fig 3. The Structure of Serial Program

IV. EXPERIMENTAL RESULTS

The research examines the performance of the Intel Haswell processor with Intel Performance Counter Monitor (Intel PCM) and AMD μprof.

A. Result for Speedup

To obtain the speedup of the processor, has some parameters to find it. These parameters are serial and parallel execution time.

Each of time execution from serial and parallel shows in Table 3 and Table 4. In Table 3, there are 2 variables ni and nf. These variables use for looping the matrix multiplication to see the workload of this program.

Table 3. Time Excecution of Program in Intel Haswell Core i7 4790

ni & nf	Time Exc. of Serial (Seconds)	Time Excecution of Parallel (Seconds)			
		Number of Thread			
		2	4	6	8
5	132,52	124,58	62,25	41,48	28,71
10	264,88	249,13	124,47	82,94	57,39
15	398,30	373,81	186,71	124,41	86,09
20	530,83	498,41	248,93	165,83	114,76
25	663,54	623,33	311,08	207,30	143,45

Table 4. Time Execution of Program in AMD Ryzen 5 1500X

ni & nf	Time Exc. of Serial (Seconds)	Time Excecution of Parallel (Seconds)			
		Number of Thread			
		2	4	6	8
5	124,613	59,775	32,912	28,111	25,249
10	257,026	121,008	63,315	56,009	50,351
15	389,233	184,248	94,345	83,951	76,033
20	528,19	247,494	125,598	112,159	101,367
25	658,241	311,206	157,478	140,225	126,441

Table 3 and Table 4 show that the number of threads used to solve a problem, the execution time required will be faster.

From Table 3 and Table 4, we can find the speedup of the processor. Speedup is the best time of the sequential program to the best time of parallel program for solving a problem[11]. The results of the speedup show in Table 5 and Table 6.

We can conclude from data in Table 5 that the speedup for 2 threads is 1.07 when the workload is repeated 15, 20 and 25 times. The best speedup for 4 threads is 2.15 when the workload is repeated 25 times. The best speedup value for 6 threads is 3.22 when the workload is repeated 25 times. The best speedup of the processor is 4.67 when using 8 threads.

Table 5. Speedup of the Processor Intel Core i7-4790 with Non-Uniform Workload

ni & nf	Number of Thread (times)			
	2	4	6	8
5	1,06	2,13	3,19	4,61
10	1,06	2,13	3,20	4,63
15	1,07	2,13	3,20	4,62
20	1,07	2,13	3,20	4,62
25	1,07	2,15	3,22	4,67

Figure 6 describes the comparison speedup among threads for more details.

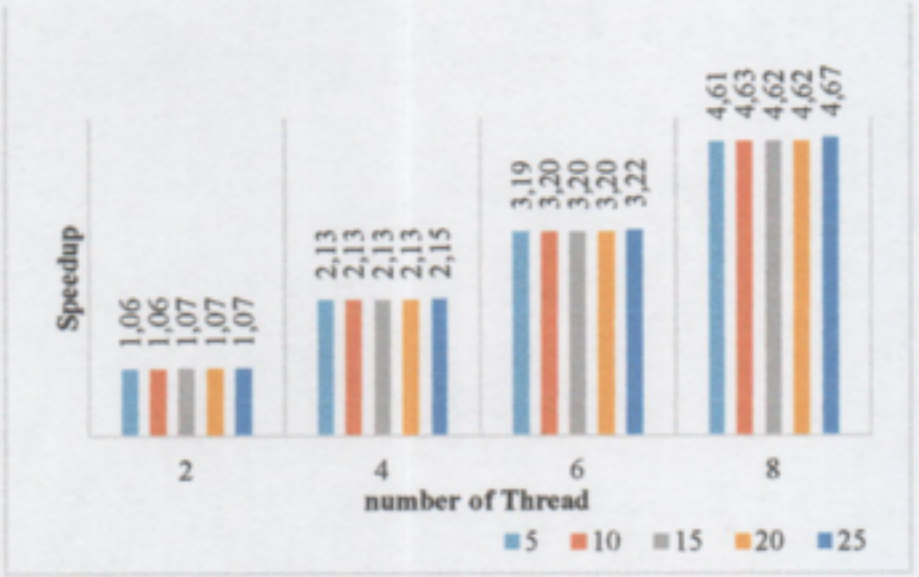

Fig 6. Throughput Speedup in Intel Core i7-4790

Table 6. Speedup of the Processor AMD Ryzen 5 1500X with Non-Uniform Workload

ni & nf	Number of Thread (times)			
	2	4	6	8
5	2,08	4,00	4,43	4,94
10	2,12	4,06	4,59	5,10
15	2,11	4,13	4,64	5,12
20	2,13	4,21	4,71	5,21
25	2,12	4,18	4,69	5,21

