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Design and architecture of Intel's core i7 processor

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I. INTRODUCTION

The Intel core i7-900 desktop processor extreme edition series and Intel core i7-900 desktop processor series are intended for high performance high –end desktop, uni- processor server and workstation systems. Core i7 is the processor using Nehalem microarchitecture. With faster, intelligent multi-core technology that applies processing power where it is needed the most the processor implements key new technologies:

A. Integrated memory controller
B. Point to point link interface based on
C. Intel quick path interconnection.

Nehalem is the code name for the Intel processor microarchitecture, successor to core microarchitecture, the first processor released with the Nehalem architecture is the desktop core i7.

The processor is optimized for performance with the power efficiencies of a low-power micro architecture to enable smaller, quieter systems.

The Intel core i7 desktop processor extreme edition series are multi-core processors based on 45nm process technology. The processors supports all the existing streaming SIMD extensions 2(SSE2), streaming SIMD extensions3 (SSE3) and streaming SIMD extensions 4(SSE4). The processor supports several advanced technologies: execute disable bit, Intel 64 technology, enhanced Intel speed step technology, Intel virtualization technology, Intel turbo boost technology and hyper- threading technology.

D. Features:

1) *Modular design:* The core i7 processors have been designed to help Intel create different versions this means 8-core processors, 6-channel memory and larger cache processors
2) *Hyper threading returns:* hyper threading is a technology that allows a single core toemulate two cores by using unused core hardware to run a separate thread.
3) *Integrated memory controller*: Intel has placed all memory controlling hardware directly into the processor this means more bandwidth and lower latencies by passing the FSB. More memory is supported due to the triple channel.
4) *Quick path interconnect:* the QPI is connection interface between processor and rest of the system. It runs independent of other modules in the processor it also transmits and receives per clocks so hence this module is rated in transfers per second instead of frequency.
5) *Turbo modes:* The processor is able to self- overclock by changing the multiplier by two speed bins. It will self-overclock if the processor senses that there is enough thermal and power headroom to overclock without straining itself. Usually this happens when there are cores in sleep state due to lack of multiple threads. The PCU (power control unit) is advanced enough to know all this and will be very self-aware
6) *Overclocking:* O v erclocking is the process of forcing the computer component to run at higher clock rate it was designed in order to increase the performance of the computers.
7) *Support for SSE4.2 and SSE4.1 instruction sets:* SSE4 is an instruction set used in intel core microarchitecture it consists of 54 instructions referred to as SSE4.1 additionally SSE4.2 a subset consisting of 7 remaining instructions will first be available in core i7.

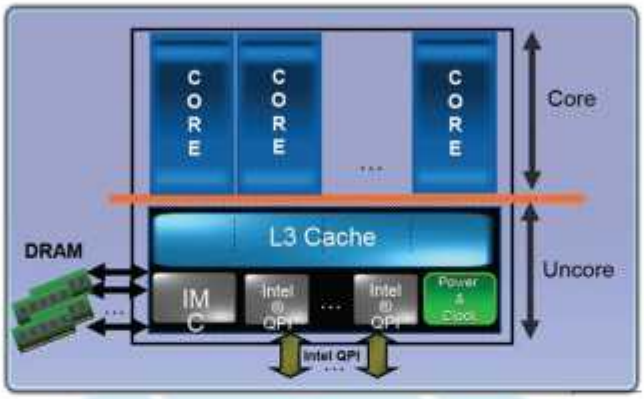
E. Electrical specifications:

[1] *Intel QPI differential signaling:* the processor provides an Intel QPI port for high speed signal transfer between other Intel QPI components it consists of two unidirectional links for transmit and receive as well.

[2] *Power and ground lands:* for clean on-chip processor core power distribution, the processor has 210 VCC pads and 119 VSS pads associated with Vcc. The processor VCC lands must be supplied with the voltage determined by the processor voltage identification signals (VID).

[3] *Processor clocking:* the processor maximum core frequency, Intel QPI link frequency and integrated memory controller frequency are set during manufacturing it is possible to override the processor core frequency setting using software.

II. ARCHITECTURE OF INTEL CORE I7 PROCESSOR



The core has been completely modularized. The two main modules are core and uncore. The core controls all the cores while the uncore controls the L3 laches, memory controller and QPI links. However each module receives its own clock so that all the different modules can run independently of each other.

