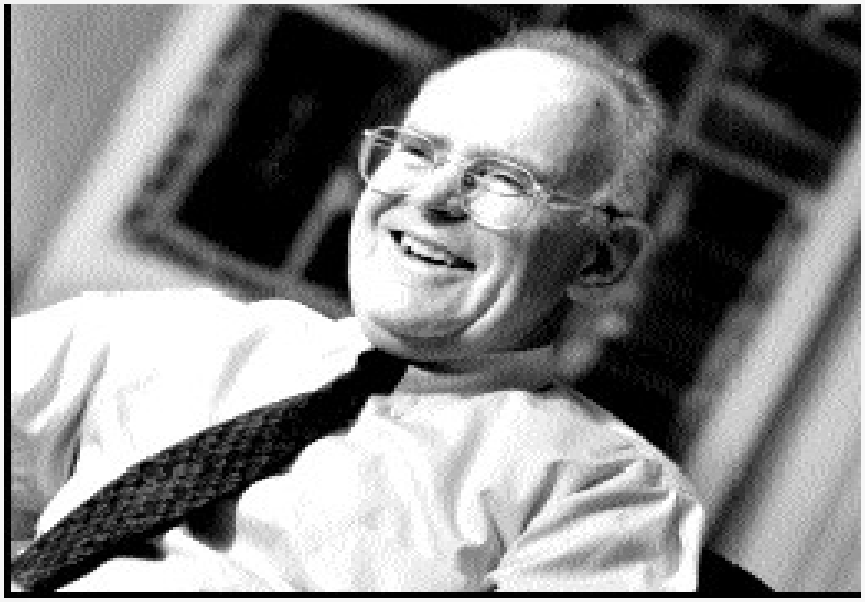
Introduction to
High performance Computer Archiceture

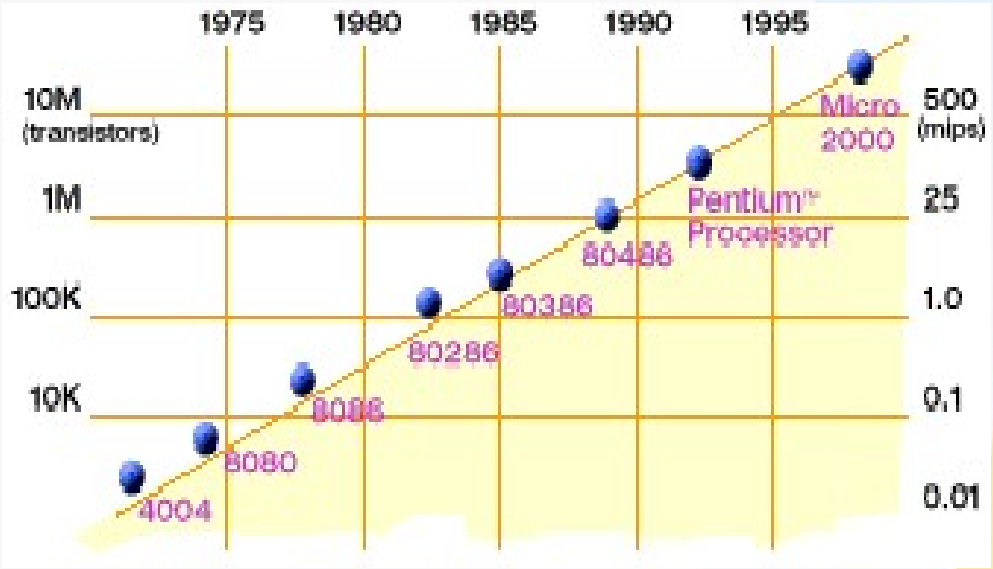
INTRODUCTION

- Computer performance has been increasing phenomenally over the last five decades.
- Brought out by Moore's Law:
  - Transistors per square inch roughly double every eighteen months.
- Moore's law is not exactly a law:
  - but has held good for nearly 50 years.

Moore's Law



Gordon Moore (co-founder of Intel)



predicted in 1965: "Transistor density of minimum cost semiconductor chips would double roughly every 18 months."

Transistor density is *correlated* to processing speed.

Moore's Law: it's worked for a long time

Trends Related to Moore's Law

- Processor performance:
  - Twice as fast after every 2 years (roughly).
- Memory capacity:
  - Twice as much after every 18 months (roughly).

