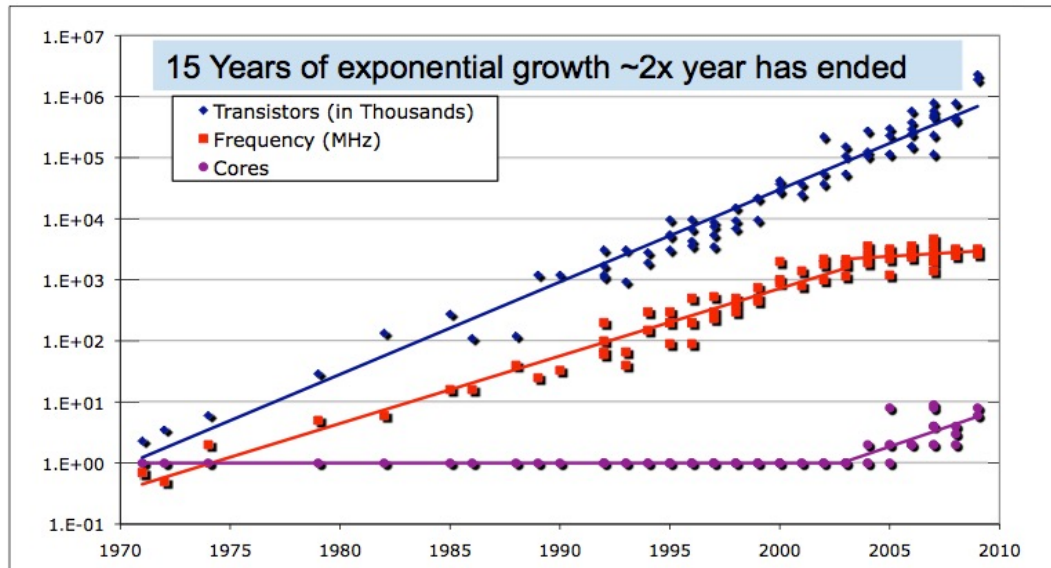


Welcome to Concurrent and Parallel Programming

Two mega trends

- Two forces driving software complexity:
 - Multicore (= parallel programming)
 - Cloud computing (= distributed programming)
- Current languages and frameworks have trouble keeping up (locks/threads don't scale)
- Need better tools with the right level of abstraction



Concurrency and Parallelism

Parallel programming

Execute programs faster on parallel hardware.

Concurrent programming

Manage concurrent execution threads explicitly.

Both pose new challenges compared to sequential programming

The Root of The Problem

Non-determinism caused by *concurrent threads* accessing *shared mutable* state.

It helps to encapsulate state in actors or transactions, but the fundamental problem stays the same.

So,

non-determinism = *parallel processing* + *mutable state*

To get deterministic processing, avoid the mutable state!

Avoiding mutable state means programming *functionally*.

```
var x = 0
async { x = x + 1 }
async { x = x * 2 }

// can give 0, 1, 2
```

Space vs Time