We can conclude from data in Table 6 that the speedup for 2 threads is 2.13 when the workload is repeated 20 times. The best speedup for 4 threads is 4.21 when the workload is repeated 20 times. The best speedup value for 6 threads is 4.71 when the workload is repeated 20 times. The best speedup of the processor is 5.21 when using 8 threads.

Figure 7 describes the comparison speedup among threads for more details.

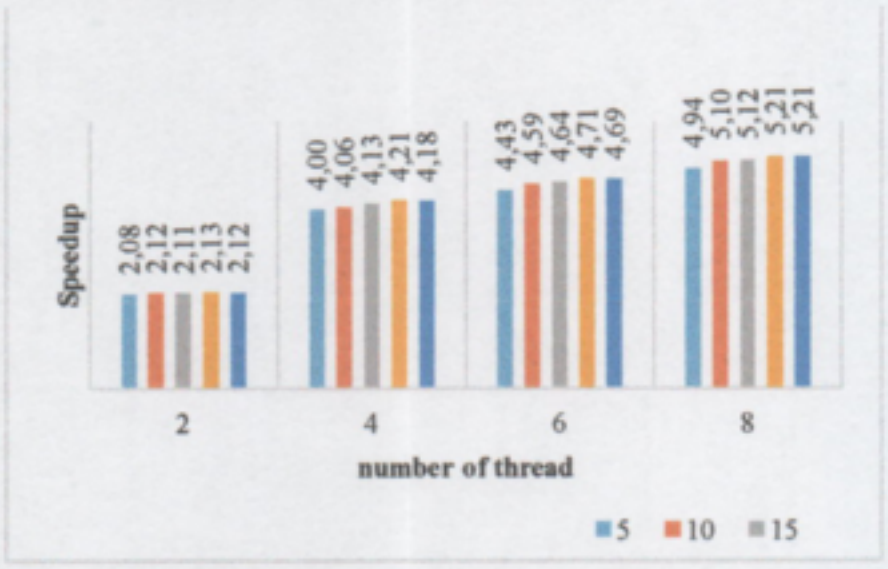

Fig 7. Throughput Speedup in AMD Ryzen 5 1500X

B. Result for Instruction per Cycle

In Intel PCM, there are several functions that can be used to see the performance of the processor. One of them is Instruction per Cycle (IPC).

Table 7 shows the IPC of Intel core i7 4790, then in Table 8 shows the IPC of AMD Ryzen 5 1500X.

Table 7. IPC of the Processor Intel Core i7-4790 with Non-Uniform Workload

ni & nf	Thread (instr. per cycle)			
	2	4	6	8
5	1,75	3,50	5,28	7,00
10	1,75	3,52	5,28	7,00
15	1,75	3,50	5,28	7,00
20	1,75	3,52	5,25	7,00
25	1,75	3,50	5,25	7,00

We can conclude from data in Table 7 that the IPC value for 2 threads is constant, 1.75. The best IPC value for 4 threads is 3.52 when the workload is repeated 10 and 20 times. The best IPC value for 6 threads is 3.22 when the workload is repeated 25 times. The best IPC of the processor is 7.00 when using 8 threads.

Figure 8 describes the comparison IPC among threads for more details..

