PARALLEL PROCESSING

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ABOUT THE COURSE

CSC 453 - Parallel Processing, 3 credits

Introduction to parallel processing. Models of parallel machines. Parallel programming paradigms and models. Performance analysis of parallel systems. Parallel programming languages and frameworks.

The course objectives are to expose the students, starting with introductory topics and progressing to advanced topics, to:

(1) Paradigms of parallel computation and measures of efficiency.

(2) Most important parallel computing architectures.

(3) Most important parallel programming models, languages and frameworks.

WHAT IS PARALLEL PROCESSING?

- **Parallel processing:** Is a method of simultaneously breaking up and running program tasks on multiple processing elements, the aim is to reduce processing time.
- Example:

Instruction N	Fetch	Decode	Execute			
Instruction N+1		Fetch	Decode	Execute		
Instruction N+2			Fetch	Decode	Execute	
Instruction N+3				Fetch	Decode	Execute

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Instruction N+3	Fetch	Decode	Execute

WHAT IS PARALLEL PROCESSING?

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What is the difference between Intel Core i3, i5 and i7 ?

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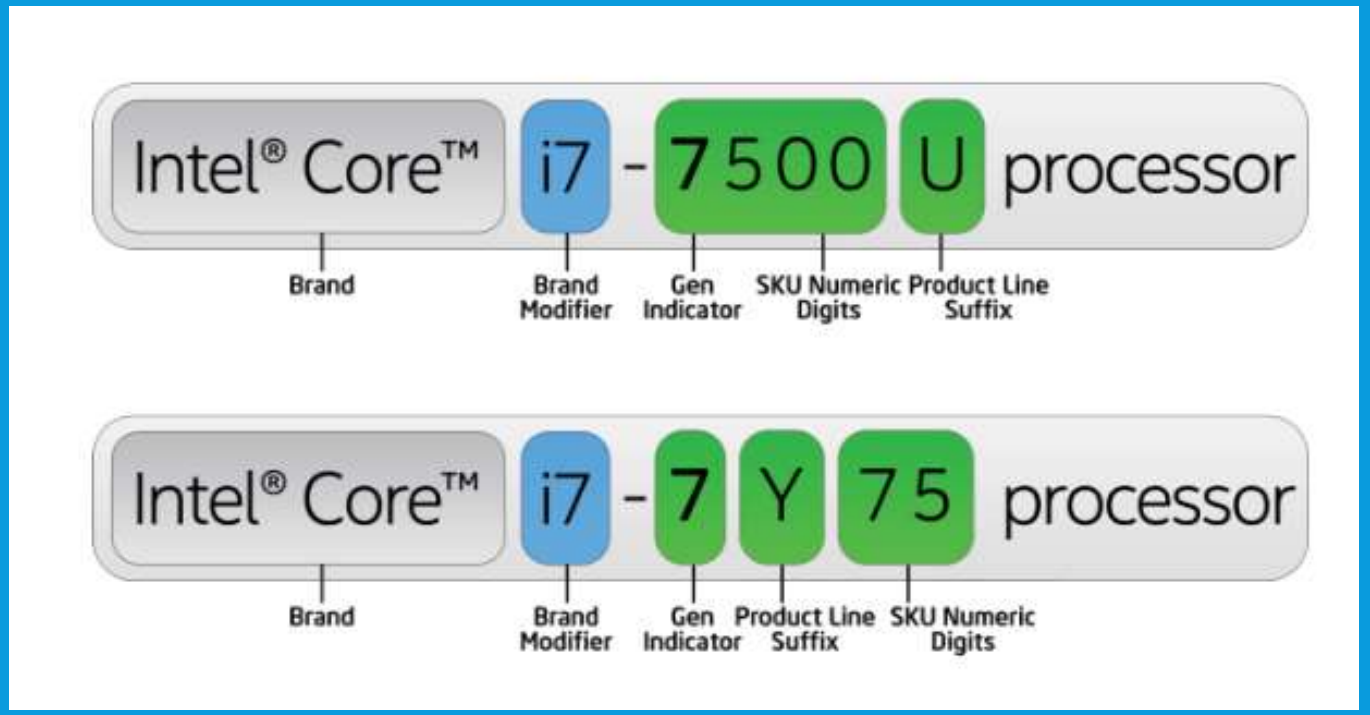


WHAT IS PARALLEL PROCESSING?

