

# Threads and Concurrency

2/9/26

# Administrivia

- HW 5 (MIPS simulator with caching) due tomorrow night

# Recall: Moore's law

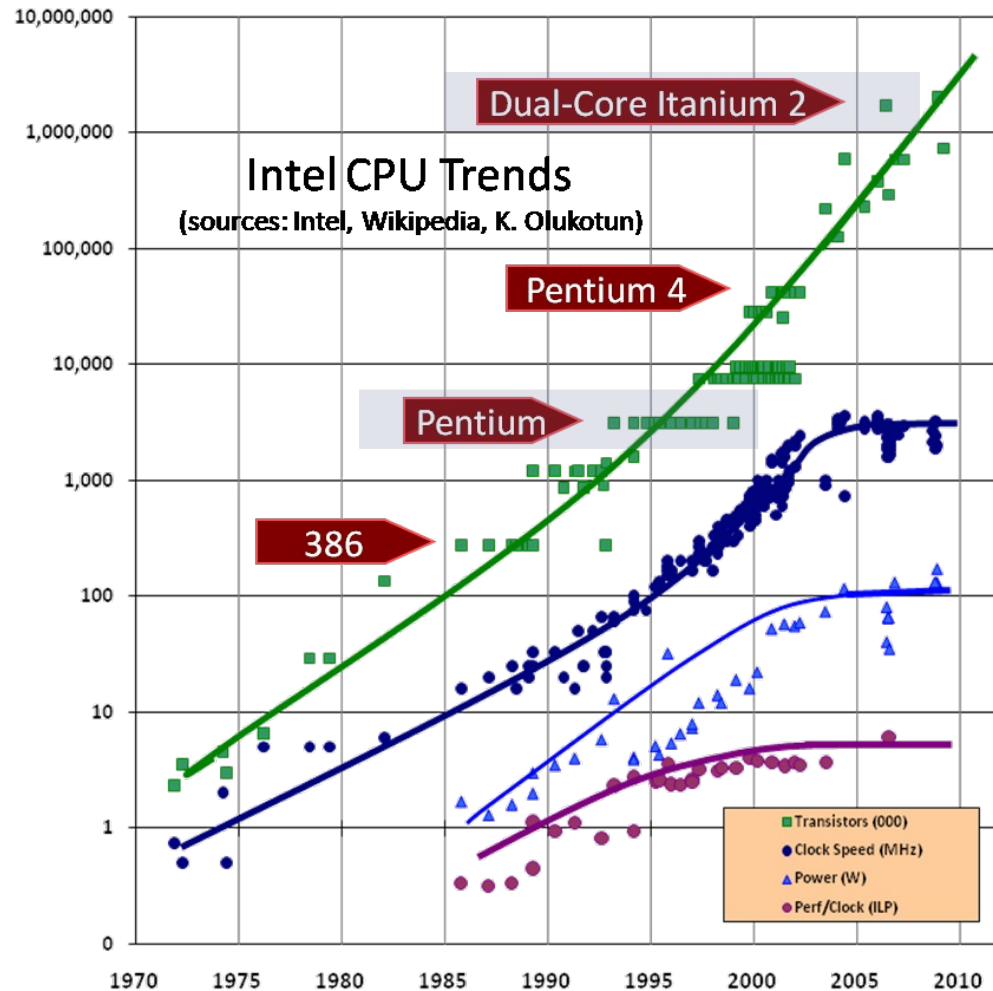
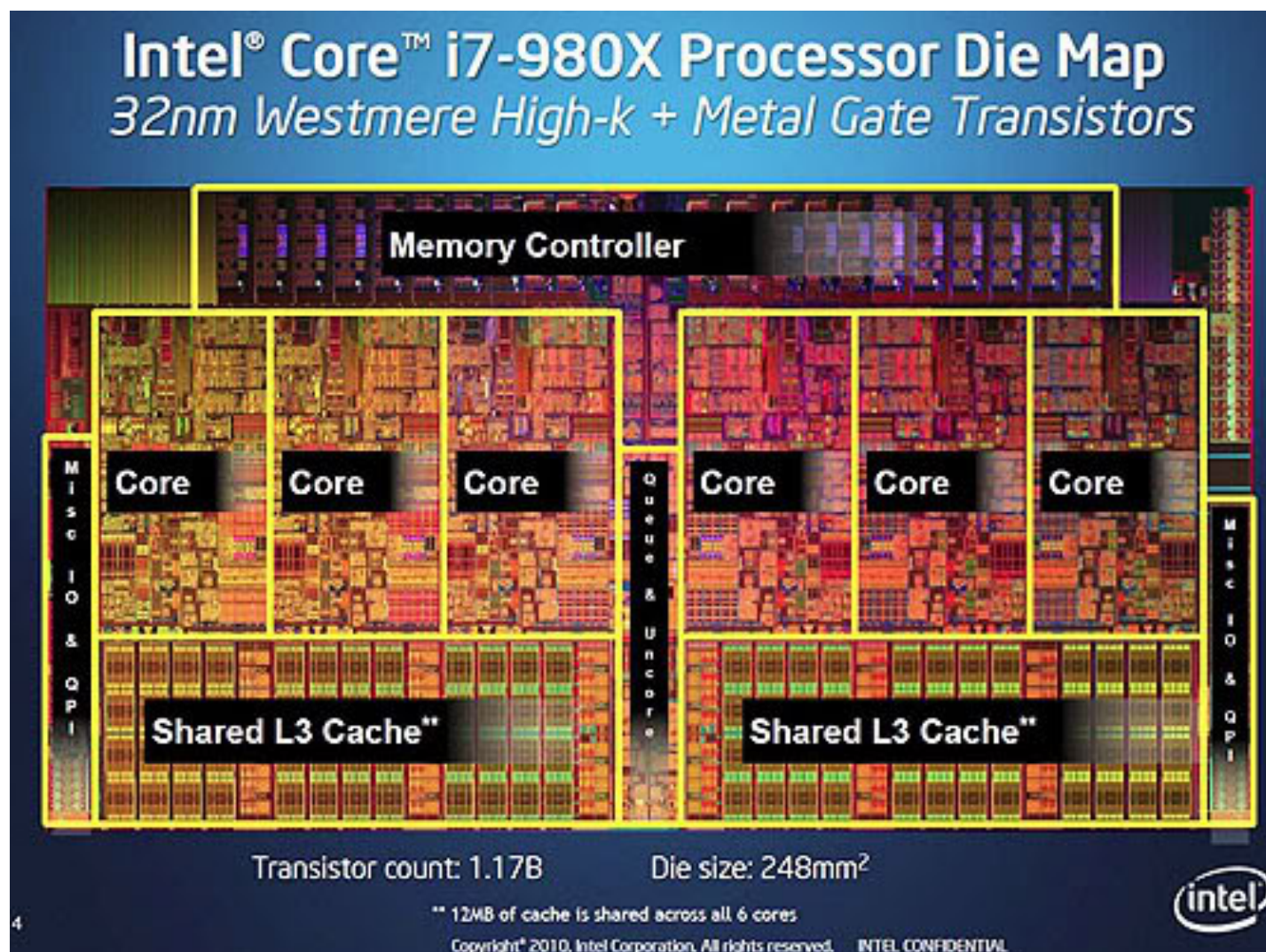