How Did Performance Improve?

- Since 1980s, most of the performance improvements have come from:
  - Architectural and organizational innovations

- What is the difference between:
  - Computer architecture and computer organization?

Architecture vs. Organization

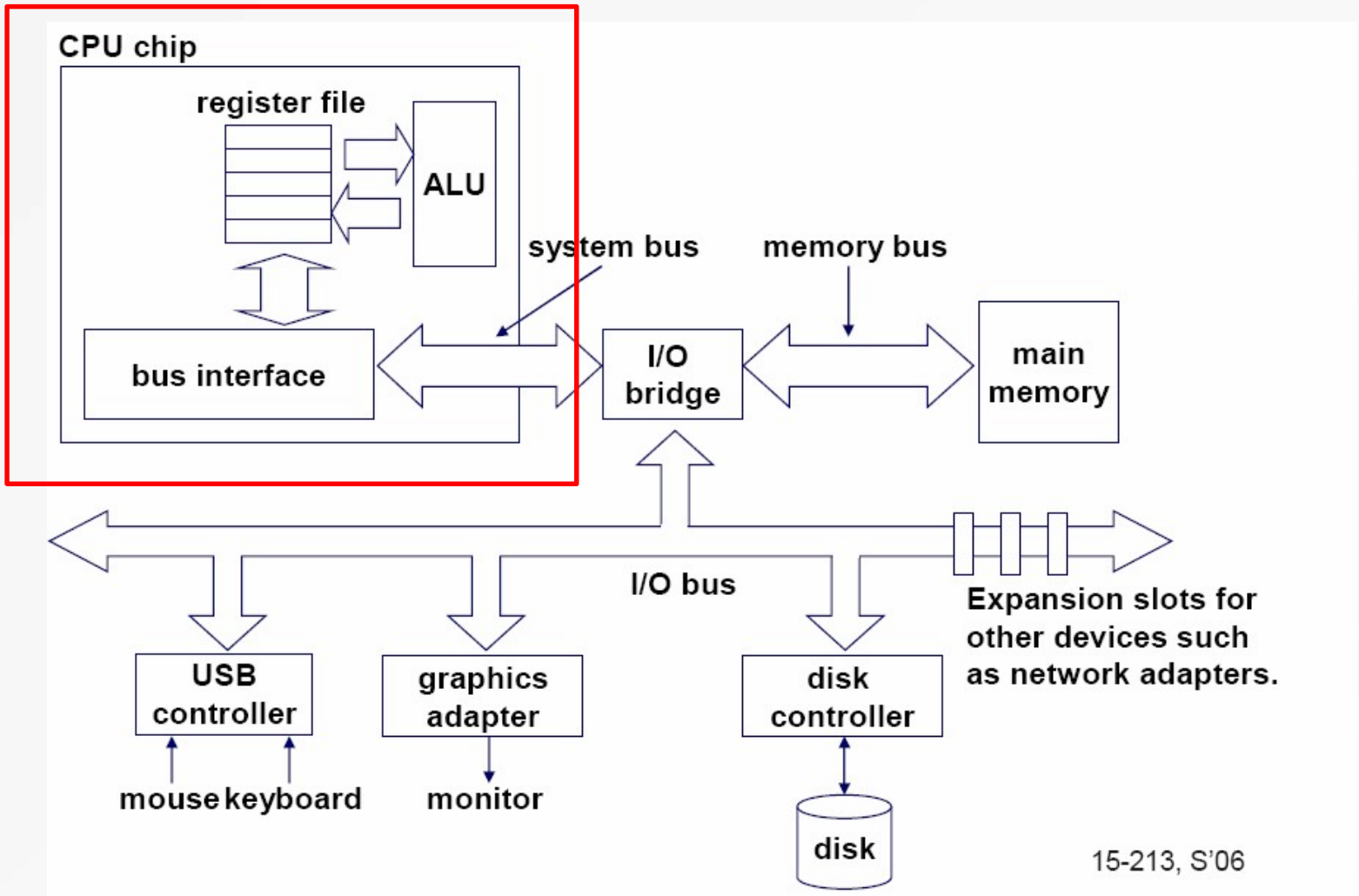
- Architecture:
  - Also known as Instruction Set Architecture (ISA)
  - Programmer visible part of a processor: instruction set, registers, addressing modes, etc.
- Organization:
  - High-level design: how many caches? how many arithmetic and logic units? What type of pipelining, control design, etc.
  - Sometimes known as micro-architecture
  - A microarchitecture is a hardware implementation of an ISA (instruction set architecture). An ISA is a structure of commands and operations used by software to communicate with hardware. A microarchitecture is the hardware circuitry that implements one particular ISA.

