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# AMD's comeback in the CPU market share with the launch of Ryzen

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**Abstract**
Advanced Micro Devices or AMD has been officially crowned as king of the CPU market with the Launch of Ryzen by beating their cutthroat competitors INTEL which was considered to be the giants of the CPU market until the comeback of AMD in 2018s. A brief description at the start of the research reflects the failures in the working of bulldozer CPUs which was released by AMD in the 2010s which strengthens INTEL's monopoly in the Technology market for the upcoming decade. This paper highlights the changes made by CEO Lisa Su along with Sir Jim Keller head of architecture in the working of the company and the introduction of ZEN CPUs which changed the whole perspective of performance in low budgets devices. Furthermore, the research emphasis the blunders made by Intel on having no further advancements in their expensive CPUs which was a setback for their customers. It further highlights the working of basic CPUs and then comparing the performance per dollar of the latest CPUs released by AMD with their Intel counterparts. This research lastly tries to cover the future scope of innovations in the field that will change the computing experiences or probably the working of the computers for the upcoming generations.

**Keywords:** Central processing units, virtual version of CPU core, multithreads and cores, graphics processing unit, market distribution

## Introduction
The proper functionality of computer devices is based on the coordination of the components like Hardware, Software, Liveware. Liveware is generally considered to be a slang word for persons operating or working on computer devices or they can be collectively called human beings working on these electronic devices. Software on the other hand is a collection of instructions programmed in the memory for the device to work in a certain manner as the operator needs or can be installed in the device for the respective use these includes operating systems, browsers, file editors etc. Hardware is basically the physical component in which the functions/instructions when called upon are carried out to get the required result. All the components are connected either externally for e.g., webcam, headphones, etc. or internally which cover components like the hard-disk, mother board, battery, etc. The software and hardware are linked together via Operating system which is itself a software and many stages of communications within many processes which functions parallelly in order to get a user output. In [1], authors explain various aspects of co-design. We highlight the commonalities and factor out the differences in numerous co-layout troubles in some application areas. Co-layout troubles and their dating to classical system implementation duties are discussed to help develop a attitude on modern digital machine design that is predicated on pc-aided layout (CAD) tools and techniques. A brief description or a rough sketch of the combined working of these softwares is depicted in fig 1.
Hardware includes the most important physical component of the computer CPU or the central processing unit in which almost all the commands/instructions are executed within a time or 'clock speed' and having a certain order of accuracy in results depending on its architecture. Most modern CPUs are microprocessors, meaning they are contained on a single integrated circuit (IC) chip. No such works can be made without the mentioning the early works of IBM or International business machines corporation in the computing sector which dated back in 19$^{th}$ century which still is one of leading computer manufacturing company in the world with having plants or operations over 150+ plus countries.
Advanced micro devices or popularly known as AMD is one of the leading computer hardware manufacturer companies in the world. In recent trends the technical community has turned over to AMD as being their first choice for CPUs not only because of their

affordability but also due to there high performance as compared to their INTEL counterparts who were considered to be the giants in the field for almost 2 decades until the AMD takeover from 2017 by the release of AMD Ryzen processors having much more to offer then their counterparts. The processors had major innovative changes like higher number of core counts, ECC ram support in short error correction. AMD was established in 1969 by Walter Jeremiah (Jerry) Sanders, a previous chief at Fairchild Semiconductor Corporation, and seven others. The organization delivered its first item in 1970 and opened up to the world two years after the fact. During the 1970s the organization started delivering microchips. Beginning as a second-source maker of microchips, the organization set an incredible accentuation on quality and developed consistently. In 1982 the organization started providing second-source chips for the Intel Corporation, which made the microchip utilized in IBM (PCs). The concurrence with Intel finished in 1986. In 1991 AMD delivered the Am386 microchip family, a picked apart chip that was viable with Intel's cutting edge 32-digit 386 microchip. There resulted a long fight in court that was at last chosen in a 1994 U.S. High Court administering in AMDs favor. That very year, Compaq Computer Corporation contracted with AMD to deliver Intel-viable chips for their PCs. In 1996 AMD obtained a microchip organization known as NexGen and started stretching out from the Intel-viable chip market. In 2000 AMD presented the Athlon processor, which was intended to run the Microsoft Corporations Windows working framework. With the arrival of the Athlon processor, AMD turned into the primary organization to deliver a 1-GHz (gigahertz) microchip, which checked AMD as a genuine rival in the chip market.