A. *Core*: the core portion is the location of all the cores of processor. This is where the CPU frequency comes into play

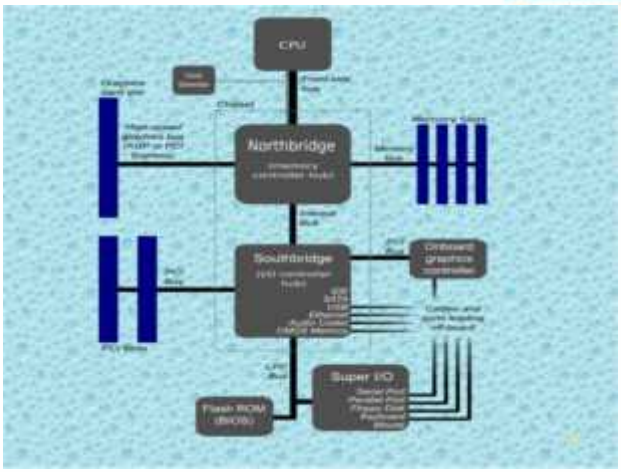
B. *Uncore:* The uncore technically includes the QPI, the QPI is able to run independent of the uncore settings the uncore controls the L3 latch and memory controller. The uncore also controls what memory speeds are available to use with the processor. The uncore must be at least double of the memory frequency due to memory being DDR. To let everything run independently there is a single based clock used throughout the processor the base clock is referred as Bclk. The stock Bclk is 133 MHz and all the components have separate multiplier to achieve their desire operating frequency

C. *Socket*: the socket is newLGA1366 (socket B) and it is incompatible with the previous versions. LGA refers to land grid array a new type of socket for latest range of processors. Intel decided to switch an LGA socket because it provides a larger contact point the LGA setup provides higher pin density allowing more power contacts and thus more stable power supply to chip.

D. *Chipset:* A chipset is group of integrated circuits or chips that are designed to work together and are usually marked as single product. In personal computers based on Intel Pentium- class microprocessors the term on refers to a specific pair of chips on the motherboard: the *Southbridge* and the *Northbridge.*

The *Northbridge* links the CPU to very high speed devices especially main memory and graphics controller. And the *Southbridge* connects to lower speed peripheral busses (such as PCI or ISA).

In many modern chipsets the Southbridge actually contains some on-chip integrated peripherals, such as Ethernet, USB and audio devices chipset is usually designed to communication between the processor and external devices the chipset plays crucial role in determining system performance.



work with specific family of microprocessors because it controls

The Northbridge typically handles communications among the CPU, RAM, AGP or PCI express and the Southbridge some Northbridge also contain integrated video controllers also known as graphic and memory controller memory hub (GMCH) in Intel systems. The Southbridge is the chip that implements the slower capabilities of motherboard because the Southbridge is further removed from the CPU it is given responsibility for slower devices on typical microcomputer.

E. Thermal specifications

The processor requires a thermal solution to maintain temperatures within its operating limits. Any attempt to operate the processor outside these operating limits may result in permanent damage to the processor and potentially other components to the system. A complete solution includes both component and system level

The processor implement a methodology for managing processor temperatures which is intended to support acoustic noise reduction through fan speed control and to assure processor reliability. Selection of appropriate fan speed is based on relative temperatures data reported by processor's digital temperature sensor (DTS) the DTS can be read using the platform environment control interface (PECI).the temperature reported over PECI is always a negative value and represent a delta below the onset of thermal control circuit (TCC). A single integer change in PECI value corresponds to approximately 1degree change in processor temperature.

F. Platform environment control interface (PECI)

The platform environment control interface (PECI) is a one wire interface that provides a communication channel between the Intel processor and chipset components to external monitoring devices. The processor implements a PECI interface to allow communication of processor thermal and other information to other devices on the platform. The processor provides a digital thermal sensor (DTS) for fan speed control. The DTS is calibrated at the factory to provide a digital representation of relative processor temperature; averaged DTS values are read using the PECI interface.

The PECI physical layer is self-clocked one- wire bus that begins with each bit with a driven, rising edge from an ideal level near zero volts. PECI is largely a fault tolerant interface, including noise immunity and error checking improvements over other comparable industry standard interfaces the PECI will always respond to requests and protocol itself can be relied upon to detect any transmission failures.

III. PURPOSE OF INTEL'S I7 CORE PROCESSOR

The core i7 processors series targets the gaming industry and for applications that demand efficient performance

Core processor i7 is recommended for:

A. multitasking, for running multiple programs at same time
B. Multithreading applications
C. Extreme 3D gaming

D. Creating professional movies and editing graphical tasks
E. More than enough for basic tasks such as word processing, internet browsing and E-mail.