What is the difference?

- **Number of cores**
- **Clock speed**
- **Number of threads**
- **Cache**

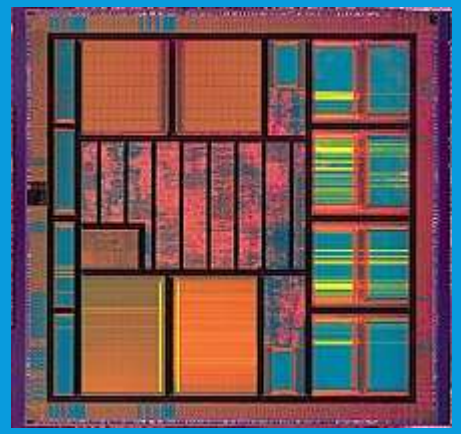
WHAT IS PARALLEL PROCESSING?

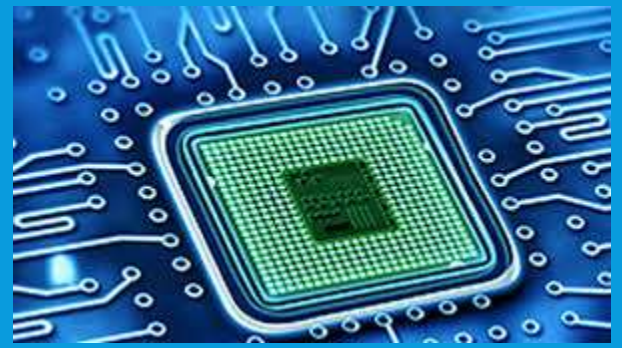
Benchmark your computer?

https://cpu.userbenchmark.com/

WHY PARALLEL PROCESSING?

- It becomes more possible because of Hardware improvement
  - Moore's law 1965 : The growth of microprocessor speed/performance by a factor of 2 every 18 months.
  - VLSI chips with millions of transistors per chip for microprocessors, and billions for dynamic random-access memories (DRAMs)





