# Analysis and Comparison of Different Microprocessors used in Computer Architecture

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## ABSTRACT
In the current world, it's almost impossible to imagine that someone can live without computers. Computers have become an electronic device of almost every day use for individuals of every age. we cannot imagine of advancements without computers. Hence it becomes very important to understand the principal running entity of the computer architecture. The microprocessor is the brain of a computer. it is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. Hence, it is significant to analyze various processors and then compare them. So that we can know about pros and cons of different processors. We have to select the best microprocessor and for that , it is really important to analyze & make a comparison among them. Parameters like speed, number of cores, power, graphics, memore types , cache etc can be used to make comparison. Hence this paper aims at thorough analysis and comparison of different microprocessors.

## 1. INTRODUCTION
Microprocessor is an important part of the computer. Without it the computer is totally useless. It is a chip that has all the functions of the CPU of a computer. The micro processor has the following functions of data storage, interaction with other peripheral devices and other time related functions. The Micro processor is the CPU (central processing unit) itself which has undergone marvelous changes since its invention. Its role is to send and receive data and make the computer function well. Commands need to be given for this chip to function that is already fed inside the device in the form of current variations. On the whole we can say that a microprocessor is a CPU integrated into a small silicon chip that comprise of thousands of small components such as- diodes, transistors and resistors that work together.Top companies that are producing microprocessors are Intel, AMD, Via Technologies, Motorola, DEC, Transmeta, MIPS & Texas Instruments. Among all this names, Intel has captured bigger market followed by AMD.

## 2. TYPES OF MICROPROCESSOR
### 2.1 Complex Instruction Set Microprocessors
They are also called as CISM in short and they categorize a micro processor in which orders can be executed together along with other low level activities. It mainly performs the task of uploading, downloading and recalling data into and from the memory card. Apart from that it also does complex mathematical calculations within a single command.

### 2.2 Reduced Instruction Set Microprocessor
This processor is also called as RISC. These kinds of chips are made according to the function in which the microprocessor can carry out small things within a particular command. In this way it completes more commands at a faster rate.

### 2.3 Superscalar Processors
This is a processor that copies the hardware on the microprocessor for performing numerous tasks at a time. They can be used for arithmetic and as multipliers. They have several operational units and thus carry out more than a one command by constantly transmitting various instructions to the superfluous operational units inside the processor.

### 2.4 The Application Specific Integrated Circuit
This processor is also known as ASIC. They are used for specific purposes that comprises of automotive emissions control or personal digital assistants computer. This kind of processor is made with proper specification but apart from that it can also be made using the off the shelf gears.

### 2.5 Digital Signal Multiprocessors
Also called as DSP's, these are used for encoding and decoding videos or to convert the digital and video to analog and analog to digital. They need a microprocessor that is excellent in mathematical calculations. The chips of this processor are employed in SONAR, RADAR, home theaters audio gears, Mobile phones and TV set top boxes.

## 3. MICROPROCESSOR: IT'S ARRANGEMENT AND SPEED
### 3.1 Arrangement
The processor is placed on a motherboard with a bus speed that can match the processor. This allows the processor to go as fast as the wires making up the bus can handle. This means less resistance in the wire the faster system can run. The bus is measured in megahertz and is connected to the memory for the processor to store in memory. The

faster the operation can occur the better the system operates.

## 3.2 Speed

The CPU uses a clock speed that tells how many operations can happen in a single second. A CPU's clock is calculated by multiplying the processor megahertz by 1,000,000. Suppose if there is a 500 MHz processor then the operations will be equal to 500,000,000 per second. The operation, is the individual commands sent by the program. The faster is the processors bus and clock speed, the faster is FPU's (floating point units). This contributes the mathematical portion of processor.

# 4. INTEL MICROPROCESSORS

The company 'INTEL' was founded by two scientists, Robert Noyce and Gordon Moore in 1968. They aimed for semi-conductor memory products. In 1971, Federico Faggin, Ted Hoff and Stanley Mazor invented world's first single chip microprocessor known as Intel 4004. It had clock speed of 108 KHz, 2300 transistors, addressable memory of 640 bytes, bus speed of 108 KHz and no cache. It was commonly used for Busicom calculator and arithmetic manipulation.