Computer Architecture

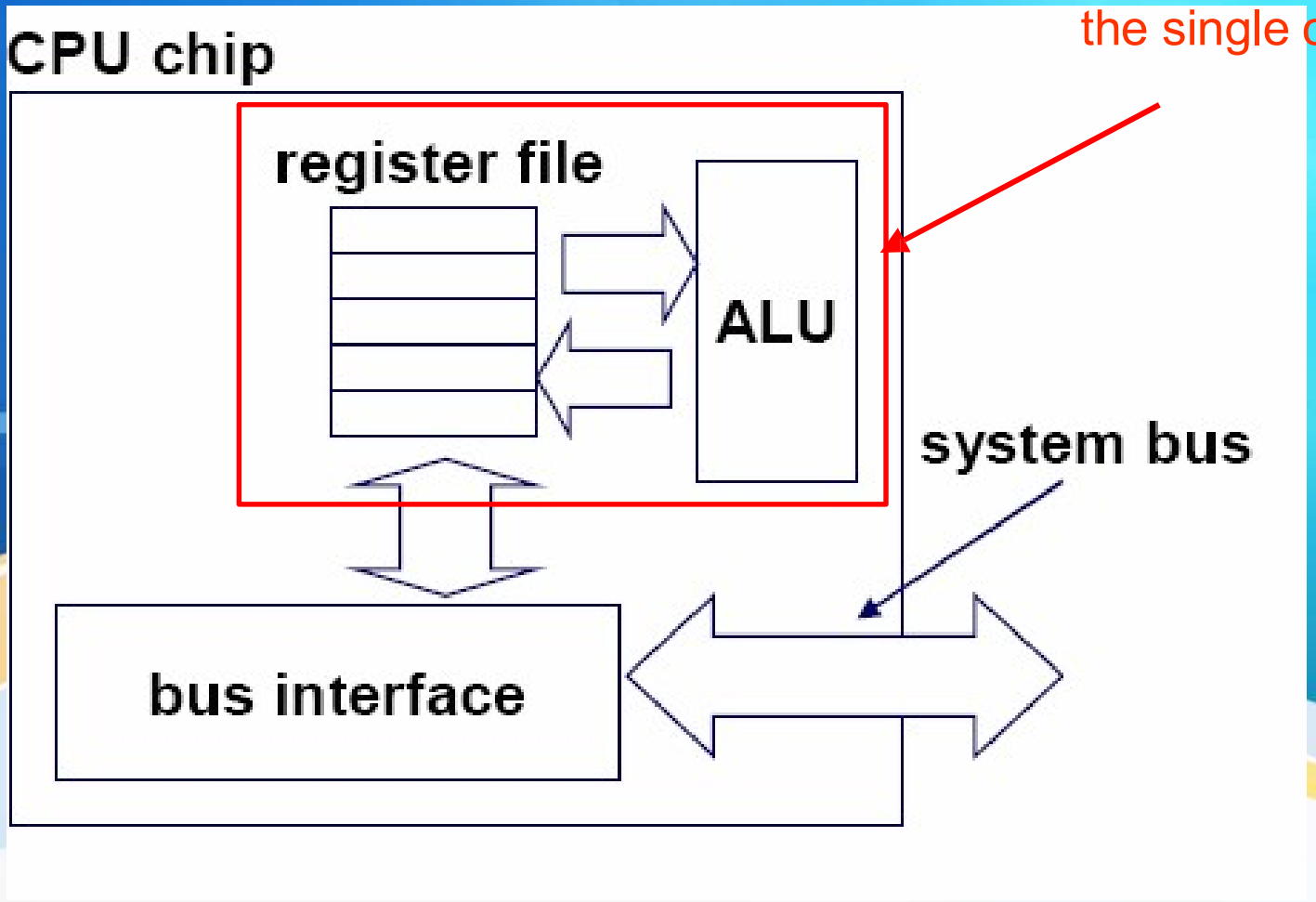
- The structure of a computer that a machine language programmer must understand:
  - – To be able to write a correct program for that machine.
- A family of computers of the same architecture should be able to run the same program.
  - – Thus, the notion of architecture leads to "binary compatibility."

