CS 100: Parallel Computing

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Week 12

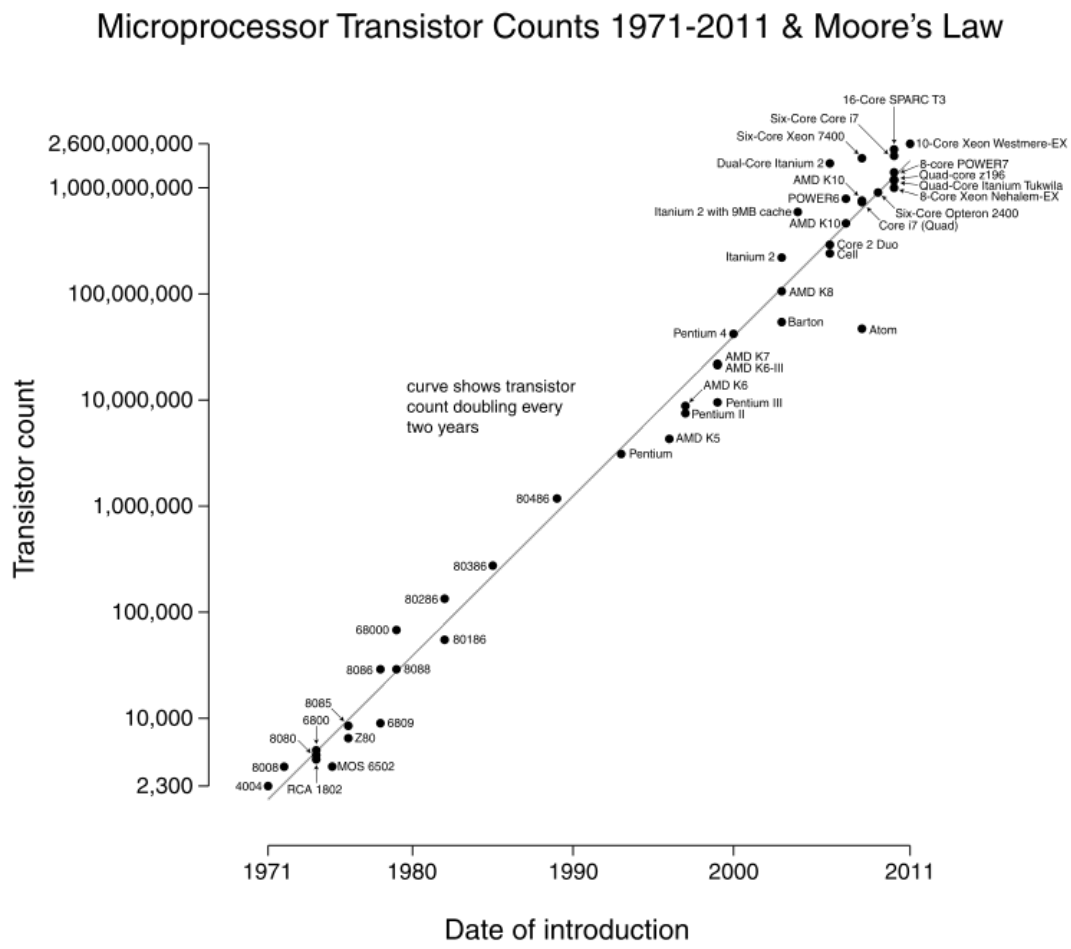
Logistics

Upcoming

- HW 5: Due Friday by 11:59pm
- HW 6: Up by Early Next Week

Moore's Law: CPUs get faster

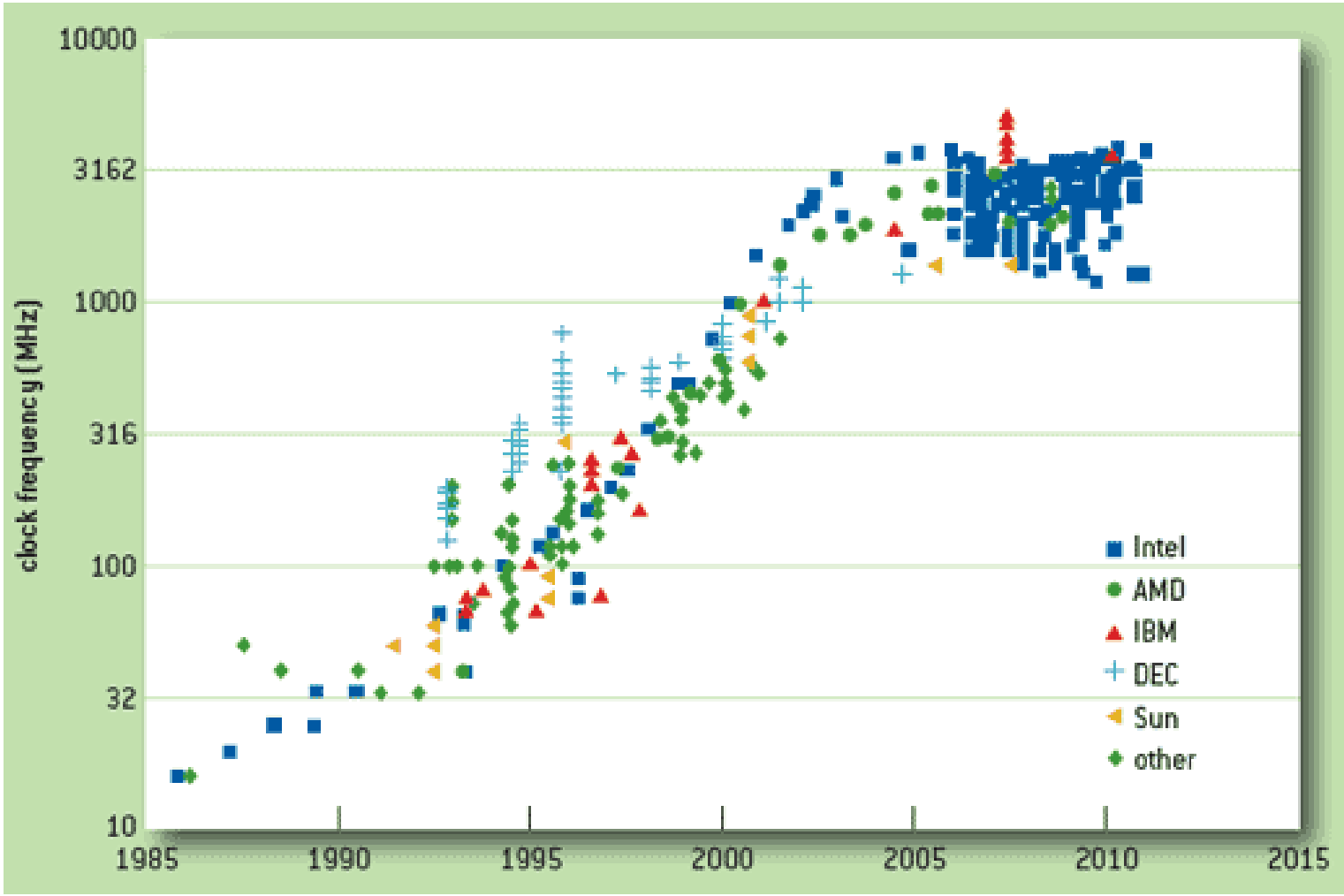
- Smaller transistors $\rightarrow$ closer together
- Smaller transistors can "flip" faster
- More faster transistors on a chip $\rightarrow$ more speed
- Processor speed doubles every 18 months



How Small are Transistors?

- Intel Core i7 uses a 32 nanometer process
- Distance between memory units in the processor is about 64 nanometers
- A hard sphere radius of a hydrogen Atom is about 0.11 nanometers
- About 591 atoms apart
- 22 nanometer processor is close

However...



Source: Danowitz et al

- CPU speed isn't getting faster these days
- Fastest Dell Speed I found was 4.0 GhZ

Why The Slow Down

Faster = Energy

- Changing bits faster requires energy, generates heat
- Faster processors suck down more power, get hotter
- Consider the data center: lots of CPUS stacked together get hot

Source

Google Me This

- How much energy total energy do datacenters consume?
- How many homes could you power with that amount of

Answer: The Cloud is Hungry

US data centers consumed about 70 billion kilowatt-hours of electricity in 2014, the most recent year examined, representing 2 percent of the country's total energy consumption, according to the study. That's equivalent to the amount consumed by about 6.4 million average American homes that year. This is a 4 percent increase in total data center energy consumption from 2010 to 2014, and a huge change from the preceding five years, during which total US data center energy consumption grew by 24 percent, and an even bigger change from the first half of last decade, when their energy consumption grew nearly 90 percent.