## 4.1 Intel Earlier Processors

Intel increased its work quite fast. It launched its second chip after one year with increased parameters. It was named as 8008. This trend continued every alternate year. The microprocessor were respectively named as 4004, 8008, 8080, 8085, 8086, 8088, 80286. 8088 and 80286 were used for desktops and were the standard CPU"S for all the IBM PC's. Then after that came the series from Intel 386 DX Processor to Intel 486 SL Processor (Nov, 92). The last one was particularly designed for notebook PC's.

## 4.2 Intel Mobile Processors

Intel launched the mobile processors typically for mobile PC and mini-notebooks from 1997 to 1999. They were Pentium Processors with MMX Technology. They had the clock speed of the range of 200 to 300 MHz.

## 4.3 Intel Desktop Processors

Desktop processors were on the hike from 1993 to 2007. They were all Pentium processors except in 2007 when Pentium dual core processors were launched. Desktop processors had clock speed of 66 MHz to 3.7 MHz. Dual Core processor contained cache of around 1 MB and addressable memory up to 64 GB. They had bus speed of up to 800 MHz. They were commonly used for desktop PC's and mobile PC's.

**Table 1. Intel Earlier Processors with specifications**

| Processor | Clock Speed | Addressable Memory | Cache | Bus Speed |
|---|---|---|---|---|
| 4004 | 108 KHz | 640 Bytes | None | 108 KHz |
| 8008 | 200 KHz | 16 KB | None | 200 KHz |
| 8080 | 2 MHz | 64 KB | None | 2 MHz |
| 8085 | 2 MHz | 64 KB | None | 2 MHz |
| 8086 | 10 MHz<br>8 MHz<br>4.77 Mhz | 1 MB | None | 10 MHz<br>8 MHz<br>4.77 Mhz |
| 8088 | 8 MHz | 64 KB | None | 8 MHz |
| 80286 | 12 MHz<br>10 MHz<br>6 MHz | 16 MB | None | 12 MHz<br>10 MHz<br>6MHz |

**Table 2. Intel Mobile Processors with specifications**

| Processor | Clock Speed |
|---|---|
| Intel Pentium Processor with MMX Technology | 300 MHz |
| Intel Pentium Processor with MMX Technology | 266 MHz |
| Intel Pentium Processor with MMX Technology | 233-200 MHz |

# 5. INTEL SINGLE-CORE PROCESSING

A standard processor has one core. Single core processors only process one instruction at a time but they do use pipelines internally, that allow several instructions to be processed together.

## 5.1 Intel Pentium Processors

Pentium processors were quite successful. They were single core processors with higher performances.

**Table 3. Intel Pentium Processors with specification**

| Processor | No. of | Clock rate | Bus speed | Cache |
|---|---|---|---|---|
| Pentium | Single | 60MHz | 50-66 MHz | N/A |
| Pentium MMX | Single | 120-300 MHz | 60-66 MHz | N/A |
| Pentium Pro | Single | 150-200 MHz | 60,66 MHz | 256 KiB<br>512 KiB<br>1024 KiB |
| Pentium II | Single | 233-450 MHz | 66,100 MHz | 256 KiB<br>512 KiB |
| Pentium III | Single | 450MHz-1.4 GHz | 100,133 MHz | 256 KiB<br>512 KiB |
| Pentium IV | Single | 1.3-3.8 GHz | 400 MHz<br>533 MHz<br>800 MHz<br>1066 MHz | 256 KiB-2MiB |

| | | | | |
|---|---|---|---|---|
| Pentium IV Extreme Edition | Single | 3.2-3.73 GHz | 800 MHz 1066 MHz | 512 KiB-1 MiB |

## 5.2 Intel Atom and Celeron Processors

Intel Atom and Intel Celeron were the processors which were available in both versions of single and double core.