- Modern processors such as Intel Pentium, AMD Athlon, etc. use:
  - Many architectural and organizational innovations
  - Innovation in memory, bus, and storage designs as well.
  - Multiprocessors and clusters

Single-core computer

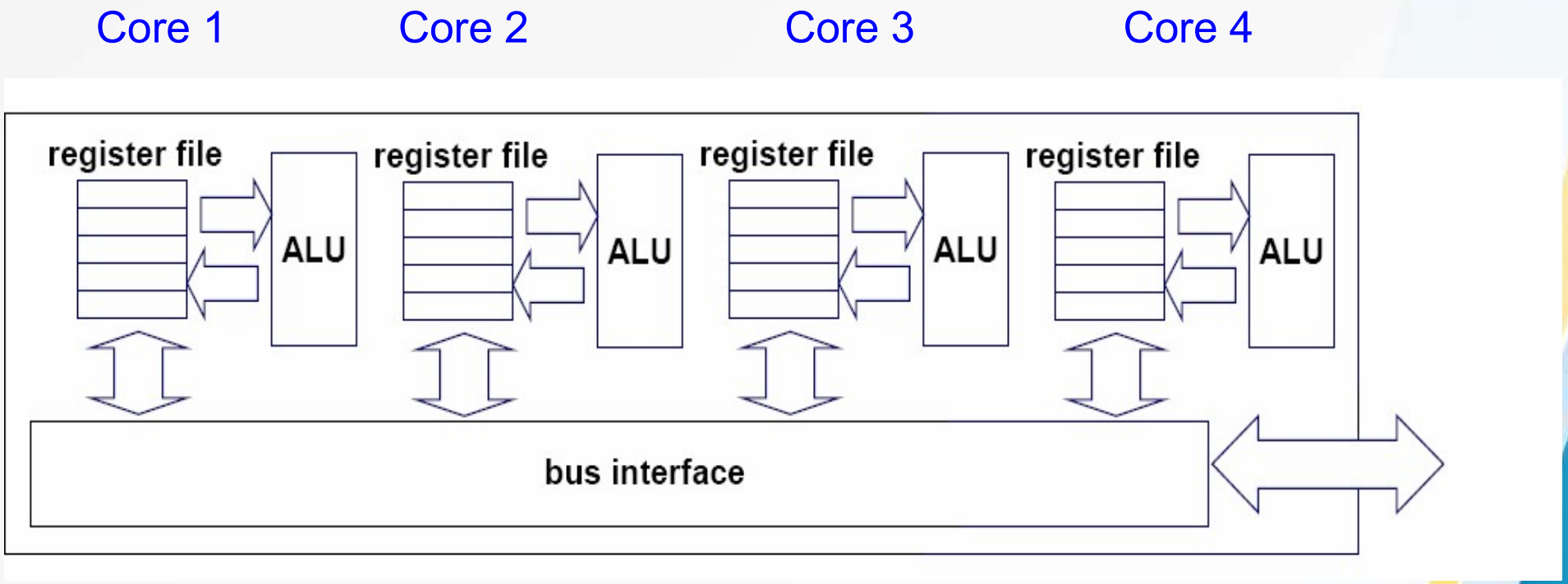


Single-core CPU chip



Multi-core architectures

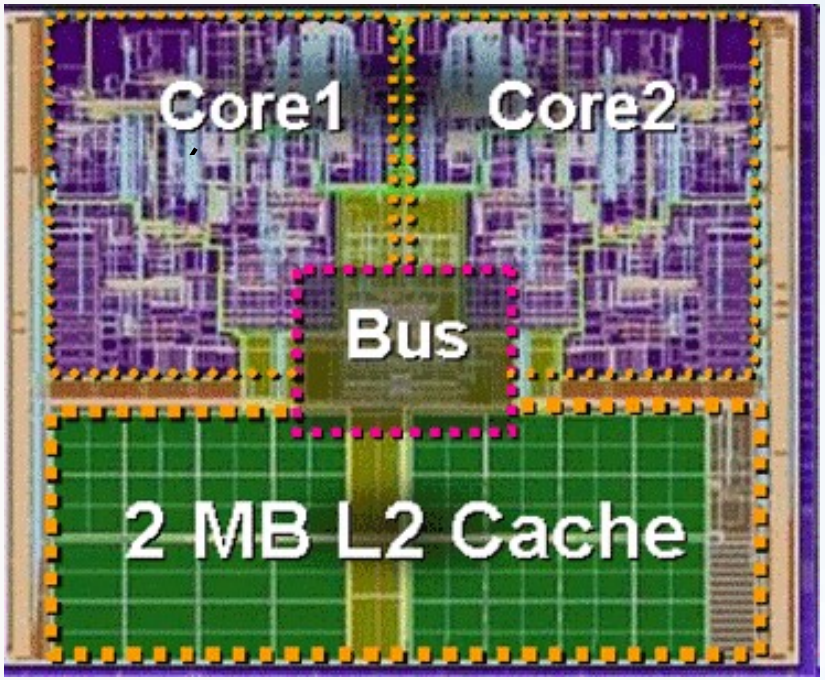
Replicate multiple processor cores on a single die.