In [2], author explains Technology and Performance Leadership for x86 Microprocessors launched by AMD in the same. In 2003 the organization delivered the Opteron chip, one more item that displayed the company's capacity to create top of the line chips. In 2006 AMD retained ATI Technologies, a producer of video illustrations cards for use in PCs. In 2008 AMD declared designs to part the organization in two with one section planning chip and the other assembling them. This declaration followed news that the Advanced Technology Investment Company and the Mubadala Development Company, both situated in Abu Dhabi, would obtain a controlling revenue in AMD, forthcoming endorsement by investors and the U.S. what's more, German states. In 2009, following a progression of protests stopped by AMD, the European Commission fined rival Intel a record 1.06 billion (948 million; $1.45 billion) for taking part in anticompetitive practices that disregarded the European Union's antitrust laws. These practices purportedly involved monetarily redressing and giving refunds to makers and retailers who inclined toward its microchips over those of AMD, just as paying makers to drop or delay the starting of items using AMDs chips. In 2014 the organization was rebuilt into two sections: registering and designs, which made processors for PCs, and endeavor, inserted, and semi-custom, which made more-specific processors. On the other hand, their counterparts Intel Corporation is an American multinational employer and technology corporation headquartered in Santa Clara, California. It is the sector's biggest semiconductor chip producer through revenue and is the developer of the x86 collection of microprocessors, the processors discovered in maximum private computers (PCs). Incorporated in Delaware, Intel ranked No. Forty five inside the 2020 Fortune 500 listing of the biggest United States businesses by way of overall sales for almost a decade, from 2007 to 2016 economic years. In [3], the author gives a brief description about the innovations made by INTEL as whole in the microprocessors which changed the computing experiences and left an impact in the CPU market which made them the tech-giants and monopolize the market for nearly two decades.

Having a world-wide market of the CPU creates opportunities and wide varieties for users to have affordable yet efficient devices to work on and spreads curiosity among tech-enthusiasts regarding the upcoming innovations in the field. In [4] author describes the innovations made by INTEL in the microprocessors changing the technical field experiences.

