First Zen Architecture Based Commercial Processor

Ruchit Naik, Shivani Patel

Electronics and Communication Department, Institute of Technology, Nirma University, Ahmedabad, India

***Abstract* - AMD has always promised that Zen is core suitable for high-performance server parts. AMD by far has launched Ryzen7 for high-end desktop and Ryzen5 for mainstream consumers. This paper is an overview of AMD Ryzen SKUs. The purpose of this research is to understand architecture used by AMD, Zen architecture. Zen was designed to enhance performance. Based on this architecture, AMD has launched Ryzen stack ranging from Ryzen3 1200 to Ryzen 7 1800X. Also, the study on how improvements are done by AMD on very new version launched is done and compared. The performance of Ryzen 7 1950X: latest Ryzen processor is analyzed. The major drawbacks leading to low demand of Ryzen in market are studied. Intel processors have given a huge competition to AMD Ryzen in terms of performance. The comparison of Ryzen with Intel Xeon shows where Ryzen is lacking in its specifications.This study will give a detailed explanation on AMD Ryzen: its architecture, performance and drawbacks.**

***Keywords:* AMD Ryzen, Threadripper, workstation**

I. INTRODUCTION

Ryzen is a brand name of central processing units and accelerated processing units which is marketed by a microprocessor manufacturing giant, AMD. This was introduced to the commercial market in 2017. This is the first commercial microprocessor implementing Zen microarchitecture. AMD Ryzen is conserved as boon for this era of technology. These chips are more efficient in both the aspects i.e. performance and cost. These are considered to be high performance multi core chips. This is the reason that it has very wide scope of application in various fields like high end gamming, Artificial intelligence, unmanned vehicles, etc. Ryzen results in such high multi core performance and parallel computing only because it uses the Zen microarchitecture. This is the reason Ryzen CPUs offer stronger multi-threaded performance and weaker single-threaded performance, comparable to the Intel's core i7 processor.

II. ARCHITECTURE – ZEN MICROARCHITECTURE

A. Design

Zen is an innovative design that differs completely from the traditional bulldozer architecture (available in IBM, Intel and Oracle processors). Zen based processor uses 14nm FinFET(Fin Field Effect Transistors) process. Thi0s technology allows it to be power efficient and helps it to execute significantly more instructions per cycle. Simultaneous Multithreading (SMT) was introduced in this architecture which allowed each core to run 2 threads. In addition to these changes the cache system has been redesigned.

Zen is based on System on Chip (SoC) design; this integrates all its peripherals onto the same chip. For an instance, SATA, PCIe, memory and USB controllers are integrated onto to the same chip as the cores. This design has advantage in the power efficiency and the bandwidth at the trade-off of chip complicity and the die area. Such design has led to the chance of much wider application of Zen based processors, for example, laptops and small form factor mini PCs.

The major difference between Ryzen CPU and the Zen APU is, the Ryzen relies upon the external GPU unlike that in Zen-which has on chip GPU.

B. Performance

Zen was designed with an aim to develop the performance per core. It is targeting to achieve 40% improvement in the Instructions per Cycle (IPC) than the previously designed traditional architectures.

AMD announced the latest microprocessor to have achieved 52% improvement as compared to the excavator (previous architecture). The major achievement is the inclusion of the SMT technology which allows 2 threads per core, hence increase the performance by 2X only by using the available resources.

Zen microprocessors employ sensors all over the chip to measure dynamically the frequency and voltage levels. This allows adjusting the performance of the chip depending upon the above mention parameter. This helps in the heat efficient performance of the chip.

Zen supports AVX2 instruction sets, but requires 2 clock cycles to complete the same.

C. Memory

Zen based processor supports DDR4 memory specifically upto 8 channels and Error Correction Code Memory (ECC Memory).

Earlier it was planned that the processor could support High Bandwidth Memory (HBM). However, later on it was not included on the first version of the CPU.

The Ryzen has multiple versions and all of them L2 cache memory as 512 KB per core.

III. COMMERCIAL VERSIONS

A. Ryzen 3 – 4 core CPUs (4 threads)

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B. Ryzen 5 - 4 core APUs (8 threads) 8 core APUs (16 threads)
6 core APUs (12 thread) 12 core APUs (24 threads)
C. Ryzen 7 - 8 core APUs (16 thread) 16 core APUs (32 threads)
D. Ryzen Threadripper –

Table 1 RYZEN VERSIONS

Target Segment	Cores (Threads)	Processor Branding & Model		Clock Rate(GHz)		Cache (MB)
				Base	*Boost*	
High-End	16 (32)	Ryzen Threadripper	1950X	3.4	4.0	32
	12 (24)		1920X	3.5		
			1920	3.2	3.8	
	8 (16)		1900X	3.8	4.0	16
Performance	8 (16)	Ryzen 7	1800X	3.6	4.0	16
			1700X	3.4	3.8	
			Pro 1700X	3.5	3.7	
			1700	3.0		
			Pro 1700			
Mainstream	6 (12)	Ryzen 5	1600X	3.6	4.0	16
			1600	3.2	3.6	
			Pro 1600			
	4 (8)		1500X	3.5	3.7	
			Pro 1500			
			1400	3.2	3.4	8
Entry-Level	4 (4)	Ryzen 3	1300X	3.5	3.7	8
			Pro 1300			
			1200	3.1	3.4	
			Pro 1200			

IV. PERFORMANCE ANALYSIS

A. Performance

This analysis shows the performance of AMD Ryzen TR 1950X – The high version of the AMD Ryzen series of processors. Threadripper can boost single threaded performance to 4.0 GHz with an extra 200MHz extended frequency range (XFR) allowance. This also has the flexibility to clock and modify all cores on this processor to 4.0 GHz. All Ryzen processors support auto-overclocking system. This helps it get twice than the usual boost (100MHz overclock vs. 50MHz overclock).