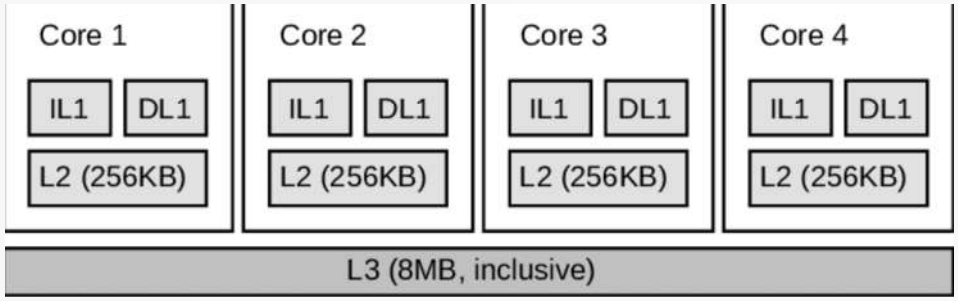
Multi-core CPU chip

Intel Core 2 Duo

- Homogeneous cores
- Bus based chip interconnect.
- Shared on-die Cache Memory.



Source: Intel Corp.



Intel Core 2 Duo

- Replacement for Pentium 4 and Pentium D CPUs.
- Intel claims:
  - Core 2 duo provides 40% more performance at 40% less power compared to the Pentium D.
- All Conroe processors are manufactured with 4 MB L2 cache:

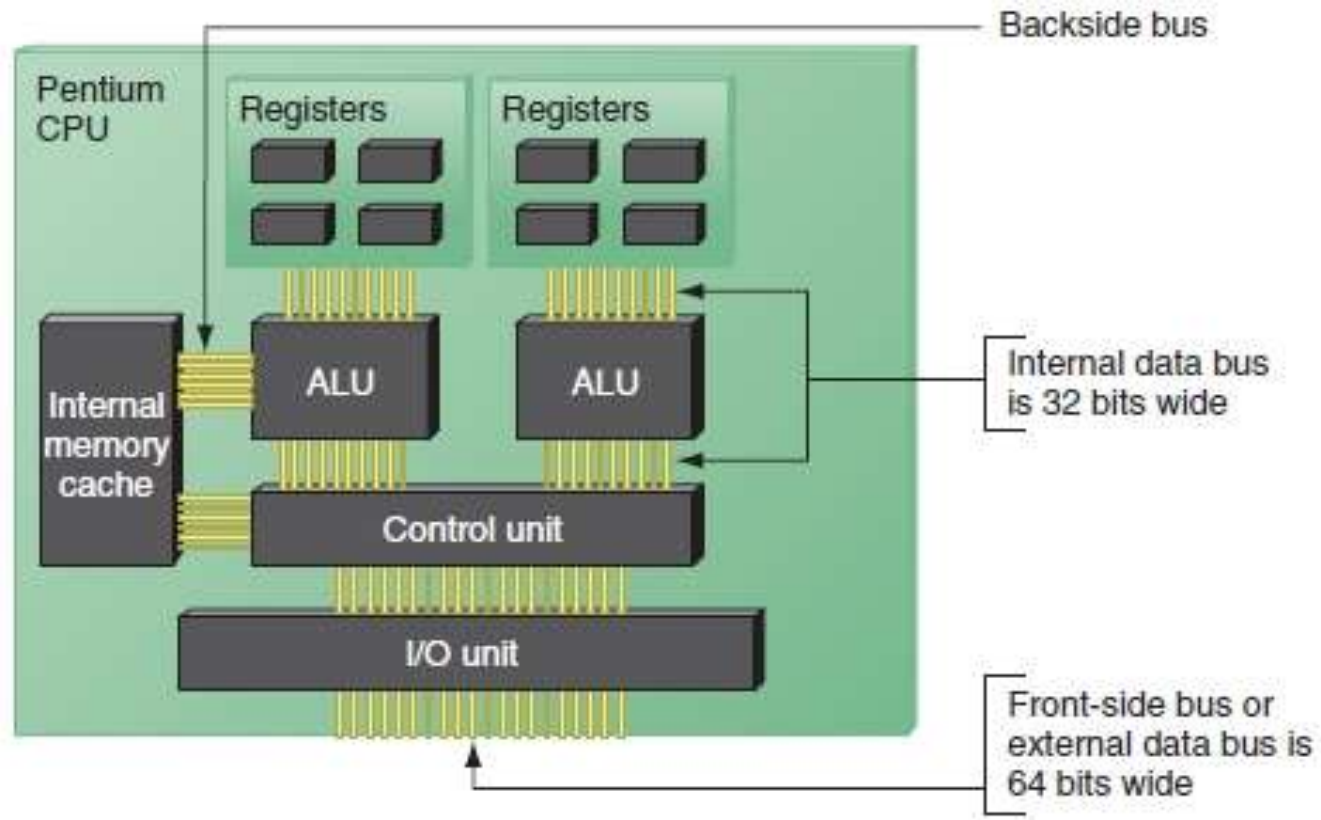


Figure : Since the Pentium processor was first released in 1993, the standard has been for a processor to have two arithmetic logic units so that it can process two instructions at once

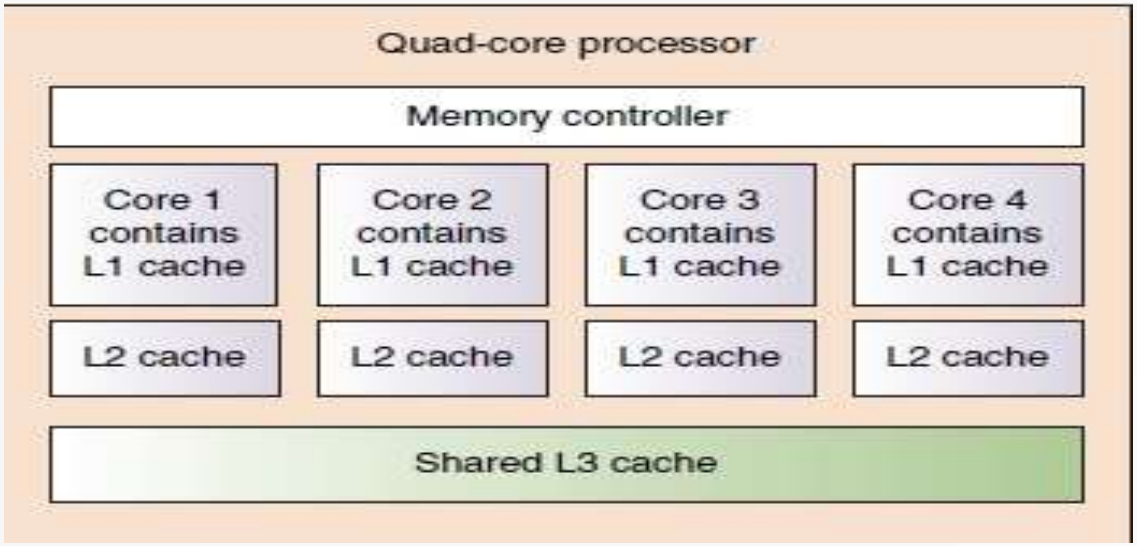


Figure: Quad-core processing with L1, L2, and L3 cache and the memory controller within the processor housing
Courtesy: Course Technology/Cengage Learning