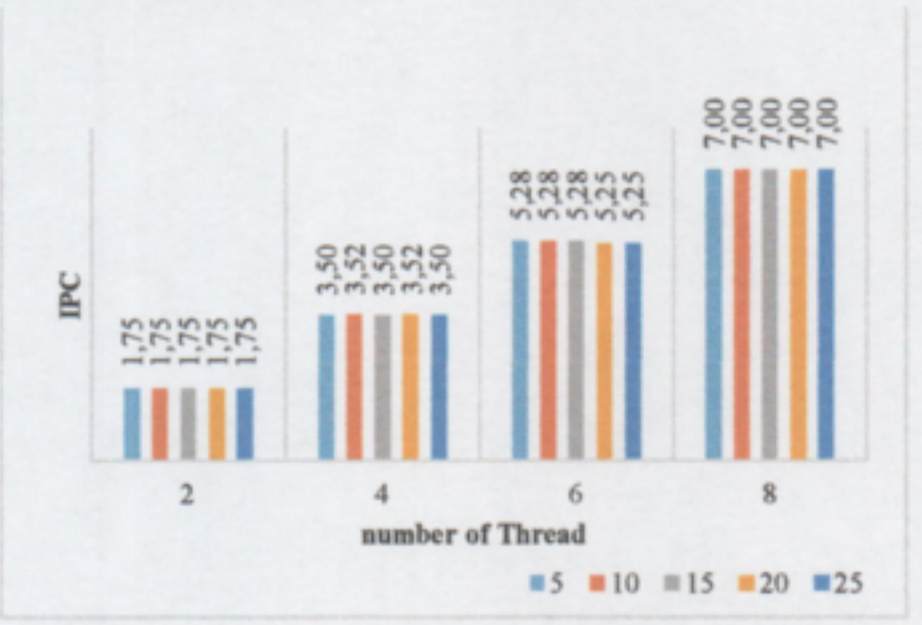

Fig 8. Throughput IPC in Intel Core i7 4790

Table 8. IPC of the Processor AMD Ryzen 5 1500X with Non-Uniform Workload

ni & nf	Thread (instr. per cycle)			
	2	4	6	8
5	3,13	5,90	6,60	7,20
10	3,13	5,90	6,60	7,20
15	3,13	5,90	6,60	7,20
20	3,13	5,90	6,60	7,20
25	3,13	5,90	6,60	7,20

We can conclude from data in Table 8 that the IPC value for 2 threads is 3.13. The best IPC value for 4 threads is 5.90. The best IPC value for 6 threads is 6.60. The best IPC of the processor is 7.20 when using 8 threads.

Figure 9 describes the comparison IPC among threads for more details..

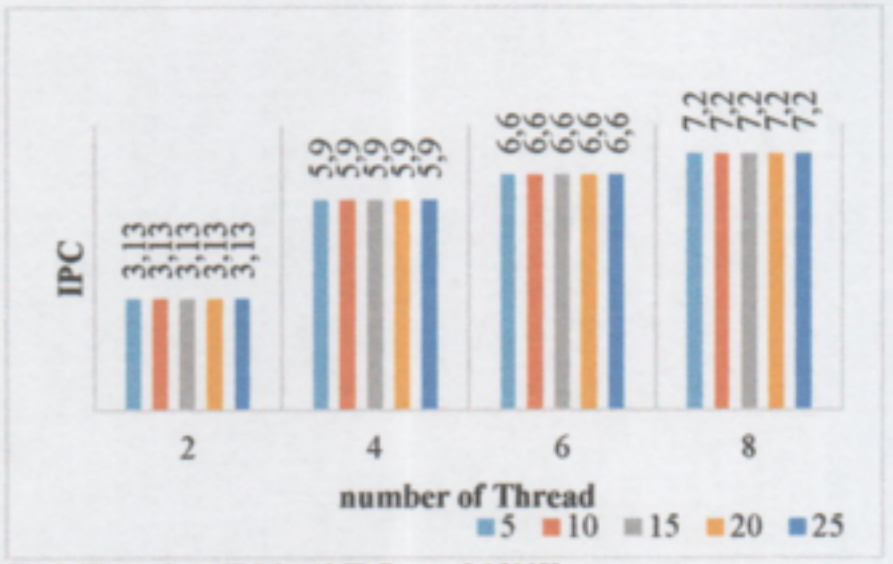

Fig 9. Throughput IPC in AMD Ryzen 5 1500X

C. Analytical Result

The result of this study will present it in a comparison graph. This comparison graph will show directly the comparison between the two processors.

Figure 10 and Figure 11 show clearly the performance comparison between Intel Core i7-4790 and AMD Ryzen 5 1500X.