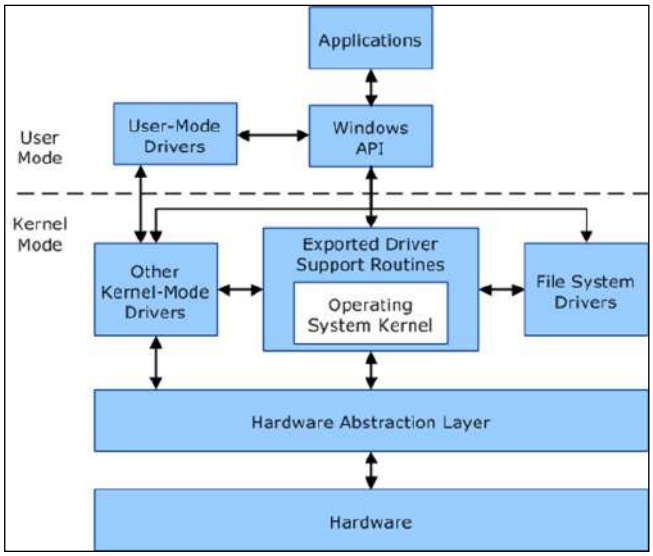


**Fig 1:** Structure of OS

## Background

### CPUs

Central processing unit or CPU consists of components like Registers, Counters, Arithmetic logic Unit, cache memory, etc. In [5], authors have detailed description on how these different components of CPU works. Alternatively called a processor, crucial processor, or microprocessor, the CPU (stated sea-pea-you) is the vital processing unit of the computer. A pc's CPU handles all instructions it receives from hardware and software program strolling on the laptop. As an instance, the CPU processed the commands to apply a web browser to open and display this web page to your computer or it can task the OS to perform certain task by giving certain instructions via CMD or the command prompt. CPU is the brain of computers which is tasked along with RAM to process, access and provide output to the command given by the user. But the same process takes time to reduce the time taken a separate memory slot called 'Cache memory' which can range up to 8MB within the core. It gathers information based on the processes it performed over the years of functioning and stores only important information within the 'CACHE'. In [6], the author gives emphasis on the reduction of memory traffic while gathering information for the processes that needs to be performed on the basis of collected data. There are five basic processes for the CPU:

- **Fetch:** Instructions are fetched from the main memory.
- **Decode:** Instructions are decoded in a certain manner to be implemented.
- **Execute:** The stage where the actual computation takes place consisting of ALUs, BITs shifter.
- **Memory:** Data memory if required at a certain state to store data.
- **Writeback:** The outputs are stored in the respective registers to be transferred in the main memory.

A core or CPU center, is the "cerebrum" of a CPU. It gets guidelines, and performs estimations, or activities, to fulfill those directions. A CPU can have different centers. A processor with two centers is known as a double center processor; with four centers, a quad-center; six centers, hexa-center; eight centers, octa-center. Starting at 2019, most of buyer CPUs include somewhere in the range of two and twelve centers. Workstation and server CPUs might include upwards of 48. Each center of a CPU can perform tasks independently from the others. Or then again, numerous centers might cooperate to perform equal procedure on a common arrangement of information in the CPU's memory store. Classical computers take one clock for each process to complete hence CPI or clock cycles per instructions for such devices are '5' hence the concept of pipelining was given preference in which each process is completed in a single clock or the processes are done simultaneously hence reducing the CPI by 1 hence making the core more efficient relative to the earlier computers. In [7], the author shows that cycles per instruction (CPI) is a simple dot product of event frequencies and event penalties, and that it is far more intuitive than its more popular cousin, instructions per cycle (IPC). Now depending on the processor speed and the number of cores present for instance suppose a quad core device in a second can have billions of such cycles based on the GHz of the respective processor. With a solitary execution-unit processor, the best CPI achievable is 1. Be that as it may, with a various execution-unit processor, one might accomplish far and away superior CPI esteems (CPI < 1). For this situation, the processor is supposed to be superscalar. To improve CPI esteems without pipelining, the quantity of execution units should be more noteworthy than the quantity of stages. For instance, with six executions units, six new guidelines are brought in stage 1 solely after the six past directions finish at stage 5, hence by and large, the quantity of clock cycles it takes to execute guidance is 5/6 (CPI = 5/6 < 1). To improve CPI esteems with pipelining, there should be something like two execution units. For instance, with two executions units, two new directions are brought each clock cycle by taking advantage of guidance level parallelism, in this manner two distinct guidelines would finish stage 5 in each clock cycle, and on normal the quantity of clock cycles it takes to execute a guidance is 1/2 (CPI = 1/2 < 1). Further many such concepts like multithreading, Hardware level parallelism, Software level parallelism to increase the efficiency of the computer processors.

**Multithreading**

Threading refers to the virtual component or is simply a program that runs the process over multiple cores in order to complete the process faster. The instructions can be broken down into segments and threaded to the core for the functions. Paper [8] has described briefly regarding the threads in operating system. The authors in Paper [9] describe free floods of guidelines, entwined on a solitary processor, fill it's generally inactive cycles thus help its exhibition. They detail how such multithreaded designs take the tack of concealing idleness by supporting different simultaneous floods of execution. At the point when a long-inactivity activity happens in one of the strings, another starts execution. Along these lines, helpful work is performed while the tedious activity is finished hence providing in-depth knowledge about the same. Fig [2] describes the threading in a multicore processor.

