Introduction to
High performance Computing

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COMPUTER ARCHITECTURE

A Quantitative Approach

MK
MORGAN KAUFMANN

High performance computing (HPC) is the ability to process data and perform complex calculations at high speeds.

Moore's Law

- The number of transistors per square inch on integrated circuits had doubled every year since their invention (1958).

  (Prediction - This trend will continue into the foreseeable future)

- New Definition –

  The number of transistors per square inch has doubled approximately every 18 months that is computing power doubles every 18-months.
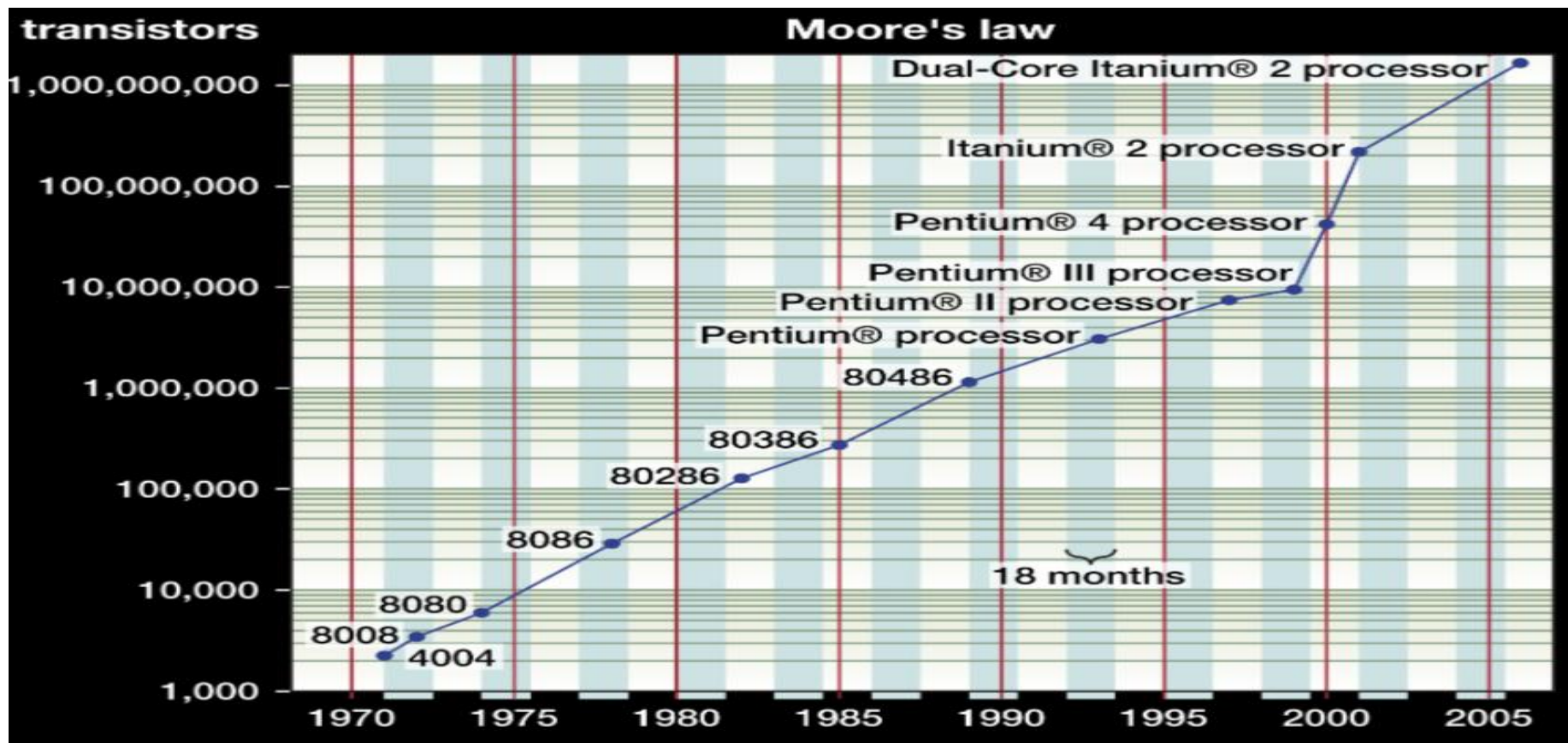
Gordon E. Moore