**Table 4. Intel Atom and Celeron Processors with specifications**

| Processor | No. of cores | Clock rate | Bus speed | Cache |
|---|---|---|---|---|
| Atom | Single, Double | 800MHz-2.13GHz | 400 MHz 533 MHz 667 MHz 2.5 GT/s | 512 KiB-1 MiB |
| Celeron | Single, Double | 266MHz-3.6GHz | 66 MHz 100 MHz 133 MHz 400 MHz 533 MHz | 0KiB-1MiB |

## 5.3 Intel Xeon Processors

Intel Xeon processor had huge range of cores, that is single, double, quad, hexa, octa cores.

**Table 5. Intel Xeon Processor with specifications**

| Processor | No. of cores | Clock rate | Bus speed | Cache |
|---|---|---|---|---|
| Xeon | Single, Double, Quad, Hexa, Octa | 400MHz-4.4GHz | 100 MHz, 133 MHz, 400 MHz, 533 MHz, 667 MHz, 800 MHz, 1066MHz, 1333MHz, 1600MHz, 4.8 GT/s, 5.86 GT/s, 6.4 GT/s | 256 KiB-12Mib |

# 6. INTEL MULTI-CORE PROCESSING

A multi-core processor consist of two or more independent cores, each core is capable of processing individual instructions. A dual-core processor contains two cores, a quad-core processor contains four cores, and a hexa-core processor contains six cores.

Multiple cores can be used to run two programs side by side and when an intensive program is running, (Video conversion, CD ripping etc.) another core can be utilized to run parallel work like browser checking email etc. Multiple cores tend to be really valuable when a program is run that can utilize more than one core to improve the program's efficiency and addressability. Programs such as graphic software, games etc. can run more than one instruction at the same time and deliver faster, smoother results. If CPU-intensive software is used, multiple cores can more likely provide a better computing experience.

## 6.1 Dual-Core Processing

Intel implemented dual core processors across every sector like desktop, workstation, mobile, mainframe, These products include Intel Core 2 Duo desktop and mobile processors, and Dual-Core Intel Xeon 5100 processor 5100 series for dual-processor servers. The Dual-Core Intel Xeon 5100 server processor delivers up to 135 percent performance improvements and up to a 40 percent reduction in energy consumption over previous Intel server products. The Intel Core 2 Duo desktop processor delivers up to a 40 percent improvement in performance and up to a 40 percent reduction in power as compared to today's high-end Intel Pentium D processor 960.4. The Intel Core 2 Duo mobile processor delivers greater than 2X CPU performance5 and up to a 28 percent power reduction with new Intel Centrino Duo mobile technology laptops based on the Intel Core 2 Duo processor as compared to previous-generation Intel Centrino mobile technology based laptops.

## 6.2 Quad-Core Technology

Intel Core 2 Extreme Quad-Core Processor was World's First Quad-Core for the Desktop. For today's increasing need of multiprocessing, multithreading this quad-core technology serves the purpose. It is great plus for gaming and multimedia processing machines and engines. In addition to being excellent for intensive multitasking, the Intel Core 2 Extreme quad-core processor is intended to provide impressive gaming performance, plenty of emphasis on thread-intensive games. Gamers can expect a smoother, more exciting gaming experience through the distribution of artificial intelligence (AI), physics and rendering across four hardware threads. Intel Core 2 Extreme quad-core processor can be ideal for processor-intensive, highly threaded applications as well as it can be the top choice for multimedia enthusiasts, gamers, and workers who intend to demand multitasking environments. It is intended to feature 2.66 GHz core speed and 1066 MHz front side bus speed.

## 6.3 Basic differences between i3, i5 and i7

i3, i5, i7 processors are great advancements of Intel. I3 is a dual core processor, i5 can have both two or four cores, that is it can be dual core or quad core depending upon the model being used, i7 can have two, four or six cores, that is dual core or quad core or hexa core, depending on the model being used.