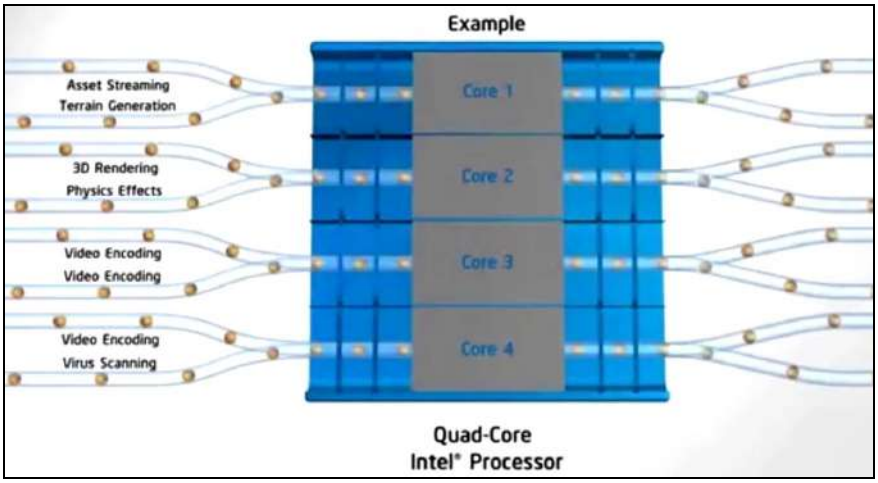


**Fig 2:** Intel Processor

Hence multithreading is the ability of the central processing unit to provide multiple threads or paths for execution of the commands concurrently as per the support system of the operating systems. In 2011 AMD launched its Bulldozer chips or popularly called as Fx series of CPUs having higher number of core counts, highest clock counts were considered that the efficiency of the CPUs might change dramatically but the reverse happened the launch of the Fx series was disaster pushing AMD towards bankruptcy. The reason behind the failure of the CPUs were quite controversial. As the Fx series promised to have a greater number of cores as they stated but in architecture the Cache of different cores had shared Floating point unit, instruction-cache and L2 cache were shared between two cores which

made the processors slow also as each core didn't have their own set of resources but had to use shared resources this called as CMT or clustered multithreading hence, each pair cores were acting as module instead of functioning as separate cores fig (3) explaining the above concept diagrammatically.

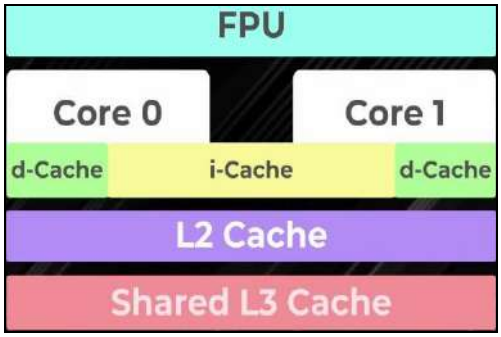


**Fig 3:** Pair in Clustered multithreading

**Launch of Zen CPUs**

Such a controversial build up made things worse for AMD and had to payout $12.1 million for falsely advertising about the working of the Bulldozer chips which lead to their downfall to a state where they couldn't manufacture any processors for competing with the tech giants INTEL for several years. On the other INTEL 's sandy bridge series of processors were victorious over the FX series and already started to monopolize the market over the next 3-4 years until the release of the Ryzen series by AMD which changed the Computing experience. In late 2014s Mr. Rory Read stepped down as the CEO of AMD and was replaced by none other than Dr Lisa Su who had a long experience of working in semiconductor field, she along with Jim Keller leaded the team who were going to design the newly announced Zen CPUs.