- ✓ Co founder of the reputed INTEL corporation who is basically a chemist and physicist.
- ✓ The term "Moore's law" was named after him
- ✓ He published this article on 19th April 1965 in the electronic magazine.
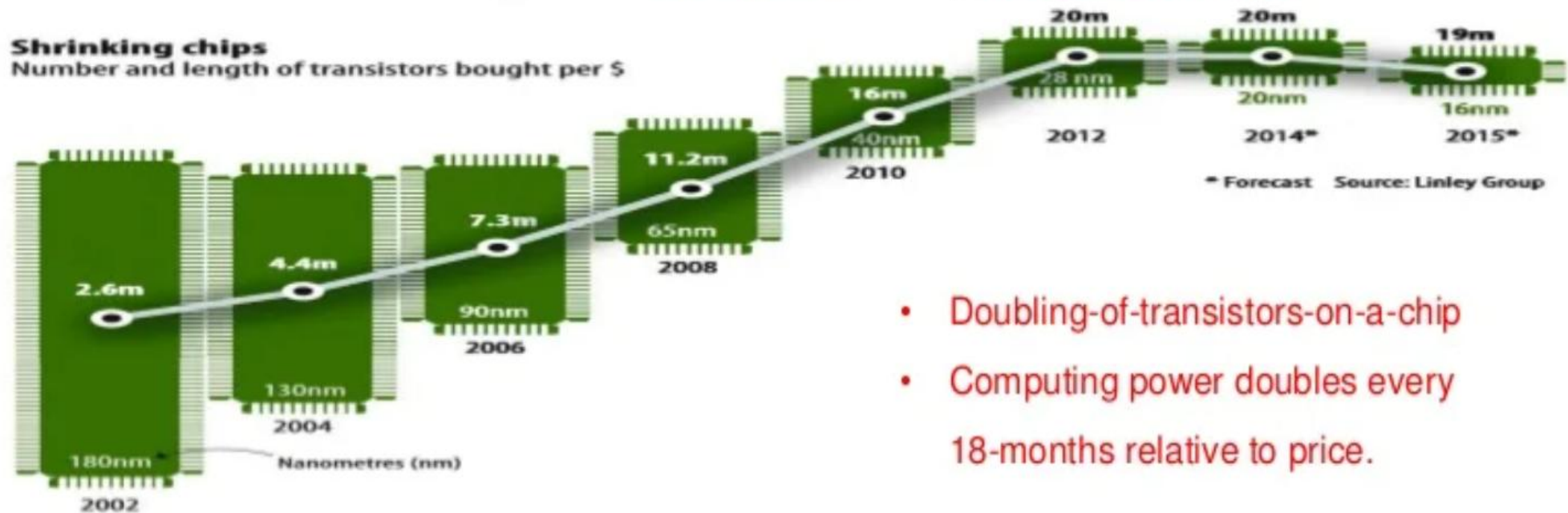
Moore's law.

Gordon E. Moore observed that the number of transistors on a computer chip was doubling about every 18–24 months. As shown in the graph of the number of transistors on Intel's processors at the time of their introduction, his "law" was being obeyed.

transistors — Moore's law

1,000,000,000	Dual-Core Itanium® 2 processor
100,000,000	Itanium® 2 processor
10,000,000	Pentium® 4 processor / Pentium® III processor / Pentium® II processor / Pentium® processor
1,000,000	80486
100,000	80386 / 80286
10,000	8086 / 8080 / 8008 / 4004
1,000	

18 months

1970 1975 1980 1985 1990 1995 2000 2005

Is Moore's law still holding?

Moore's law is not a natural law, it is an observation did by Gordon E. Moore.

Shrinking chips
Number and length of transistors bought per $

- 20m
- 20m
- **19m**
- 28 nm
- 20nm
- 16nm
- 2012
- 2014*
- 2015*

*Forecast   Source: Linley Group

- 16m
- 40nm
- 2010

- 11.2m
- 65nm
- 2008

- 7.3m
- 90nm
- 2006

- 4.4m
- 130nm
- 2004

- 2.6m
- 180nm
- Nanometres (nm)
- 2002

- Doubling-of-transistors-on-a-chip
- Computing power doubles every 18-months relative to price.

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).

With Moore's Law -
1. Drastically reduce the cost of a processor by making the same processor with a smaller area.
2. Use same area to make a better processor

How Did Performance Improve?