F. Instruction set

An instruction set is the list of all the instructions, and all their variations that a processor can execute. A single instruction multiple data (SIMD) is one in which single instruction stream has ability to process multiple data streams simultaneously these machines are useful in applications such as general digital signal processing , image processing and multimedia applications such as audio and video. Originally, super computers known as array processors and vector processors provided SIMD processing capabilities.
Intel's core i7 implements the MMX, streaming SIMD extensions (SSE), streaming SIMD extensions 2 (SSE2), and streaming SIMD extensions 3 (SSE3), supplemental streaming SIMD extensions 3 (SSSE3), streaming SIMD extensions 4 (SSE4) instruction sets that are capable of processing multiple data elements in a single clock. The multiple data elements are stored in the floating point registers. A multiple instruction, multiple data (MIMD) machine is capable of is executing multiple instruction streams, while working on a separate and independent data stream, the instruction set MMX is 64-bit instruction set. The instruction set SSE is 128-bit instruction set.

	instructions
SSSE3	Supplemental streaming SIMD extensions 3 instructions
SSE4	Streaming SIMD extensions 4 instructions

Comparison between i3, i5 and i7 processor:

G. Intel core i3 processor

This particular Intel processor is entry level processor of this new series of Intel processors. While it may not be the fastest one of the bunch, it can get the job done, at least for more applications.
1) Uses 4 threads: it uses hyper threading technology which is latest craze due to its improved efficiency over earlier processors that were put on the market.
2) This processor consists of 2-4 cores depending on which on you get your hands on.
3) Contains a 3-4 MB cache.
4) Uses less heat and energy than earlier processors, which is always a good thing in this day and age.

H. Intel core i5 processor

This is the mid-size processor recommended for those who demand a little speed, but not quite enough where the user will be running resource intensive applications.
1) As with the core i3 processor, this comes with 2-4 cores, the main difference is that it has higher clock speed than the core i3.
2) This is also a heat and energy efficient processor, but it does seem to be better at this particular job than the core i3 processor.
3) The number of threads is used in this is no different than the core i3 with 2-4 threads and it also uses the hyper threading technology for a boost in performance.
4) The cache of core i5 is bigger than core i3 it is at 3-8 MB.
5) The core i5 is where the turbo mode is made available, this provide users with the opportunity to turn off a core if it is not being utilized.

I. Intel core i7 processor

This is for the users that demand power; it does provide more power and great for gamers and other resource intensive users.

1) The cache on this one is 4-8 MB.
2) This processor comes with 8 threads; definitely enough to get the job done quickly may be even at the speed of light if you are lucky.
3) It also utilizes the hyper threading technology as well as turbo boost technology
4) It has 4 cores to take advantage of this processor
5) It is more energy efficient and produces less heat

Name	Description
MMX	MMX SIMD instructions
SSE	Streaming SIMD extensions (SSE) instructions
SSE2	Streaming SIMD extensions 2 instructions
SSE3	Streaming SIMD extensions 3

IV. ADVANTAGES AND DISADVANTAGES OF INTEL'S CORE I7 PROCESSOR

A. Advantages

1) *Big cache size:* this processor has 8MB last level caches shared among four cores this helps to increase instruction execution speed.
2) *Very fast:* using the combination of intel turbo boost technology and Intel hyper threading technology processor speed becomes faster, it is very fast processor as compare to other processor.
3) *Better cooling systems:* A 4-pin connector is included for fan speed control to help minimize the acoustic noise levels generated from running the fan at higher speeds for thermal performance. For cooling of processor it provides cooler running technology, less heat and less noise, supplied with Intelreference heat-sink and fan as temperature increase speed of fan get become increase.

B. *Disadvantages*

1) *Cost:* the main disadvantage of this processor is its cost, it is an expensive processor as compared to previous processor. Its cost is over 15000 Rs.
2) *Power consumption***:** power consumption of core i7 processor is not better as compare with the core 2 duo processors.