Processor	Clock Speed	Front Side Bus	Description
Core Family			
Core i7 Extreme	3.20GHz	6.4 GT/s	8 MB cache, quad-core, DDR3 memory, desktop
Core i7	2.66 to 2.93 GHz	4.8 GT/s	8 MB cache, quad-core, DDR3 memory, desktop
Core 2 Extreme	2.53 to 3.2 GHz	800 to 1600 MHz	4 to 12 MB cache, quad-core, dual-core, desktop, or mobile
Core 2 Quad	2.0 to 3.0 GHz	1066 to 1333 MHz	4 to 12 MB cache, quad-core, desktop, or mobile
Core 2 Duo	1.06 to 3.33 MHz	533 to 1333 MHz	2 to 6 MB cache, dual-core, desktop, or mobile
Core Duo	1.5 to 2.33 GHz	533 to 667 MHz	2 MB cache, dual-core, desktop, or mobile
Core 2 Solo	1.06 to 1.2 GHz	533 or 800 MHz	Single-core mobile
Core Solo	1.06 to 1.83 GHz	533 or 667 MHz	Single-core mobile
Pentium Family			
Pentium Extreme	3.20 to 3.73 GHz	800 or 1066 MHz	2 or 4 MB cache, dual-core for gaming
Pentium 4 Extreme	3.20 to 3.46 GHz	800 or 1066 MHz	2 MB cache, high performance
Pentium Dual-Core	1.6 to 2.6 GHz	800 MHz	1 or 2 MB cache, dual-core, mobile, and desktop
Pentium D	2.66 to 3.6 GHz	533 or 800 MHz	2 or 4 MB cache, dual-core, desktop
Pentium M	1.0 to 2.26 GHz	400 or 533 MHz	1 or 2 MB cache, mobile
Pentium	1.6 to 2.7 GHz	533 or 800 MHz	1 MB cache, dual-core, desktop, or mobile

Intel Processors (cont'd.)

Processor	Clock Speed	Front Side Bus	Description
Pentium 4	2.8 to 3.8 GHz	800 MHz	256 K to 2 MB cache, single-core, desktop, or mobile
Mobile Pentium 4	2.8 to 3.46 GHz	533 MHz	512 K or 1 MB cache, single-core, mobile
Celeron Family			
Celeron	1.6 to 2.2 GHz	667 or 800 MHz	128 KB to 1 MB cache, for basic computing, desktop, and mobile
Celeron D	2.13 to 3.6 GHz	533 MHz	256 KB to 512 KB cache, some only 32-bit processing, desktop
Celeron M	900 MHz to 2.16 GHz	400 to 667 MHz	128 KB to 1 MB cache, some only 32-bit processing, mobile
Atom Family			
Atom	800 MHz to 1.86 GHz	400 or 533 MHz	512 K or 1 MB cache, single-core, low-end desktop, or mobile

Table Current Intel processors (continued)

Intel® Core™ processors

- A processor is like a computer's brain - and **Intel® Core™ processors** are the most powerful. They have multiple cores for more power and smoother multi-tasking.

- **There are 4 main categories: i3, i5, i7 and i9.**

- Each year the Intel® Core™ processors are updated. 2018's updates are known as the 8th generation.
- The number after the hyphen on its serial number should give you a clue – for example, an Intel® Core™ i7-7820HQ is 7th gen

- **8th Generation Intel® Core™ processors**

- Intel®'s 8th Generation of processors has moved with the times and delivered some exciting new features. Including:

- Incredible VR experiences
- High-quality 4K UHD content
- Two more cores – up to 6 instead of the original 4
- Introduction of the super powered Intel Core i9 and X-series.