Additionally XFR values are doubled on Threadripper CPUs having 200MHz in X models rather than the usual 100MHz.Also, it provides further flexibility to tweaking. The clock speed can be taken to 4.1 GHz or 4.2 GHz, but this requires high voltage range like 1.4 volt. This on the contrary leads to heat and energy consumption. This tread-off should be kept in mind while designing the most efficient processor.It may not have a good experience of gaming on it as compared to its counter- part. Instead it can easily be improves by interfacing a GPU with faster clock to it externally.

B. Memory

It has Double Data Rate 4 (i.e. DDR4) with 3200Hz of memory access speed which is sufficient enough for any Task. The 1950X has 4 memory channels, this might be little slower as the bandwidth increases in high end tasks. This, however, does not affect much upon the expected tasks which it is capable of performing.

C. Power

The 14 nm FinFET architecture acquires Thermal Design Power (TDP) of around 180 Watts (this is highest in its kind). A PC mounted with Ryzen TR 1950X at idle will acquire 95 Watts of power with its dedicated GPU. If we work on it with some other GPU then it will increase the power consumption significantly, but this will be least as compared to any of its 16 core counter- part in the same scenario.

D. Heat handling capacity

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Ryzen is considered to be one of the most optimum processor in the terms of the TDP. The Zen architecture gives it an upper hand to give less heating effect even at higher performance. AMD has also use a good and efficient cooling technique which further lowers down the TDP. AMD along with Ryzen has introduced a line of stock coolers, the "Wraith Spire", "Wraith Stealth" and "Wraith Max". Amongst these, Stealth is the low end cooling unit used along with lower-end CPUs; it is rated for 65 W of TDP. On the other hand, the Spire is the mainstream cooler with TDP measure of 95 Watt and modest headroom of overclocking, along with the RGB lighting on some of its commercial models. The Wraith Max is a large technological breakthrough; it can handle more intensive overclocking as compared to Spire in higher-end CPUs. This gives AMD Ryzen an upper edge over its other counterparts. This is one of the most important reason, Ryzen can be proves as gamming friendly CPU. Along with the high speed of processing and optimized graphics, it can keep the TDP up to 95W.

E. Compatibility

AMD verifies that Ryzen series has ability to boot windows 7 and windows 10, Microsoft officially supports Ryzen only on windows 10. This restriction can be bypassed by installing an unofficial patch on the unsupported operating system. Also Ryzen is fully compatible on Linux. It suggests that optimum performance can be enabled on kernel version 4.10 and above.

F. Negatives

- The idle power consumption is poorer as compared to its running mode consumption. The 16 core processor has two 8 core processors. When it is kept in idle mode, it means two of the 8 core processors are in idle mode. Each processor has around 45 watts of power consumption at an average. So, this make overall idle power consumption around 90 watts which is significantly high.
- Tweaking of the clocks remains poorer here. We can achieve 4.0 GHz of tweak as discussed earlier. On the contrast, high end Intel processors can tweak their clocks up to 4.5 to 5.0 GHz
- The processor faces system locks when any particular application executes a certain sequence of FMA3 instructions. This issue is expected to be solved in the newer versions

Table 2 COMPARISION

Sr. No.	Specifications	Processors	
		AMD Ryzen TR 1950X	***Intel Xeon Platinum 8180M***
		 Figure 1 AMD Ryzen	 Figure 2 Intel Xeon
1	Total clock speed	16 x 3.4 GHz	28 x 2.5 GHz
2	RAM Speed	2667MHz	2670MHz
3	CPU Threads	32	56
4	Integrated Graphics	No	No
5	Thermal Design Power	180W	205W
6	Supports 64-bit	Yes	Yes
7	Turbo clock speed	4GHz	3.8Ghz
8	Unlocked multiplier(Overclocking)	Yes	No
9	Uses hyper threadingtechnology	No	Yes
10	Dynamic frequency scaling	No	Yes
11	Memory channels	4	6
12	L2 cache	8Mb	28Mb
13	L3 cache	32Mb	38.5Mb

V. CONCLUSION

AMD Ryzen is the first processor designed based on the Zen architecture. It is the series of processors designed by AMD to compete its rival Intel and also so to develop its existing series of processors which were based on the bulldozer architecture. AMD Ryzen has successfully taken an edge over its counter-part of Intel. The processors come with the number of cores ranging from 4 to 16 which was one of its

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kinds in the market. It has successfully adopted the technology of multithreading. This allows 2 processes at a time per core. This design helped it achieve the clock speed of 4.0 GHz and over. AMD used Zen architecture targeting 40% improvement in performance. The latest version of Ryzen helped it achieve 52% of improvement. This improvement is the result of it compatibility with overclocking. Ryzen having all these features and such high end processing capability was expected to get negative points in the subject of power consumption and heat handling capacity. It architectural design and new cooling design helped it achieve TDP of 180W in its higher-end processors, which is less than expected for such high performance processors. These properties put Ryzen in healthy competition with the latest processor developed by Intel – Intel Xeon.Ryzen shows sufficient compatibility with other operating systems for better performance. It does not have on chip GPU, this allows user to interface the GPU depending upon the personal requirement and the processor's compatibility. This gives excellent gaming experience for graphically heavy games.

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