Computational Economics with Python

Copenhagen Summer School
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Lecture 1

Resources

Homepage and resources:

- https://quantecon.org/copenhagen-summer-school-2018

To-do

1. Install Anaconda Python
2. Download files from GitHub repo

Assumptions / Prerequisites

- Coding experience assumed
- But no Python required

Structure

Lecture 1: Introduction and Foundations

- Why Python?
- Environment (Jupyter / Anaconda / IPython)
- Python syntax and semantics
- Simple examples

Lecture 2: Standard Scientific Libraries

- NumPy
- SciPy
- Matplotlib
- Pandas

Lecture 3: JIT Compilation and Parallelization

- Numba
- Parallel execution
- Cloud computing
- Inventory dynamics
- Exercise: Option pricing

Lecture 4: Applications

- Wealth dynamics and inequality
- Optimal stopping (job search)
- Optimal savings

Programming Background — Software

A common classification:

- **low** level languages (assembly, C, Fortran)
- **high** level languages (Python, Ruby, Rust, Nim)

Low level languages give us fine grained control

Example. $1 + 1$ in assembly

```
pushq   %rbp
movq    %rsp, %rbp
movl    $1, -12(%rbp)
movl    $1, -8(%rbp)
movl    -12(%rbp), %edx
movl    -8(%rbp), %eax
addl    %edx, %eax
movl    %eax, -4(%rbp)
movl    -4(%rbp), %eax
popq    %rbp
```

High level languages give us

- abstraction
- automation
- interactivity
- readability, etc.

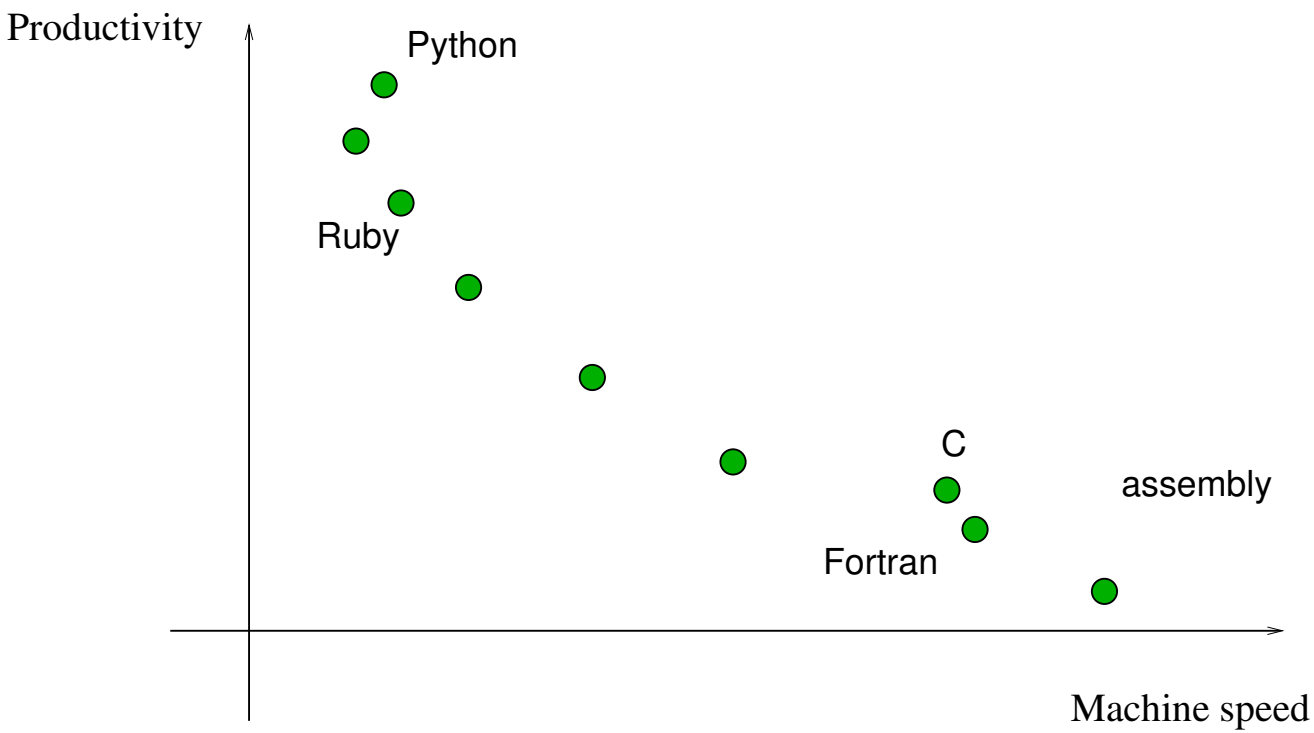
Example. Reading from a file in Python

```
data_file = open("data.txt")
for line in data_file:
    print(line.capitalize())
data_file.close()
```

Jane Street on readability:

> *There is no faster way for a trading firm to destroy itself than to deploy a piece of trading software that makes a bad decision over and over in a tight loop.*
>
> *Part of Jane Street's reaction to these technological risks was to put a very strong focus on building software that was easily understood—software that was readable.*
>
> – Yaron Minsky, Jane Street