The main Goal behind these Zen Microarchitecture was:

- Affordable CPUs
- Easy scalability i.e., one device can be scaled to 4 cores or 16 cores
- Space for innovation in the structure
- Working on Architectural failures

AMD's Ryzen base models characteristic eight cores and 16-thread processing at 3.4Ghz with 20MB cache, neural net-primarily based prediction hardware, and clever prefetch. Codenamed Zen in improvement, Ryzen is the first predominant architectural alternate for AMD because Bulldozer. The AMD processor runs on new 1331 pin AM4 socket motherboards shared by using FX fashions in high-give up systems in addition to APU models. AM4 motherboards support DDR4 RAM, PCIe Gen3. Ryzen can feature as a device on a chip for low-fee, bare-bones setups. AM4 gives other chipset-enabled capabilities, such as extra PCIe slots, superior sound, SATA express, and USB three.1 gen2 10Gbs connectivity. The shared socket additionally makes it simpler to upgrade from base APU systems to discrete portraits cards at the side of FX CPUs for upgrades in addition to those looking to start access-stage. Also, of hobby are claims of system getting to know to are expecting commands, making the CPU able to studying the way to run applications quicker. In release demonstrations, un-boosted at 3.4 Ghz, AMD Ryzen did slightly higher than Intel's 6900K three.2-3.7Ghz with faster enabled. Those stats identical performance with an $1100 Intel component. One historical drawback to AMD's competitiveness has been Intel's manufacturing method lead. Using a smaller process has often given Intel's processors the potential to run at better speeds. The launch of Ryzen represents the first time the two could be the usage of the identical system: 14 nm FinFET. Up until April 2021, Intel's processors remained stuck on a 14 nanometre (nm) node. It had originally hoped to move to 10nm in 2016, but that was delayed. In the meantime, AMD overtook Intel in this area. While Intel has only just moved away from 10nm, some of AMD's computer processing units (CPUs) are already on 7nm. Meanwhile, Apple is capable of producing 5nm through the Taiwan Semiconductor Manufacturing Company (TSMC).

In [10], the author explains about Ryzen processor power efficiency the usage of SPECjbb2015 because the workload. We examine it in evaluation to Phenom II, a CPU of the preceding era from the identical producer AMD. In terms of maximum transaction throughput, Ryzen plays 218% of Phenom. With the reaction time constraint, the relative overall performance of Ryzen is 288%. In the strength efficiency, Ryzen achieves 309% (at most throughput) and 389% (with reaction time constraints) of Phenom. Dynamic frequency scaling (DFS) is effective for reducing the energy consumption of both processors, but the load degrees at which DFS is most effective are pretty one of a kind. Intel battled to move from a 14-nanometer chip to a more modest, all the more impressive 10-nanometer chip. During that troublesome change, Intel's stockpile of 14 nm chips utilized in PCs neglected to satisfy need last year an issue that constrained it to deliver a surprising open acknowledgment in November. In the interim, AMD acquired a processor comparable capacity to the 10 nm chip to advertise in front of Intel and fostered an item design that permits it to minimize expenses. Intel's difficulties have cleared the runway for AMD to get a bigger cut of a portion of the overall industry in key regions. "(Intel's) absence of execution and AMD's impeccable execution still can't seem to work out as far as the portion of the overall industry AMD will acquire before very long". Mosesmann said. "That wouldn't shock me the slightest bit in the event that they caught a large portion of the server farm market". The server farm market has turned into a need for AMD, as a developing number of organizations hope to move their tasks to the cloud and as information serious cutting-edge advances, as 5G, start to arise. An industry could introduce a $20 billion to $30 billion freedom for semiconductor organizations throughout the following, not many years, as indicated by Mosesmann.