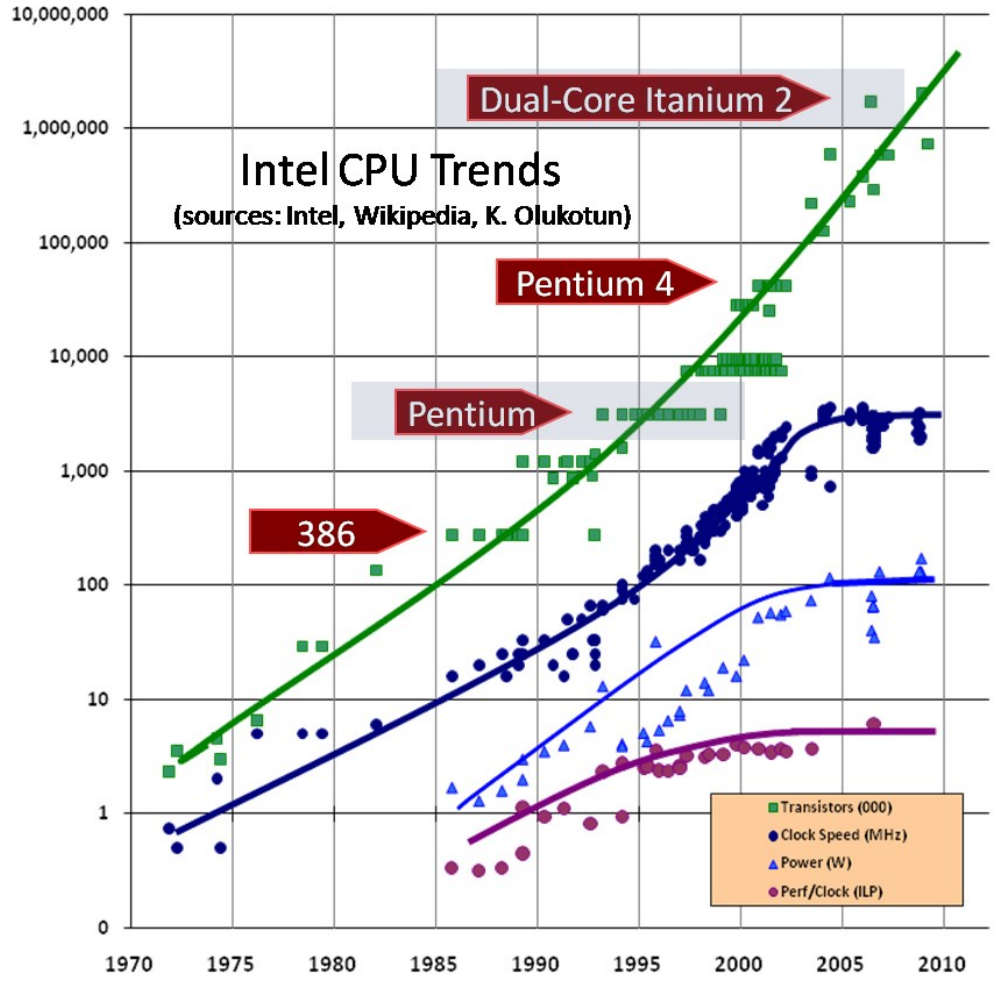
– *Here's How Much Energy All US Data Centers Consume by Yevgeniy Sverdlik on June 27, 2016, datacenterknowledge.com*

Consequences

At least a dozen major data centers have been cited for violations of air quality regulations in Virginia and Illinois alone, according to state records. Amazon was cited with more than 24 violations over a three-year period in Northern Virginia, including running some of its generators without a basic environmental permit.
– *Power, Pollution and the Internet, NYTimes by James Glanz, 9-22-2012*

Today's Processors: Mini-Parallel Computer

- Multiple independent processors
- Can add 2 or 4 or 8 numbers independently
- Can actually run multiple programs simultaneously
- Allows multitasking



Source: The death of CPU scaling: From one core to many

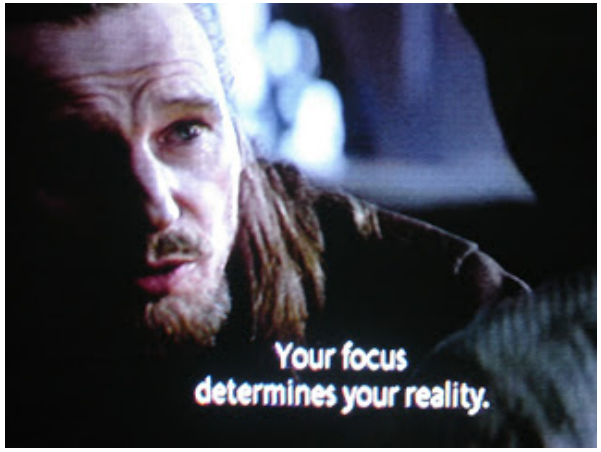
Can Humans Multi-task?