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

- 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

Classes of Computer

Classification on the basis of purpose
- microcomputer
- mini computer
- super computer
- mainframe computer

Classification on the basis of Functionality
- Server
- Workstation
- Embedded Computer

Microcomputers (personal computers)

The term "microcomputer" was introduced with the advent of systems based on single core chip or multicore chip.

- ✓ **Desktop computers ,**
- ✓ **Laptop Computers and notebook computers –**
- ✓ **Portable Tablet computer – Like laptops, but with a touch-screen, entirely replacing the physical keyboard.**
- ✓ **Smartphones, smartbooks, and Palmtop computers – Small handheld personal computers with limited hardware specifications.**
- ✓ **Video game consoles – Fixed computers built specifically for entertainment purposes.**
- ✓ **Handheld game consoles – The same as game consoles, but small and portable.**
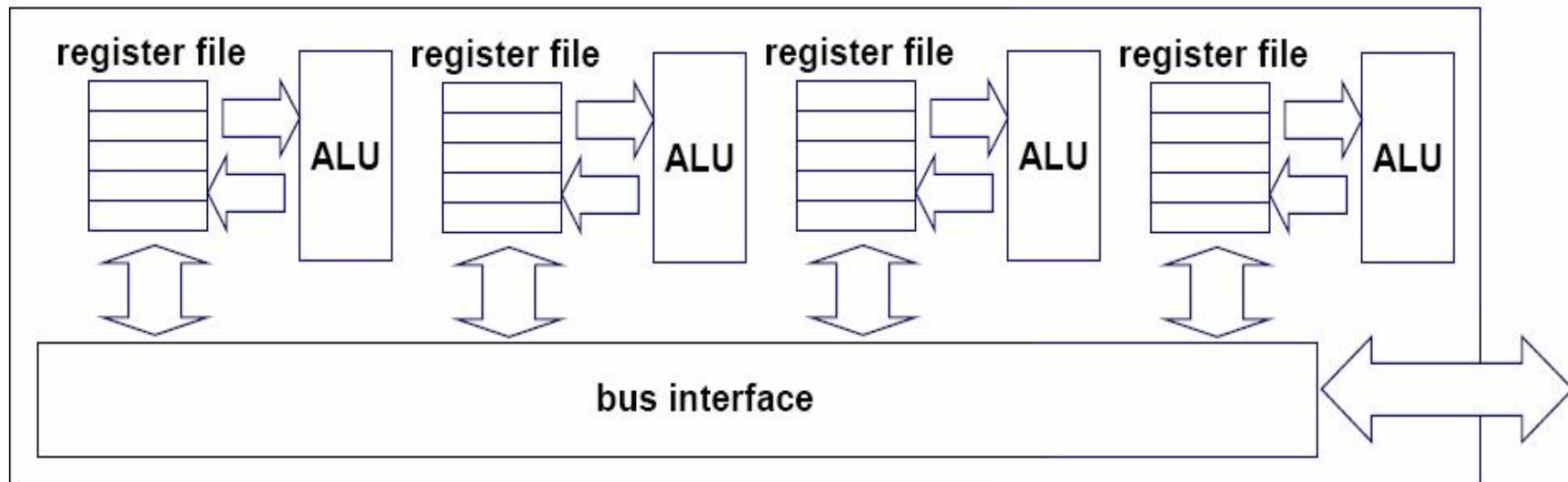
Single-core computer
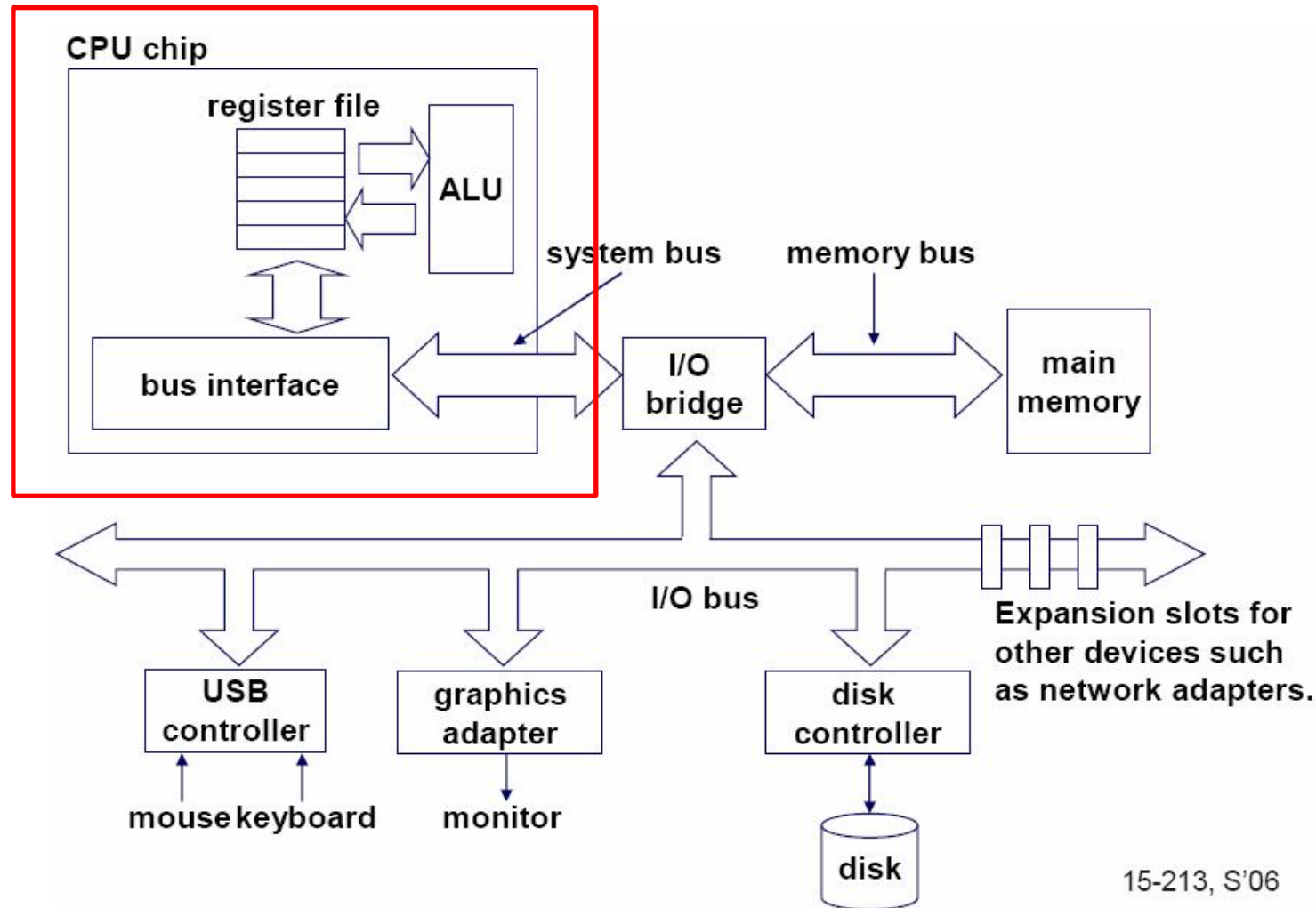
Multi-core CPU chip