**Market change**

From the threshold of bankruptcy to a 1,300% stock advantage with the launch of Zen CPUs AMD started to make their position in the CPU market. AMD has made profits over Intel in server and cellular shipments and slipped slightly when it comes to consumer computing device shipments, in keeping with new statistics from Mercury Research measuring relative market percentage adjustments among the 2 agencies. AMD has been chipping away at Intel's marketplace share since the debut of Ryzen 4 years in the past, and that chipping has paid dividends, however the effect of the semiconductor shortage and COVID-19 pandemic has blunted AMD's capacity to take proportion in each marketplace. When Intel or AMD is

production restrained, they recognition on delivery the maximum valuable elements they are able to construct. This typically means each companies prioritize server and cell advertising and marketing proportion over computing device. The desktop market is bifurcated between decrease-quit normally cheaper systems and high-cease computer and notebook hardware used by content material creators and gamers. Intel still dominates the x86 market, server CPU market shares as AMD still have much more to cover up after their downfall in 2012. Intel's non-innovative attitude made AMD's comeback in the CPU market easy.

Fig (4) gives an idea about the desktop market distribution of the two giants in the latest year 2021.

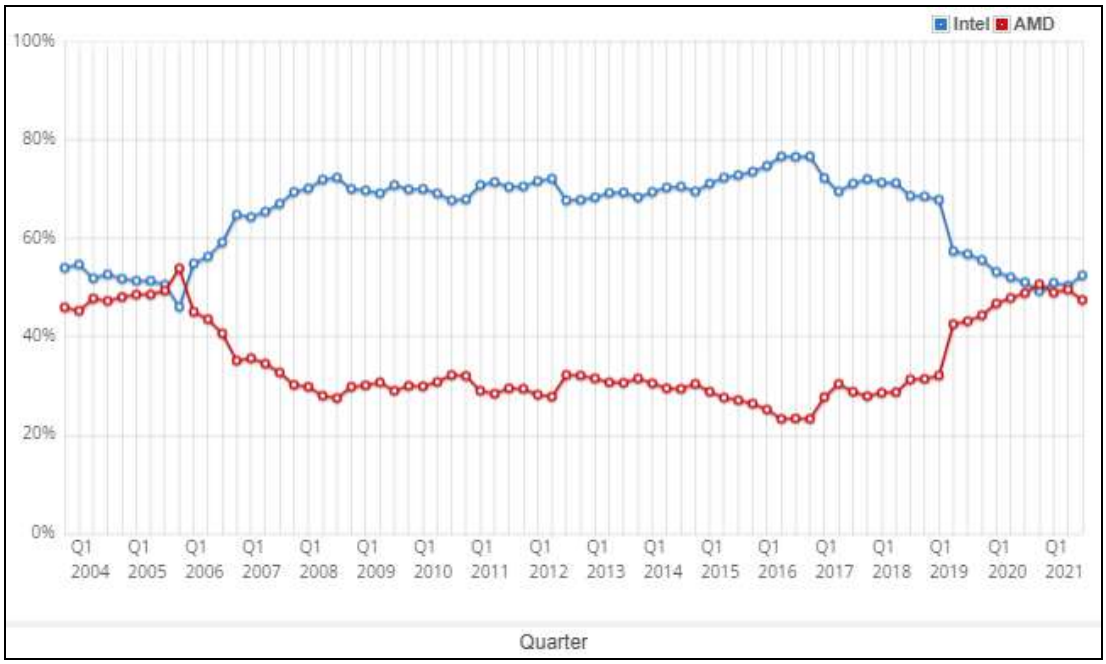


**Fig 4:** The desktop market distribution

Fig (5) depicts the laptop market distribution of the two.