The crux has been shown in the following table :

**Table 6. Processors and their number of cores, threads**

| Processor | No. of Cores | No. of Threads (2 per core) |
|---|---|---|
| i3 | 2 | 4 |
| i5 | 2 or 4 (Depending on the model) | 4 or 8 |

| | | |
|---|---|---|
| i7 | 2, 4 or 6 (Depending on the model) | 4, 8 or 12 |

## 6.4 Differences between usage of i3, i5, i7

Choice of the processors depends on the type of work one wish to do with the computer. If a computer does a light-handed work, then there is no worth in spending a lot of money for a powerful processor. Or again there is no worth in purchasing a cheaper processor which does not serve one's purpose.

### *6.4.1 i3 processor*

If one has to do simple word processing, spreadsheet etc. often listen to music and watch movies, i3 processor can be a good choice or any dual core processor like core 2 duo.

### *6.4.2 i5 processor*

If one has to play occasional games and watch HD movies parallel to doing the things mentioned for i3, then i5 processor can be a good choice.

### *6.4.3 i7 processor*

If one has to do graphic publishing, create music, do programming and compiling, watch HD movies, play games which are visually appealing parallel to all the things mentioned for i3 and i5, then a quad core i5 or i7 can be a very good choice.

# 7. AMD (Advanced Micro Devices) Microprocessors

AMD was founded by Jerry Sanders in 1969. In 1972-74, AMD went on public with their first manufacturing facility. In 1976-78, AMD signed a cross-license agreement with Intel as there was a huge competition between the two. In 1981, sales and components got doubled since 1978. In 1982, second source for 8086 and 8088 CPU's got launched. 1985 was quite fruitful for AMD as sales touched the highest point in 1985. Year 1991 was again quite important for AMD as that year AMD's Am386 microprocessor family debuts through which AMD challenged Intel. ATI introduces Mach8 chip and board products which were first ATI products to process graphics independently of the CPU. In 1993, Am486 microprocessor family and flash memory got launched by AMD. In 1994, agreement with Compaq was signed. One major partnership announced in 1998 paired AMD with semiconductor giant Motorola. In the announcement, Sanders referred to the partnership as creating a "virtual gorilla" that would enable AMD to compete with Intel on fabrication capacity while limiting AMD's financial outlay for new facilities. This partnership also helped to co-develop copper-based semiconductor technology, which would become a cornerstone of the K7 production process. In August 1999, AMD released the Athlon (K7) processor.

# 8. AMD ATHLON PROCESSORS

AMD designed and manufactured a series of x-86 compatible processors. AMD gave this series the brand name as Athlon. Athlon means "contest" in Greek. First Athlon was released ion June 23, 1999.

## 8.1 Athlon Classic

The first Athlon processor of the series which is now called Athlon classic, was the first processor to reach the speed of 1GHz. It was launched with superior performance as compared to all the x86 processors available at that time.The Athlon Classic is a cartridge-based processor. In commercial terms, the Athlon "Classic" was an enormous success. It was not just because of its own merits, but also because Intel delayed a series of major production, design, and quality control issues at this time. In particular, Intel suffered delays due to its transition to the 180 nm production process, starting in late 1999 and running through to mid-2000. There was also the shortage of Pentium III parts. In contrast, AMD enjoyed a remarkably smooth process transition and had ample supplies available, causing Athlon sales to become quite strong.

**Table 7. Athlon Classic processor specifications**

| L1 Cache | L2 Cache | Clock rate |
|---|---|---|
| 64 + 64 kB (Data + Instructions) | 512 kB | 500-700 MHz (K7), 550-1000 MHz (K75) |

## 8.2 Thunderbird (T-Bird)

It was the second generation Athlon. It was launched on June 5, 2000. It was designed for the speeds ranging from 600 MHz to 1.4 GHz. Athlon Classic used to clock up to 1 GHz. So here it was an advancement. However, the major difference was of the cache design. There is a general rule that more cache improves performance but faster cache improves it further still. Hence, just as Intel had done when they replaced the old Katmai- based Pentium III with the much faster Coppermine-based Pentium III, AMD replaced the 512 kB external reduced-speed cache of the Athlon Classic with 256 kB of on-chip, full-speed exclusive cache.