Replicate multiple processor cores on a single die.

Core 1   Core 2   Core 3   Core 4

Multi-core CPU chip   4

Minicomputers : are a class of multi-user computers that lie in the middle range of the computing spectrum, in between the smallest mainframe computers and the largest single-user systems (microcomputers or personal computers).

- ✓ higher-end SPARC, POWER and Itanium-based systems from Oracle Corporation, IBM and Hewlett-Packard.

Mainframe computers
- ✓ Institutional computer intended to service multiple users from the smaller, single-user machines.
- ✓ These computers are capable of handling and processing very large amounts of data quickly.
- ✓ Mainframe computers are used in large institutions such as government, banks, and large corporations.
- ✓ They are measured in MIPS (million instructions per second) and can respond to hundreds of millions of users at a time.

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**

Classification on the basis of Functionality

Servers: database server, file server, web server

Workstation: desktop PCs with high-performance hardware

Embedded computers: are computers that are a part of a machine or device.

- ✓ Embedded computers generally execute a program that is stored in non-volatile memory and is only intended to operate a specific machine or device.
- ✓ Embedded computers are typically required to operate continuously without being reset or rebooted, and once employed in their task the software usually cannot be modified.
- ✓ An automobile may contain a number of embedded computers; however, a washing machine or DVD player would contain only one microcontroller.
- ✓ Embedded computers are chosen to meet the requirements of the specific application, and most are slower and cheaper than CPUs found in a personal computer.