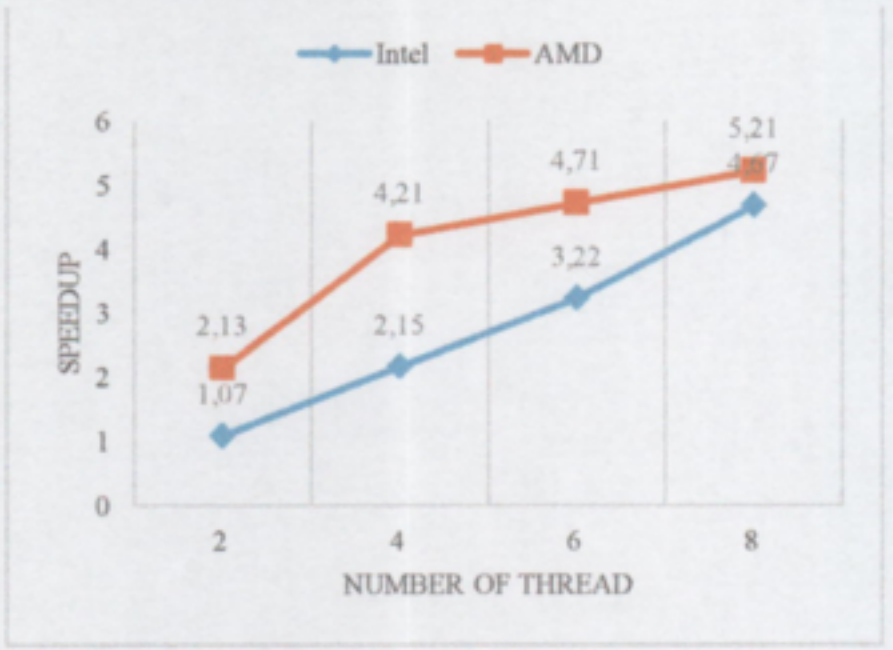

Fig 10. Speedup Comparison Between Intel Core i7 4790 and AMD Ryzen 5 1500X

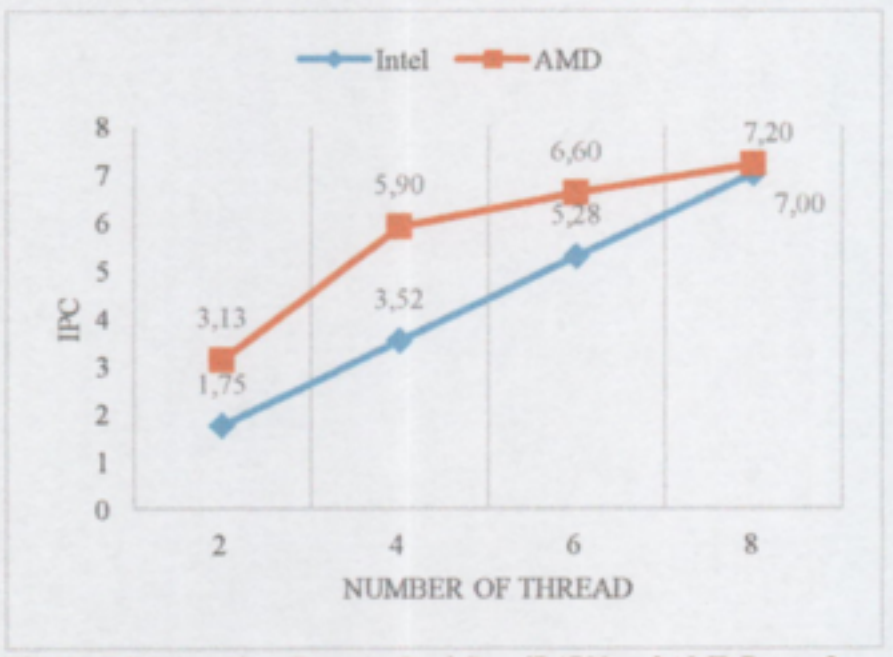

Fig 11. IPC Comparison Between Intel Core i7 4790 and AMD Ryzen 5 1500X

Figure 10 describes the performance of AMD processors, which immediately increased when running from 2 to 4 threads. From 4 to 6 threads and 6 to 8 threads , the performance improvement did not increase significantly, but only increased 0.5 times.