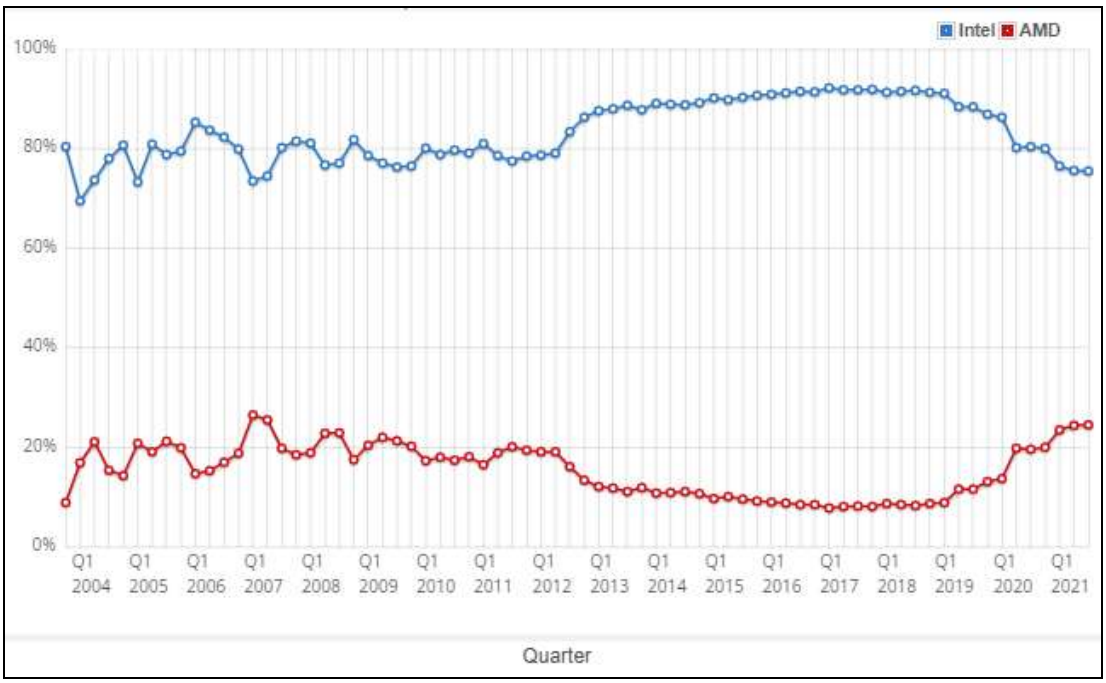


**Fig 5:** Laptop market distribution

Fig (6) shows the Server CPU market distribution of the year 2021.