Trade-Offs

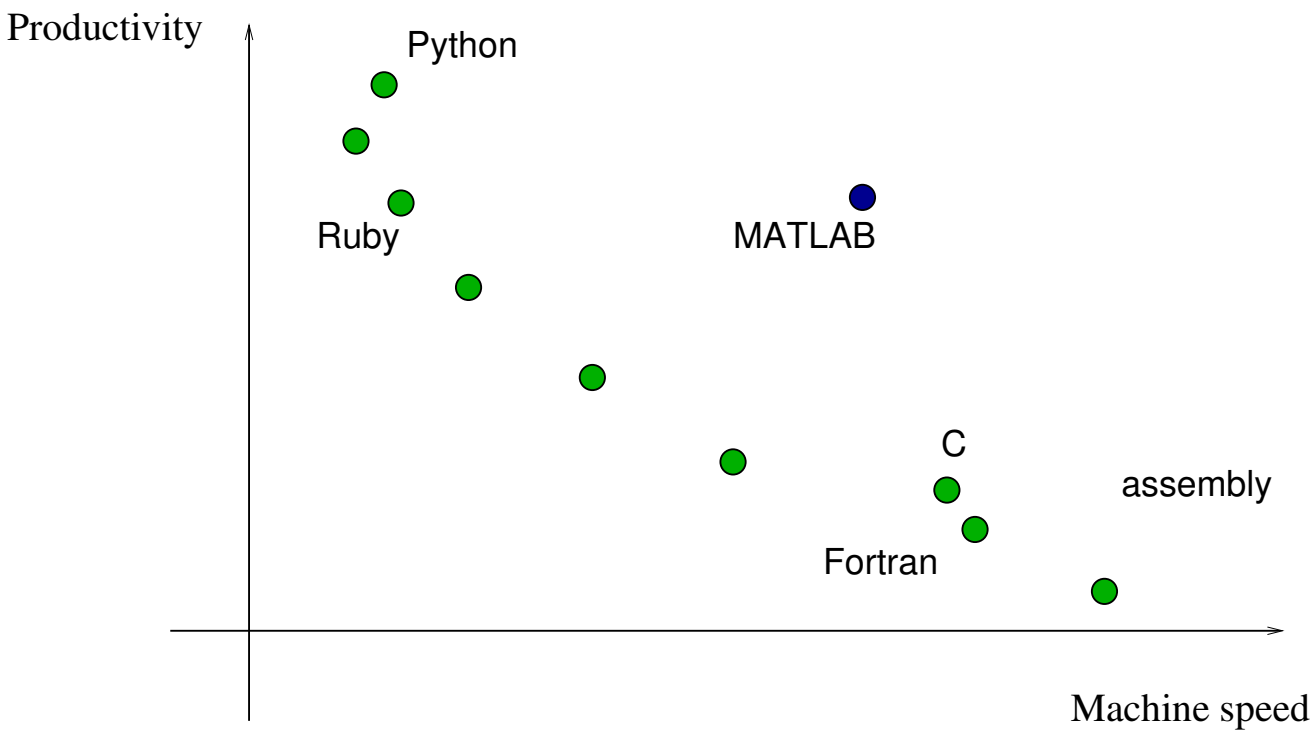

Productivity
Python
Ruby
C
assembly
Fortran
Machine speed

But what about scientific computing?

