You Are Here!

Software | *Hardware*

- Parallel Requests
  - Assigned to computer
  - e.g., Search "Katz"
- Parallel Threads
  - Assigned to core
  - e.g., Lookup, Ads
- Parallel Instructions
  - >1 instruction @ one time
  - e.g., 5 pipelined instructions
- Parallel Data
  - >1 data item @ one time
  - e.g., Add of 4 pairs of words
- Hardware descriptions
  - All gates functioning in parallel at same time

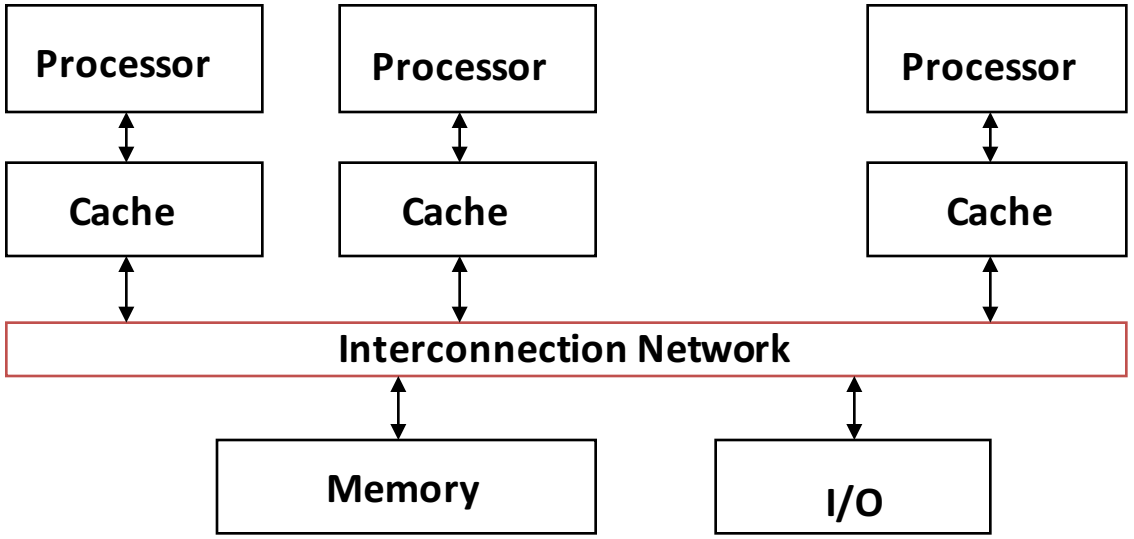
Harness Parallelism & Achieve High Performance

Warehouse Scale Computer

Smart Phone

Parallel Processing: Multiprocessor Systems (MIMD)

- Multiprocessor (MIMD): a computer system with at least 2 processors



1. Deliver high throughput for independent jobs via job-level parallelism
2. **Improve the run time of a single program that has been specially crafted to run on a multiprocessor - a parallel processing program**