The Thunderbird was one of the most successful products of AMD. It had quite improved mainboard designs. In October 2000, the Athlon "C" had been introduced which raised the motherboard front-side bus speed from 100 MHz to 133 MHz and parallel to that it provided around 10% of extra performance per clock.

**Table 8. Thunderbird (T-Bird) processor specifications**

| L1 Cache | L2 Cache | Clock rate |
|---|---|---|
| 64 + 64 kB (Data + Instructions) | 256 kB, fullspeed | Slot A: 650–1000 MHz Socket A, 100 MHz FSB (B-models): 600–1400 MHz Socket A, 133 MHz FSB (C-models): 1000–1400 MHz |

## 8.3 Athlon XP (Palomino)

AMD released third generation Athlonits code name was Palomino. It was launched as Athlon XP on October 9, 2001. XP

meant to be "Extended Performance". It is also believed to be an unofficial reference to Microsoft Windows XP. Athlon XP was launched at speeds between 1.33 GHz and 1.53 GHz. It January, 2002, AMD enhanced this and released the subsequent 1.67 GHz Athlon XP 2000+. Palomino was the first K7 core to include the full SSE instruction set from the Intel Pentium III, as well as AMD's 3DNow! Professional. It is around 10% faster than Thunderbird at the same clock speed. The core has enhancements to the K7's

**Table 9. Athlon XP (Palomino) processor specification**

| L1 Cache | L2 Cache | Clock rate |
|---|---|---|
| 64 + 64 kB (Data + Instructions) | 256 kB, fullspeed | Athlon 4: 850–1400 MHz<br>Athlon XP: 1333–1733 MHz (1500+ to 2100+)<br>Athlon MP: 1000–1733 MHz |

## 8.4 Thoroughbred (T-Bred)

It was fourth generation Athlon and was released on June 10, 2002. It had the speed of 1.8 GHz. It was released with two cores: Tbred-A and Tbred-B. AMD was successful in reducing the production cost per processor but was not able to expectedly reduce the heat and clock scalability. This occurred because of the unmodified design of Palomino. AMD's T-Bred was targeted to replace Palomino but could not increase its speed as compared to Palomino. T-Bred was only sold in the versions of 1333 MHz to 1800 MHz. It was only able to displace more production-costly Palomino. Thus AMD redesigned T-Bred. It was already a complex structure of 8-layer but now AMD added another ninth metal layer. Its competitor Pentium 4 utilized only six. And its successor Prescott used 7 layers. The Tbred-B was more improved in headroom compared to Tbred-A. So it became very popular for overlocking. While Tbred-A always struggled in reaching clock- speeds above 1.9 GHz, Tbred-B could easily reach 2.3 GHz and above.

**Table 10. Thunderbird (T-Bred) processor specifications**

| L1 Cache | L2 Cache | Clock rate |
|---|---|---|
| 64 + 64 kB (Data + Instructions) | 256 kB, fullspeed | Thoroughbred "A": 1400–1800 MHz (1600+ to 2200+)<br>Thoroughbred "B": 1400–2250 MHz (1600+ to 2800+) |

## 8.5 Barton and Thorton

It was fifth generation processor. It got released in early 2003. Its L2 cache was increased to 512 KB. It did not have higher clock rates than Thoroughbred-core processors. By the time of its release, Intel's Pentium 4 had become more competitive.

AMD simply increases the L2 cache to 512 kB but it did not make any impact as the Athlon pipeline was not as cache constrained as of Pentium 4. AMD increased the performance but not as much as that it could beat Intel's Pentium 4. The 800 MT/s bus used by many later Pentium 4 processors was well out of the Athlon XP's reach. In order to reach the same bandwidth levels, the Athlon XP's bus would have to be clocked at levels simply unreachable. To maintain or exceed the performance of Intel's newer processors would require a significant redesign.