Figure: Herb Sutter "The free lunch is over: A fundamental turn toward concurrency in software"  
Dr. Dobb's Journal, 30(3), March 2005.  
<http://www.gotw.ca/publications/concurrency-ddj.htm>

# Parallel computing in the small

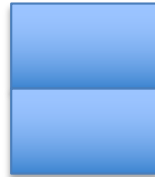


[http://i561.photobucket.com/albums/ss59/gamenews86/Die\\_Map.jpg](http://i561.photobucket.com/albums/ss59/gamenews86/Die_Map.jpg)

# Why have multiple threads?

- Performance

– run like this



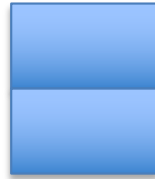
instead of this



# Why have multiple threads?

- Performance

- run like this



- instead of this



- Responsiveness

- one thread runs user interface while others compute in background (ex: mobile platforms, web servers)

# Two relevant concepts

- Parallelism
  - Using more resources to complete job faster
  - Ex: multiple cooks splitting food prep
- Concurrency
  - Managing access to shared resources
  - Ex: two cooks both trying to get dish into oven

Situation: You call a professor to see if they are free to meet. They say “yes”, but another student is in their office by the time you get there.

Is this situation an example of an issue with parallelism or concurrency?