- **With a Core™ i3 you can:(no of core 2-4)**

- Browse multiple webpages smoothly
- Work in Word or Excel
- Stream movies and TV shows from Netflix in HD
- Listen to music on Spotify
- Multi-task efficiently with Intel® Hyper-Threading technology

With a Core™ i5 (no of core(2-4),you can:(

- **Smoothly multitask - work on spreadsheets, stream music and browse the web**
- **Work on complicated tasks – like rendering big Excel files**
- **Edit in Photoshop and sketch in Illustrator**
- **Create, share and watch 4K content**
- **Play intensive PC games – see more Intel®'s gaming processors**
- **Benefit from faster repeated tasks thanks to the large cache size**
- **Stream from multiple sites**
- **Get a temporary boost when using demanding programs with Intel® Turbo Boost Technology 2.0**

- With a Core™ i7(no-of core 4-6) you can:

- Encode video more efficiently
- Work smoothly in 3D modelling programs
- Smoothly edit in Photoshop and sketch in Illustrator
- Watch and edit 4K UHD content and 360° videos
- Work productively with demanding creative programs – each core uses 2 'threads' rather than 1 with Intel®'s Hyper-Threading technology
- Benefit from faster repeated tasks thanks to the large cache size

- Core™ i9 – Extreme gaming, mega-tasking and high-end content creation

- The newest addition to the Intel family, the Core™ i9 X-Series, is Intel's most powerful processor with 18 cores and 36 threads. And with updated Intel® Turbo Boost Max Technology 3.0, it elevates everything you do to new heights.
- With a Core™ i9 (no-of core-8-16)you can:

- Produce, edit and share 4K UHD content and 360° videos
- Work smoothly in 3D modelling programs
- Produce and edit high-quality music
- Smoothly edit in Photoshop and sketch out in Illustrator
- Enjoy the ultimate gaming and VR experience
- Work more productively when using demanding creative programs
- Benefit from faster repeated tasks thanks to the large cache size

Classes of Computer

The computer systems can be classified on the following basis:

1. On the basis of size.
2. On the basis of functionality.
3. On the basis of data handling.

Classes of Computer

Classification on the basis of size

- super computer
- mainframe computer
- mini computer
- microcomputer

Classification on the basis of Functionality

- Server
- Workstation
- Embedded Computer

Classification on the basis of Data Handling

- Analog
- Digital
- Hybrid

Classification on the basis of size:super computer

- A supercomputer is a computer with great speed and memory. This kind of computer can do jobs faster than any other computer of its generation. They are usually thousands of times faster than ordinary personal computers made at that time.
- A supercomputer can be built by stacking computer processors in a giant box and interconnecting them to work on a complex task through parallel processing. Such an arrangement is called a Cluster supercomputer. Here, each individual computer in the cluster is called a node.
- Supercomputers speed are measured in floating point operations per second (FLOPS) in units of :
  - megaflops (MFLOPS)
  - gigaflops (GFLOPS)
  - teraflops (TFLOPS)

  Used for solving high calculation and intensive tasks like:

  - Weather forecasting
  - Analysis of data and information
  - Astronomical Observation
  - Integrate design of engineering products
  - For solving large input scientific calculations and advanced scientific problems.

supercomputer manufacturer

Aspen Systems,SGI,IBM,Cray Research,Compaq, Hewlett-Packard, Thinking Machines,Cray Computer Corporation,Control Data Corporation

super computer chhallenges

- Generates large amount of heat.
- The speed of data transfer will limit the super computer's performance.
- Supercomputer's consume and produce massive amount of data in a very short period of time .

world fasted supercomputer:Jaguar

- High speed(1.759 Petaflop)
- Great performance
- High data transfer rate(284GB/s)
- High system memory(362TB)

Pratyush [Cray XC40*]
Owner -> Indin Institute of Tropical Meteorology
Processor -> Intel Xeon Broadwell E5-2695 v4 18-core processors with a clock speed of 2.1GHz
Rank -> 45th

Classes of Computer

Feature	Personal mobile device (PMD)	Desktop	Server	Clusters/warehouse-scale computer	Internet of things/ embedded
Price of system	$100–$1000	$300–$2500	$5000–$10,000,000	$100,000–$200,000,000	$10–$100,000
Price of microprocessor	$10–$100	$50–$500	$200–$2000	$50–$250	$0.01–$100
Critical system design issues	Cost, energy, media performance, responsiveness	Price-performance, energy, graphics performance	Throughput, availability, scalability, energy	Price-performance, throughput, energy proportionality	Price, energy, application-specific performance