**Table 11. Barton and Thorton processor specifications**

| L1 Cache | L2 Cache | Clock rate |
|---|---|---|
| 64 + 64 kB (Data + Instructions) | 256 kB, fullspeed | 1667–2200 MHz (2000+ to 3100+)<br>133 MHz FSB: 1600–2133 MHz (2000+ to 2600+)<br>166 MHz FSB: 2083 MHz (2600+)<br>200 MHz FSB: 2200 MHz (3100+) |

## 8.6 Competitors of Athlon

The major competitors of Athlon were Intel Pentium III, Pentium IV, Celeron, Via C3 and C7, Transmeta Efficeon.

# 9. CELERON PROCESSOR

Celeron is the brand name given by Intel to those processors which are typically aimed at budget of an individual. Because they aimed at the budget, high and advanced features are intentionally disabled by Intel. Generally, the cache is also of smaller memory in the Celeron processor. There were variable performance issues noticed due to the lack of these features. Most of the Celeron processors gave the degraded performance, but there were few which were known for very good performances. But generally Celeron processor had less performance than the higher-end processors of Intel, although it was intentional. The first Celeron processor was based on Intel Pentium II. Further versions of Celeron processors were based on Pentium III, Pentium IV, Pentium M and Intel Core brands. The latest Celeron Processor was launched in July 2011 and was based on the Intel i3/i5/i7 brands. Although, this design was independent but had only about 66% of the cache memory as of Intel i3 processor.

# 10. VIA C3 PROCESSORS

VIA C3 family is designed by Centaur Technology and sold by VIA Technologies. It has been majorly aimed at the personal

computers.

### 10.1 Design Methodology

Although, VIA's chips are quite slower than AMD and Intel, on the basis of clock, but they are quite small in size, very easy to manufacture and of low power. Hence, they are always quite attractive in terms of embedded systems. Mobile marketplace is also finding it attractive nowadays. Samuel 2 Ezra cores were used for VIA Cyrix III and then was renames as VIA C3. Nehemiah Cores were used for VIA C5. This feature of VIA has always turned in its own favor in spite of higher range processors of Intel. VIA is trying to narrow down the gap of performance which has been created.

## 11. TRANSMETA CRUSOE AND EFFICEON

Crusoe was the first in the family of x-86 compatible microprocessors developed by Transmeta. The second generation processor of Transmeta was Efficeon. It implies a software engine which converts the code written for processor to the native instruction set of the chip. Efficeon stresses computational efficiency, low power consumption, and a low thermal footprint just like its predecessor, the Transmeta Crusoe.

## 12. TRANSMETA V/S INTEL- TRANSMETA FAILED!

Transmeta became out of funds from the investors. Transmeta wanted to give good competition to Intel, but could not achieve the benchmarks. Intel always had huge backing of finances. Someone who desires to compete Intel in whole sole manner, needs to have huge backing. Intel has the all alone supremacy in the world of microprocessors. It is a mighty empire in itself. Transmeta was founded in 1995. Intel had vast financial resources, world-class engineering and its own chip fabrication plants. Compared to that, Transmeta was a quite small body which was a semiconductor company. Transmeta always tried really hard but it got realized after many years that it cannot beat Intel.

Intel had great performance desktop processors. Transmeta design was incapable of beating that. One of the major problems was Transmeta's radical new approach to microprocessor design. Transmeta processors couldn't run the x86 software by themselves. Despite using the best emulation technology, Transmeta was incapable of matching the performance of Intel in the field of desktop microprocessors. Now the company decided to move its focus on the notebook and embedded processors. But nothing went right for Transmeta. When Intel, AMD, VIA and other popular companies took over, the crusoe was in the danger. So, in all the Transmeta gave its shot but Intel wins as usual.

## 13. SUMMARY/CONCLUSION

This was an attempt to make best possible analysis and basic comparison among the microprocessors which are popularly used. As such there are thousands of microprocessors, but I hope this gives a general idea of the processors in the market including their history and strategies. In sum, Intel has always been at the top of the market and AMD always had potential to give Intel a good competition. Other companies are also famous for some of their processors and have their own pros and cons.

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