Multi Core Processor

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ABSTRACT: **Multi-core processors are widely used across many application domains including general-purpose, embedded, network, digital signal processing (DSP), and graphics. The improvement in performance gained by the use of a multi-core processor depends very much on the software algorithms used and their implementation. Multi-core chips also allow higher performance at lower energy. This can be a big factor in mobile devices that operate on batteries. Since each and every core in multi-core is generally more energy-efficient, the chip becomes more efficient than having a single large monolithic core. This allows higher performance with less energy. multi-core processor is a single computing component with two or more independent actual central processing units (called "cores"), which are the units that read and execute program instructions. This review paper covers a detailed study about multi core processor and the advantages of using it.**

I. INTRODUCTION

The microprocessor industry continues to have great importance in the course of technological advancements ever since their coming to existence in 1970s . The growing market and the demand for faster performance drove the industry to manufacture faster and smarter chips. One of the most classic and proven techniques to improve performance is to clock the chip at higher frequency which enables the processor to execute the programs in a much quicker time and the industry has been following this trend from 1983 – 2002 . Additional techniques have also been devised to improve performance including parallel processing, data level parallelism and instruction level parallelism which have all proven to be very effective. One such technique which improves significant performance boost is multi-core processors. Multi-core processors have been in existence since the past decade, but however have gained more importance off late due to technology limitations single-core processors are facing today such as high throughput and long lasting battery life with high energy efficiency.

II. EVOLUTION OF MULTI-CORE PROCESSOR

Driven by a performance hungry market, microprocessors have always been designed keeping performance and cost in mind. Gordon Moore, founder of Intel Corporation predicted that the number of transistors on a chip will double once in every 18 months to meet this ever growing demand which is popularly known as Moore's Law in the semiconductor industry . Advanced chip fabrication technology alongside with integrated circuit processing technology offers increasing integration density which has made it possible to integrate one billion transistors on a chip to improve performance. However, the performance increase by micro-architecture governed by Pollack's rule is roughly proportional to square root of increase in complexity . This would mean that doubling the logic on a processor core would only improve the performance by 40%. With advanced chip fabrication techniques comes along another major bottleneck, power dissipation issue. Studies have shown that transistor leakage current increases as the chip size shrinks further and further which increases static power dissipation to large values as shown in One alternate means of improving performance is to increase the frequency of operation which enables faster execution of programs . However the frequency is again limited to 4GHz currently as any increase beyond this frequency increases power dissipation again . "Battery life and system cost constraints drive the design team to consider power over performance in such a scenario". Power consumption has increased to such high levels that traditional air-cooled microprocessor server boxes may require budgets for liquid-cooling or refrigeration hardware . Designers eventually hit what is referred to as the power wall, the limit on the amount of power a microprocessor could dissipate .

Semiconductor industry once driven by performance being the major design objective, is today being driven by other important considerations such chip fabrication costs, fault tolerance, power efficiency and heat dissipation .This led to the development of multi-core processors which have been effective in addressing these challenges.

III. MULTI CORE PROCESSOR

"A Multi-core processor is typically a single processor which contains several cores on a chip". The cores are functional units made up of computation units and caches [7]. These multiple cores on a single chip combine to replicate the performance of a single faster processor. The individual cores on a multi-core processor don't necessarily run as fast as the highest performing single-core processors, but they improve overall performance by handling more tasks in parallel [16]. The performance boost can be seen by understanding the manner in which single core and multi-core processors execute programs. Single core processors running multiple programs would assign time slice to work on one program and then assign different time slices for the remaining programs. If one of the processes is taking longer time to complete then all the rest of the processes start lagging behind. However, In the case of multi-core processors if you have multiple tasks that can be run in parallel at the same time, each of them will be executed by a separate core in parallel thus boosting the performance.The multiple cores inside the chip are not clocked at a higher frequency, but instead their capability to execute programs in parallel is what ultimately contributes to the overall performance making them more energy efficient and low power cores as shown in the figure below [6]. Multi-core processors are generally designed partitioned so that the unused cores can be powered down or powered up as and when needed by the application contributing to overall power dissipation savings.