V. CONCLUSIONS

We have finally got acquainted with the new core i7 processors, the first solutions on Nehalem microarchitecture targeted for desktop systems. This processor is brilliant for multiple stand points. It supports new interesting technologies, such as SMT and turbo boost technology, and has an integrated memory controller with unprecedented performance. In most applications except a few gaming titles, the new processor turned out faster than core 2 processor working at the same clock speed. New core i7 are indisputably better in most aspects than core 2 quad processors of comparable price. Their performance is almost always higher which is especially evident in case of multi- threaded load. Over-clocking in the Core i7 processors is also seems to be easier. Servers will also likely benefit greatly from using an i7 processor, the memory bandwidth is simply insane it is more energy efficient and produces less heat. The core i7 utilizes hyper-threading technology as well as turbo boost technology. Core i7 is the

first processor using Nehalem micro-architecture, with faster intelligent, multi-core technology that applies processing power where it is needed most. New Intel core i7 delivers an incredible breakthrough in PC performance.

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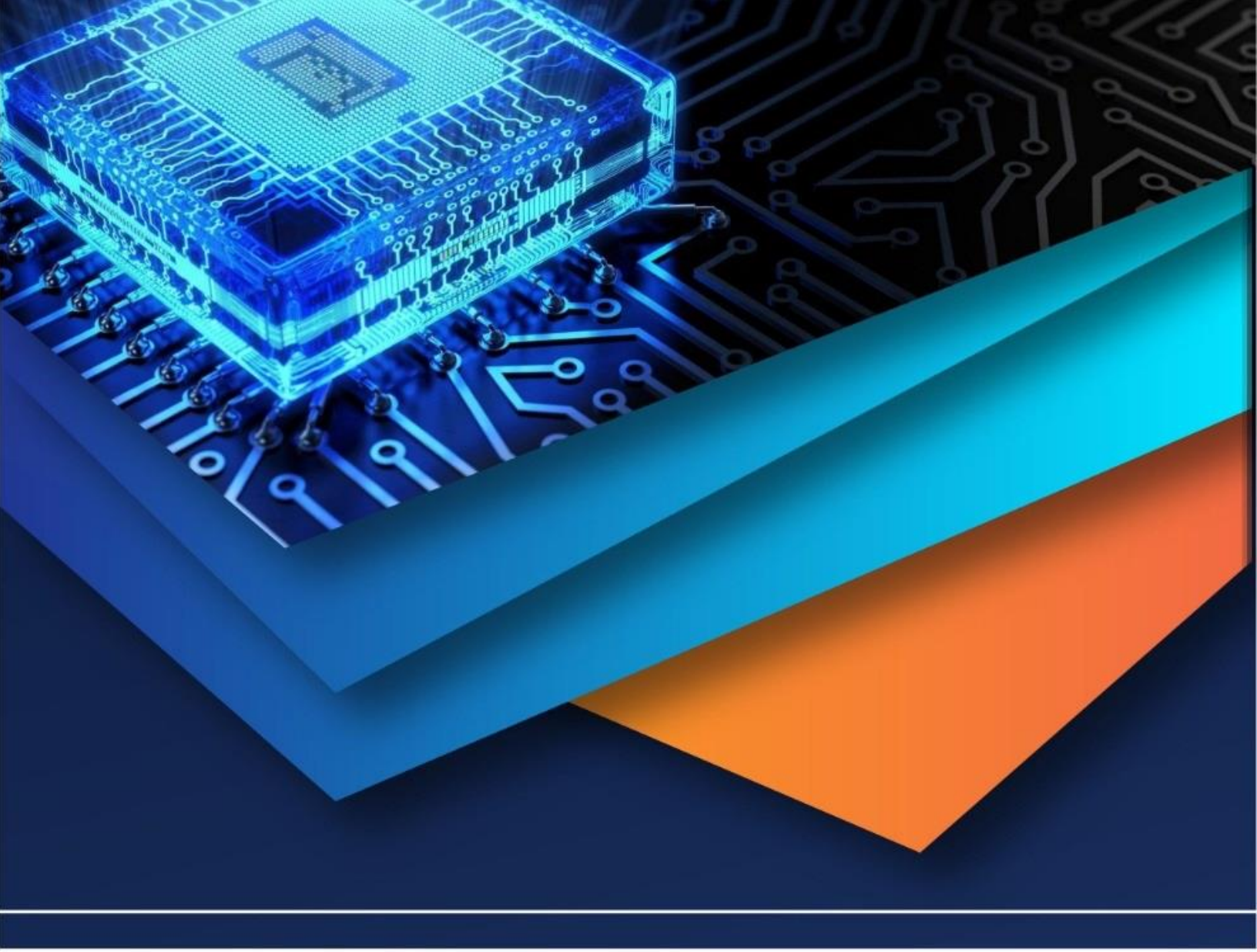

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