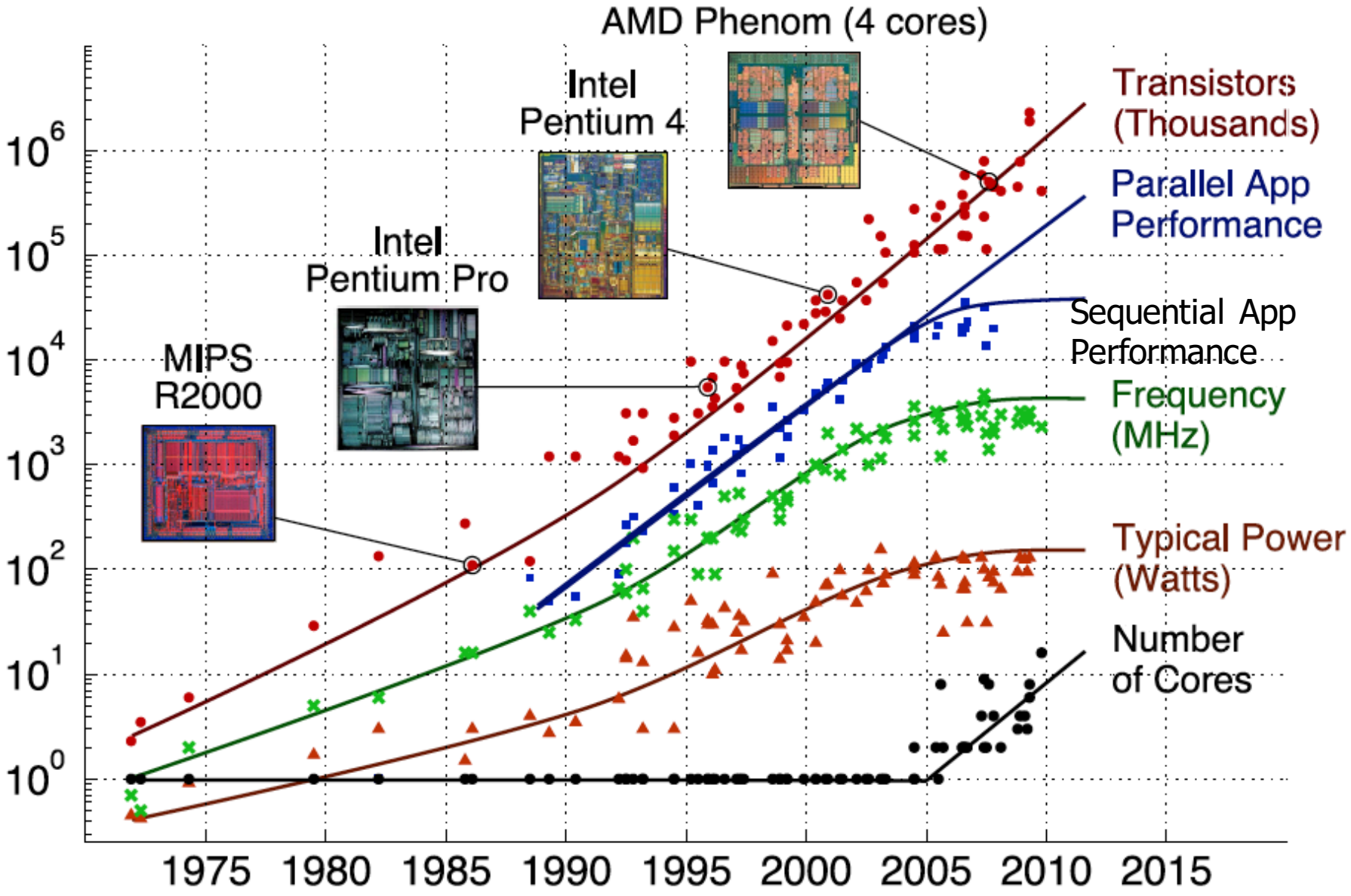
Now Use term *core* for processor ("Multicore") because "Multiprocessor Microprocessor" too redundant

Clicker Question

What significant thing happened in computer architecture around 2005?

a) CPU heat densities approached nuclear reactors
b) They started slowing the clock speeds down
c) Power drain of CPUs hit a plateau
d) CPU single-core performance hit a plateau
e) CPU manufacturers started offereing only multi-core CPUs for desktops and laptops

Transition to Multicore



Multiprocessors and You

- Only path to performance is parallelism
  - Clock rates flat or declining
  - SIMD: 2X width every 3-4 years
    - 128b wide now, 256b 2011, 512b in 2014?, 1024b in 2018?
    - **Advanced Vector Extensions** are 256-bits wide!
  - MIMD: Add 2 cores every 2 years: 2, 4, 6, 8, 10, …
- A key challenge is to craft parallel programs that have high performance on multiprocessors as the number of processors increase – i.e., that scale
  - Scheduling, load balancing, time for synchronization, overhead for communication
- Will explore this further in labs and projects

Parallel Performance Over Time

Year	Cores	SIMD bits /Core	Core * SIMD bits	Peak DP FLOPs
2003	2	128	256	4
2005	4	128	512	8
2007	6	128	768	12
2009	8	128	1024	16
2011	10	256	2560	40
2013	12	256	3072	48
2015	14	512	7168	112
2017	16	512	8192	128
2019	18	1024	18432	288
2021	20	1024	20480	320