Multi-core processors could be implemented in many ways based on the application requirement. It could be implemented either as a group of heterogeneous cores or as a group of homogenous cores or a combination of both. In homogeneous core architecture, all the cores in the CPU are identical and they apply divide and conquer approach to improve the overall processor performance by breaking up a high computationally intensive application into less computationally intensive applications and execute them in parallel. Other major benefits of using a homogenous multi-core processor are reduced design complexity, reusability, reduced verification effort and hence easier to meet time to market criterion . On the other hand heterogeneous cores consist of dedicated application specific processor cores that would target the issue of running variety of applications to be executed on a computer . An example could be a DSP core addressing multimedia applications that require heavy mathematical calculations, a complex core addressing computationally intensive application and a remedial core which addresses less computationally intensive applications .Multi-core processors could be implemented in many ways based on the application requirement. It could be implemented either as a group of heterogeneous cores or as a group of homogenous cores or a combination of both. In homogeneous core architecture, all the cores in the CPU are identical and they apply divide and conquer approach to improve the overall processor performance by breaking up a high computationally intensive application into less computationally intensive applications and execute them in parallel . Other major benefits of using a homogenous multi-core processor are reduced design complexity, reusability, reduced verification effort and hence easier to meet time to market criterion . On the other hand heterogeneous cores consist of dedicated application specific processor cores that would target the issue of running variety of applications to be executed on a computer. An example could be a DSP core addressing multimedia applications that require heavy mathematical calculations, a complex core addressing computationally intensive application and a remedial core which addresses less computationally intensive applications .

IV. ADVANTAGES OVER SINGLE CORE PROCESSOR

The multi-core central processing unit trend that began with dual-core CPUs is now leading computer users to think about the advantages and disadvantages of quad-core CPUs instead. Although they have twice the number of processors, quad-core computers may not lead to the same increase in system performance as experienced by people upgrading from single-core to dual-core CPUs. The pros and cons of quad-core CPUs should be weighed carefully before you make a decision on your next computer purchase.

Faster Processing Speed

The key pro of a multi-core processor lies in its ability to perform a greater number of simultaneous calculations. This is particularly useful for applications that offer logical places for parallel computation --- for instance a computer game that handles the calculations for the artificial intelligence separately from the calculations to display the game's graphics. Such an application is known, in computer parlance, as being "multithreaded" because, rather than one long sequence, it contains many short sequences bound up together. If an application is properly multithreaded, quad core processors have an advantage over processors with fewer cores because they have more processing horsepower available.

Diminishing Returns

Unfortunately, it's more difficult to optimize applications for more than two cores: the developer needs to be sure

that instructions finish at about the same time to prevent wasted processor cycles, a balancing act that becomes harder as the number of cores rises. As a result, quad core processors are not nearly four times as fast as single-core processors, and can be less efficient than high-powered dual-core processors because the cores remain unused a greater percentage of the time.

Greater Virtualization Versatility

In some cases, computers can make use of multiple cores without having applications that are explicitly multithreaded. Many computer servers, for example, are "virtualized" --- they permit someone to operate many different "servers" on the same physical computer. In virtualized environments, quad core computers allow a greater number of computers to be emulated at the same time, because each virtual environment can be easily allocated its own core.

Costs

For home users who do not generally operate virtual servers, the benefits of quad-core processors may not necessarily be as obvious or as dramatic. Because they are more complex to design, quad core processors are generally more expensive to purchase than a dual-core processor of the equivalent speed. They are also more expensive to operate because of increased power consumption; for AMD's line of Phenom II processors, a quad-core processor consumes more than 50 percent more power than a processor at the same speed with only two cores.

V. CHALLENGES FACED

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Another important feature which impacts multi-core performance is the interaction between on chip components viz. cores, memory controllers and shared components viz. cache and memories where bus contention and latency are the key areas of concern. Special crossbars or mesh techniques have been implemented on hardware to address this issue .

VI. CONCLUSION

Multi-core chips an important new trend in computer architecture .Several new multi-core chips in design phases.Parallel programming techniques likely to gain important.

Power and frequency limitations observed on single core implementations have paved the gateway of muticore technology and will be the trend in the industry moving forward. However the complete performance throughout can be realized only when the challenges multi core processor are facing today are fully addressed.a lot of technologies breakthrough are expected in this area of technology including a new multi core programming language, software to port legacy software to "multi - core aware" software programs.Although it has been one of the most challenging technologies to adopt to, there is considerable amount of research going on in the field to utilize multi-core processors efficiently.