You Are Here!

**Software**

- **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

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**Hardware**

- **Warehouse Scale Computer**
- **Parallelism & Achieve High Performance**

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**Computer**

- **Core**
- **...**
- **Core**
- **Memory**
  (Cache)
- **Input/Output**
- **Instruction Unit(s)**
- **Functional Unit(s)**
- **A_0 + B_0, A_1 + B_1, A_2 + B_2, A_3 + B_3**

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**Logic Gates**

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**Project 3**

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**Smart Phone**

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**Warehouse**

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**Scale**

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**Computer**

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**Harness**
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 offering only multi-core CPUs for desktops and laptops
Transition to Multicore

Data partially collected by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond
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
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