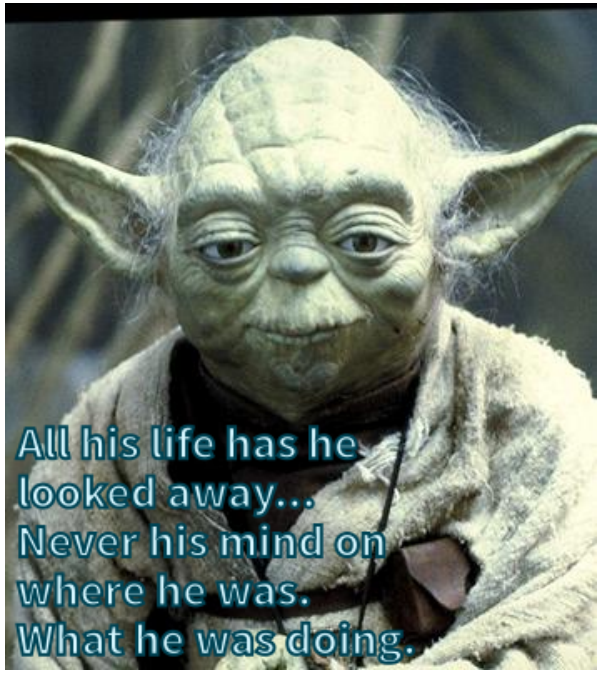
A Canadian Study

The students in the first experiment who were asked to multitask [during lecture] averaged 11 per cent lower on their quiz.

The students in the second experiment who were surrounded by laptops scored 17 per cent lower.

Laptop use lowers student grades, experiment shows, The Canadian Press, 8-14-2013





The Allure of Parallel Programming

- Having multiple CPUs is helpful for some problems just like having multiple people is helpful
- Amdahl's Law: Almost every problem has a serial component: a spot where only one proc/person can work
- Hillis: Parallel programming is faster than people believe
- Trade-offs: More CPUs cost money, is it worth it?

Source

In a call center each, person can work independently but if there are no calls to take, they get paid to watch cat videos.

Algorithms for Parallelel Execution

- Group activity to study parallel algorithms
- Need a sheet of paper

Step 1: Premise

- Find a group of 5 or 6 people
- In a moment, will show 250 Letter Grades A to F
- Be in 10 rows of 50 each like. . .

```
0: C C F A D F B
1: B B B F D F B
2: D B A F A F D
```

- Your group is a multi-processor computer
- Count all grades them into a histogram

```
Answer: A 3   B 6   C 2   D 4   F 6
```

- Write down counts on one new sheet of paper
- Bonus cards to first folks to submit correct answers
  - CK verifies answers
  - 3 cards first group of finishers
  - 2 cards to second group
  - 1 card to third group
- Bring your answer to the front

Step 2: Find an Algorithm

Task

Count letter grades into a histogram

```
0: C C F A D F B
1: B B B F D F B
2: D B A F A F D
```

- Hand paper to Chris to verify, bonus cards for quickness

Algorithm: Hand in after finishing

- In your group of 5 or 6, determine your algorithm
- How will you cooperate to sort the numbers as fast as possible?
- Write down your strategy/algorithm on a sheet of paper to turn in
- Include Full Names and NetIDs of everyone in your group

Data

```
0: A D F B D F B D D B F F B D B A B A F F B D A A A
1: F D B F D F B D A C F F D B B D B F B C C B A D D
2: D D D F F F D A F D C D B A A A B A C C D D F C C
3: D B D F B C A A C A B D A A B A F A A F F A A D C
4: F A C A A C A C F F D B B A F A B D C B B F D F B
5: A C D B F A F C A A A D A C D B F C B A A D F F F
6: C D D B C A D C D A B A B C D F F F F F F C B C D
7: A B D F A A A A F A F A A B C F A B B D A D C D B
8: B A A A A D C A A D F C F A A D D B C B F C F B B
9: F F D F B D F D A B C A D D B F F C D A A A C C C
```

Step 1: Premise

- Find a group of 5 or 6 people
- In a moment, will show 50 random numbers on the screen
- Will be 5 rows of 10 random numbers each, like. . .

86	12	45	54	61	11	49	12	15	86
99	45	12	54	11	61	49	15	12	99

- Your group is a multi-processor computer
- Sort all the numbers on the screen
- Write down entire sorted list on one new sheet of paper
- Bonus cards to first folks to submit correct answers
  - CK verifies answers
  - 3 cards first group of finishers
  - 2 cards to second group
  - 1 card to third group
- Bring your answer to the front

Step 2: Find an Algorithm

Task

- Will be 5 rows of 10 random numbers each, like...

86	12	45	54	61	11	49	12	15	86
99	45	12	54	11	61	49	15	12	99

- Write full list of sorted numbers on one sheet of paper
- Hand paper to Chris to verify, bonus cards for quickness

Algorithm: Hand in after finishing

- In your group of 5 or 6, determine your algorithm
- How will you cooperate to sort the numbers as fast as possible?
- Write down your strategy/algorithm on a sheet of paper to turn in
- Include Full Names and NetIDs of everyone in your group

Step 3: Sort it

3	43	76	96	61	0	17	5	42	64
70	52	42	21	53	71	71	92	90	71
46	45	96	66	9	91	99	48	80	35
65	33	49	23	70	3	96	94	51	75
28	32	68	58	9	95	57	17	3	22