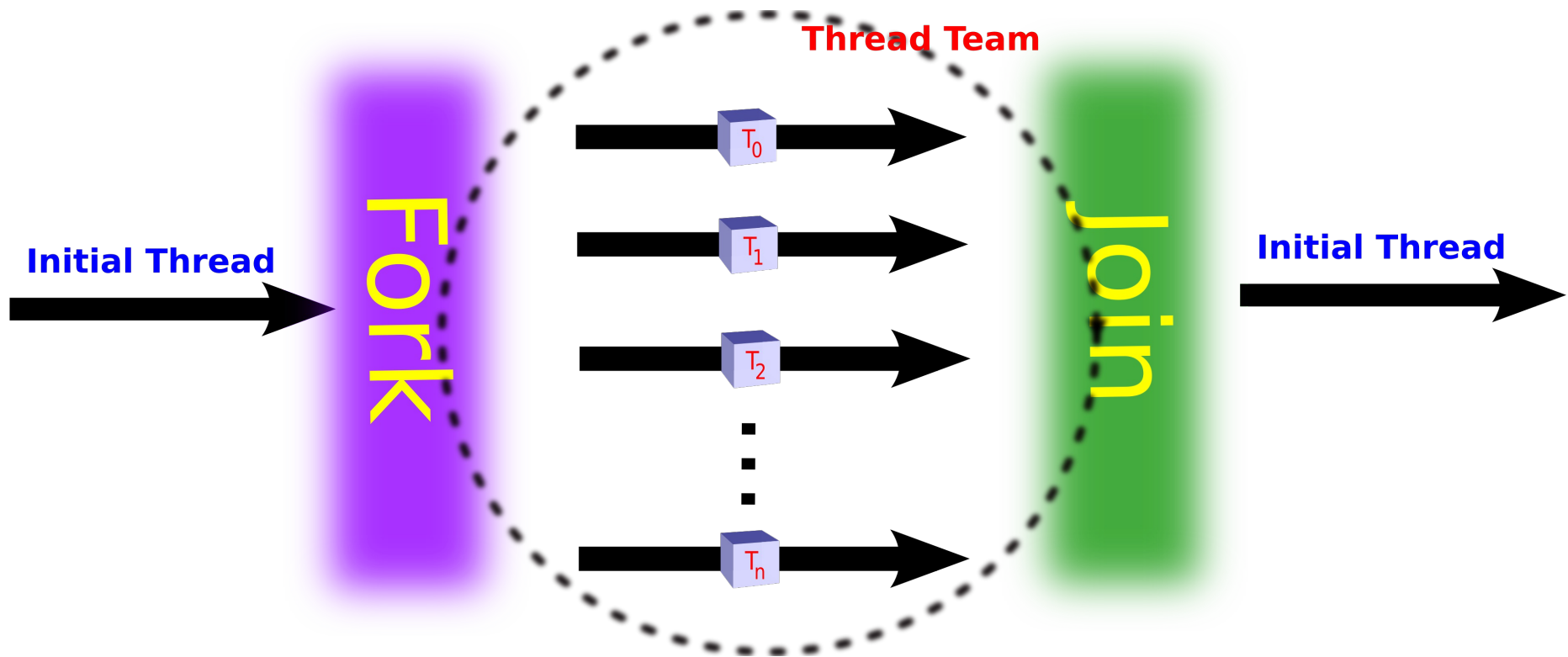
- A. Primarily parallelism
- B. Primarily concurrency
- C. Equally both
- D. Neither
- E. What are we talking about again?

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# Fork-join pattern



# How do we do this in C?

- pthreads:

```
pthread_create(&pthread_t, NULL, function, arg)
```

```
pthread_join(pthread_t, NULL)
```

```
void* function(void* arg) {
```

```
    ...
```

```
}
```

# Using threads for parallelism

- Move code for thread into a function
- Create a struct to hold arguments
- Make threads and pass appropriate structs
- Cast arguments from void\*
- Join threads
- Cast return values from void\*

# Speedup

$$\text{Speedup} = \frac{\text{Serial (non-parallel) running time}}{\text{Parallel running time}}$$

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- Linear speedup: speedup equal to the number of processing elements
- Sublinear speedup: less than this
- Superlinear speedup: more than this

Is speedup a topic related to parallelism or concurrency?

A. Primarily parallelism

B. Primarily concurrency

C. Equally both

D. Neither

E. What are we talking about again?

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# Why not linear speedup? (1)

- Some parts of the code can't run in parallel
  - Initialization
  - I/O
  - critical sections: areas where we ensure at most one thread is running

# Why not linear speedup? (1)

If  $B$  = fraction of program that must run serially

$T_1$  = total time on 1 processing element

What is best possible time on  $p$  elements?

- A.  $T_1/p + B$
- B.  $T_1B/p$
- C.  $T_1(1-B)/p + B$
- D.  $T_1(1-B)/p + T_1B$
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C.  $T_1(1-B)/p + B$

D.  $T_1(1-B)/p + T_1 B$  (called Amdahl's Law)

E. None of the above

# Why not linear speedup? (2)

- Poor load balance:



# Why not linear speedup? (3)

- Overhead
  - Extra instructions needed for running in parallel
  - Examples:
    - creating and destroying threads
    - calls needed to coordinate threads or communicate between them
    - changes to algorithm needed to expose parallelism or improve load balance