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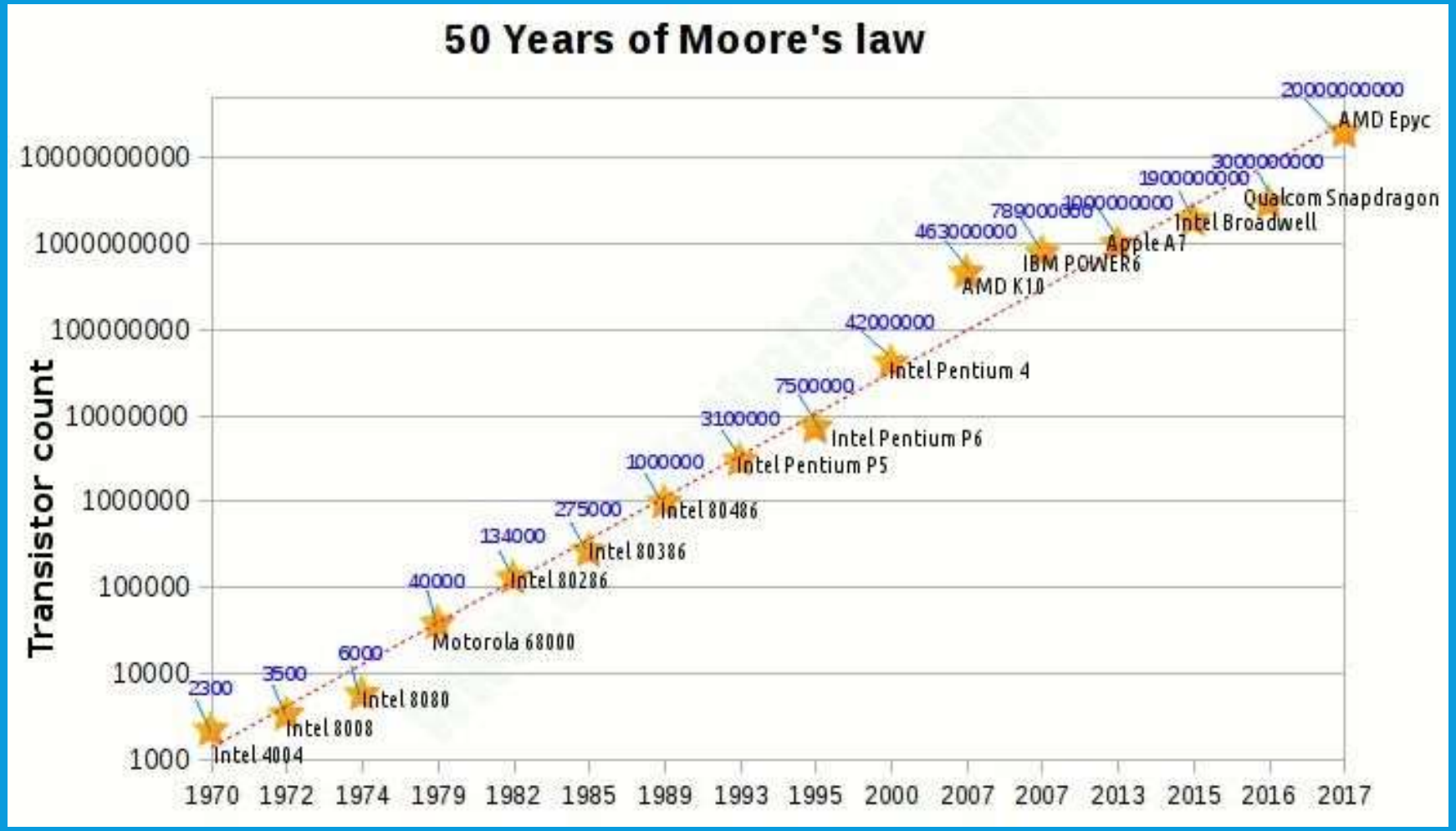

WHY PARALLEL PROCESSING?

- Architecture improvement
  - on-chip cache memories.
  - large instruction buffers.
  - multiple instruction issue per cycle.
  - multithreading.
  - deep pipelines (adding more stages to pipeline)
  - out-of-order instruction execution (dynamic execution).
  - branch prediction.

WHY PARALLEL PROCESSING?

- Motivations for parallel processing:
  - The need for faster problem solving (Some problems has a hard deadline.)
  - The need for higher throughput (solving more problems at the same time.)
  - The need for higher computational power (more detailed & accurate results.)

WHY PARALLEL PROCESSING?

Can we execute in parallel?

A = B + C

D= A + F

Why?

WHY PARALLEL PROCESSING?

A = B + C

MOV R2, B

MOV R3, C

ADD3 R1, R2, R3

MOV A, R1

D= A + F

MOV R2, A

MOV R3, F

ADD3 R1, R2, R3

MOV D, R1

EXAMPLE OF PARALLEL PROCESSING?

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- Matrix Multiplication $O(n^3)$ → $O(n^3)/p + comm$

$$\begin{bmatrix} a_1 & a_2 & a_3 \\ a_4 & a_5 & a_6 \\ a_7 & a_8 & a_9 \end{bmatrix} \begin{bmatrix} b_1 & b_2 & b_3 \\ b_4 & b_5 & b_6 \\ b_7 & b_8 & b_9 \end{bmatrix} = \begin{bmatrix} c_1 & c_2 & c_3 \\ c_4 & c_5 & c_6 \\ c_7 & c_8 & c_9 \end{bmatrix}$$