While the performance of the Intel processor, the improvement in processor performance is constant, from 2 to 4 threads, 4 to 6 threads, and 6 to 8 threads have increased 1 time.

Figure 11 describes the IPC of AMD Ryzen 5 1500X immediately increased from 2 to 4 threads. In Intel Core i7 4790, the IPC increase constantly.

V. CONCLUSION AND FUTURE WORK

In this study, we found that AMD processors, when executing an assignment from 2 to 4 threads, their performance increased up to 2 times. Then, the performance did not increase significantly from 4 to 8 threads. The best speedup is 5.21 times when the processor does the assignment with 8 threads.

In Intel processor, when executing an assignment, the processor performance is constant. It can be seen from 2, 4, 6 to 8 threads, the performance has increased 1 time. The best speedup is 4.67 times when the processor is working with 8 threads.

From the results of this study, giving a non-uniform load on a processor makes all units (both ALU and FPU) work. So that the processor works optimally.

As future work, the research wants to evaluate the performance of processors that have 8-cores or more (Intel Core i9 and AMD Ryzen 7).

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REFERENCES

[1] B. Chapman and L. Huang, "Enhancing OpenMP and Its Implementation for Programming Multicore Systems," *Publ. Ser. John von Neumann Inst. Comput. NIC Ser.*, vol. 38, 2002.

[2] Adnan, "Studi Pedahuluan Pengaruh Distribusi dan Tipe Beban Kerja Program Parallel pada Prosessor Multicore dan Teknologi Hyperthreading," *Semin. Penelit. Teknol. Terap.*, vol. 8, 2014.

[3] A. Snavely and D. M. Tullsen, "Symbiotic jobscheduling for a simultaneous multithreaded processor," *ACM SIGARCH Comput. Archit. News*, vol. 34, no. 5, p. 234, 2000.

[4] S. J. Eggers, J. S. Emer, H. M. Levy, J. L. Lo, R. L. Stamm, and D. M. Tullsen, "Simultaneous multithreading: A platform for next-generation processors," *IEEE Micro*, vol. 17, no. 5, pp. 12–19, 1997.

[5] Purwadi, K. Erwansyah, and M. Ikhsan, "Arsitektur Komputer tentang Mekanisme Kerja Prosesor dalam Menjalankan Intruksi dan Interupsi pada Sistem Kerja Komputer," *J. Ilm. Saintikom*, pp. 113–120, 2015.

[6] K. Mahfi and W. Djuriatno, "Penerapan Floating Point Unit Sebagai Co - processor yang Diimplementasikan dengan Menggunakan FPGA," pp. 1–6.

[7] P. Radojković *et al.*, "Thread assignment of multithreaded network applications in multicore/multithreaded processors," *IEEE Trans. Parallel Distrib. Syst.*, vol. 24, no. 12, pp. 2513–

2525, 2013.

[8] A. Peternier, D. Ansaloni, D. Bonetta, C. Pautasso, and W. Binder, "Improving execution unit occupancy on SMT-based processors through hardware-aware thread scheduling," *Futur. Gener. Comput. Syst.*, vol. 30, no. 1, pp. 229–241, 2013.

[9] R. Shrout, "The Haswell Review - Intel Core i7-4770K Performance and Architecture," 2013. [Online]. Available: https://www.pcper.com/reviews/Processors/Haswell-Review-Intel-Core-i7-4770K-Performance-and-Architecture. [Accessed: 11-Oct-2017].

[10] L. Hill, "AMD Ryzen 5 1500X (4C8T) CPU Review," 2013. [Online]. Available: https://www.kitguru.net/components/cpu/luke-hill/amd-ryzen-5-1500x-4c8t-cpu-review/. [Accessed: 11-Oct-2017].

[11] A. L. Wanasurya, S. Mulyanti, and M. A. Kartawidjaja, "KOMPUTASI PARALEL UNTUK PENGOLAHAN PRESTASI AKADEMIK MAHASISWA," *J. Teknol. Elektro, Univ. Mercu Buana*, vol. 8, no. 3, pp. 170–175, 2017.

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