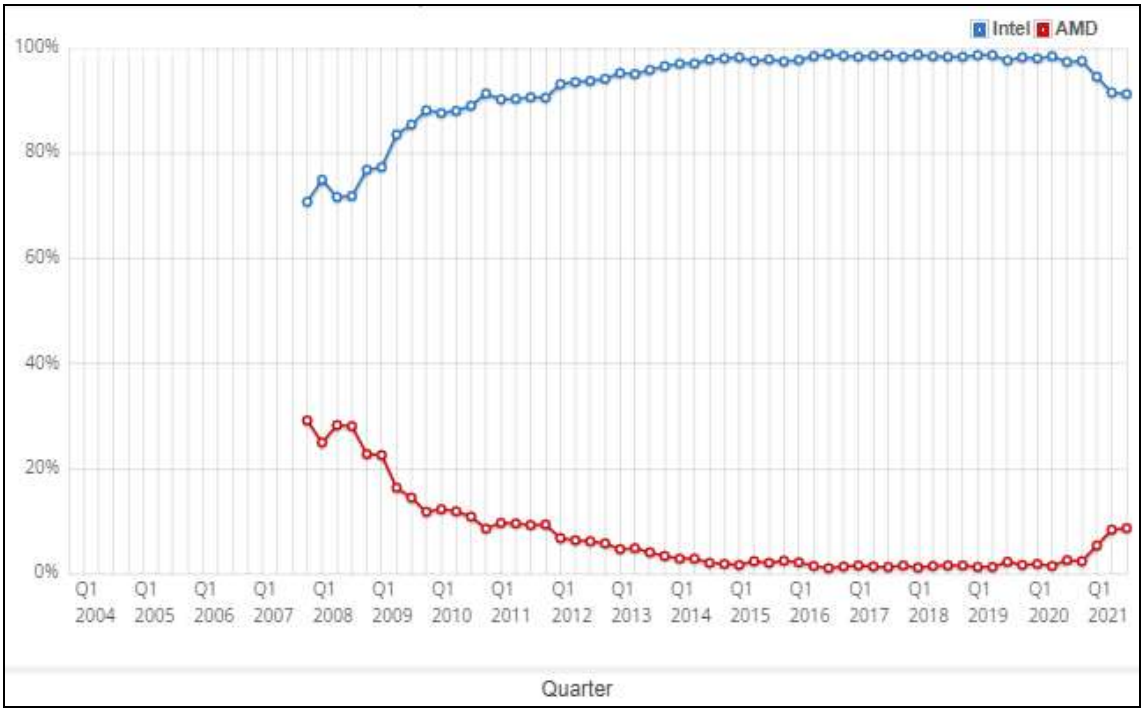


**Fig 6:** Server CPU market distribution

Things were quiet within the x86 CPU market thus far this yr. Intel's Rocket Lake release did not make a huge splash in the fanatic network, although a number of the decrease-stop Core i5 and i7 CPUs had been desirable offers against Ryzen in every metric beyond electricity performance. The reality that Rocket Lake continues to be built on 14nm places it at a drawback against AMD in such comparisons. The rest of the 12 months have to be extra interesting. AMD is promising to launch Zen three CPUs prepared with an additional sixty-four-128MB of V-Cache with an expected common overall performance uplift of 15 percent. Intel's Alder Lake will be the primary hybrid x86 CPU with a combination of huge and little cores. The exact diploma of overall performance uplift is unsure predictions have ranged from higher than the Ryzen nine 5950X to much less competitive with AMD's cellular chips. In [11], the author explains the never-ending competition in the Microprocessor market due to the possible innovations or ideas that can be put forward that may lead to an impact in the computational experiences.

**Aim/Objective**

Aim of the Research was to spotlight the innovative work put forward by AMD in developing efficient CPUs in comparison to their INTEL counterparts which had large scale impacts in the technical community which aided them to take over the CPU market.

**Future innovation**

Technology is changing the world providing better opportunities human to explore, evolve and adapt the changes around in order to lead a good life. But technology doesn't change itself it's the innovative mind of Humans themselves. When processing power meets brain power that's where the future comes alive. Talks about its future aspiration as an organization. Talking about the innovations in Computer Science field there is a wide field of topics like Data analytics, Blockchain, there has been talks regarding silicon-based transistors which can slip in small devices because of there much small sizes, use of game engines to have simulators for doctors, etc. With the launch of Zen series of AMD gaming experiences have been. But with so much competition on the CPU market INTEL is about to make a big move by launching a new generation of its processors. Alder Lake is Intel's codename for the twelfth generation of Intel Core processors based totally on a hybrid structure utilizing Golden Cove excessive-overall performance cores and Gracemont strength-green cores. It is fabricated the use of Intel's Intel 7 method, previously known as Intel 10 nm Enhanced SuperFin (10ESF). Intel officially introduced twelfth Gen Intel Core CPUs on October 27, 2021. Intel claims Alder Lake could have its excellent performance in keeping with watt. Hence, innovations/new ideas are generated due to the competitions thus favoring the users in the coming time.

Further, new innovation with emerging technologies (post COVID 19) can be found in [12-17]. These articles will help future researchers to find their research problem for continuing their research work.

**Conclusion**

The research paper has been very helpful for understanding several fundamental aspects that define the working of a computer works, it has explained the working of certain important concepts like Multithreading. The paper focused on to explain the working of the Ryzen CPUs and compared the same with their INTEL counterparts in terms of market share. Lastly, further look at into the sector is also advocated as this appears important to preserve in pace with the quick improvement technique of the computer technology area.

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