Requirements

- Productive — easy to read, write, debug, explore
- Fast computations

Trade-Offs


Productivity
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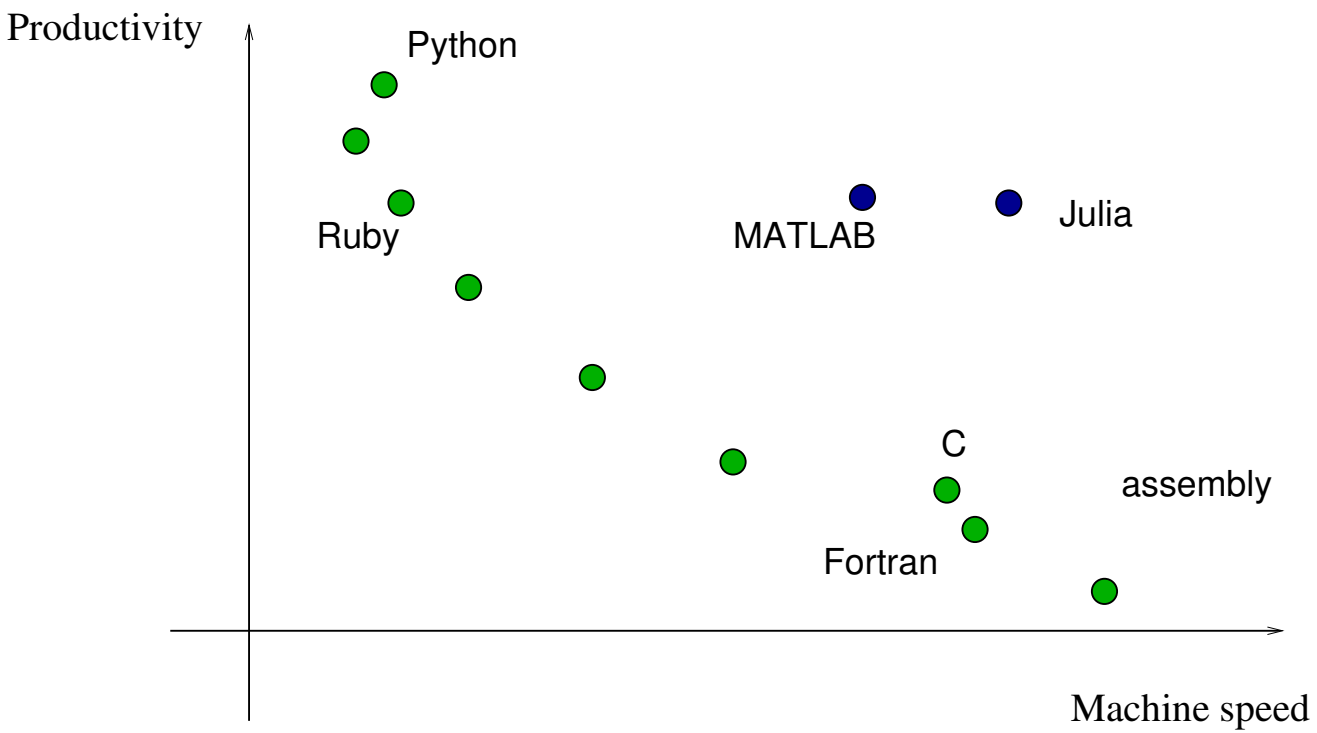
Trade-Offs


Productivity
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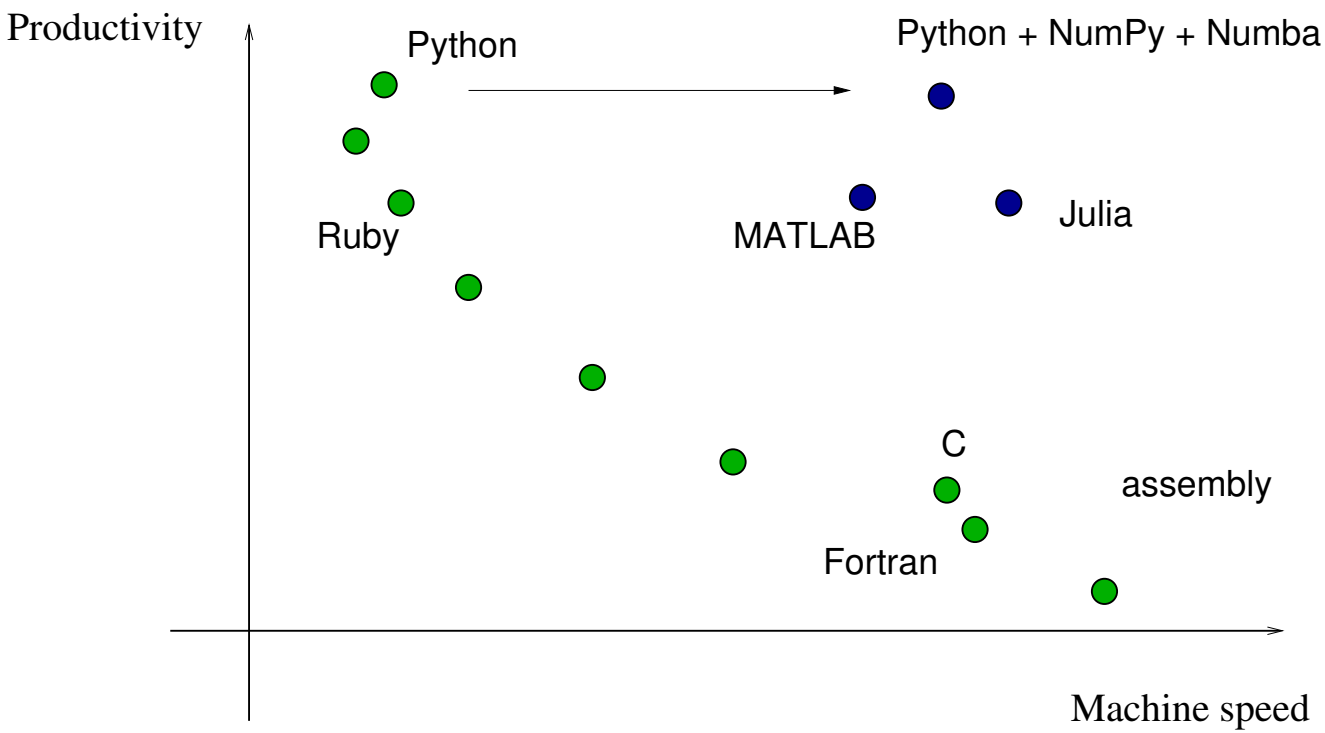
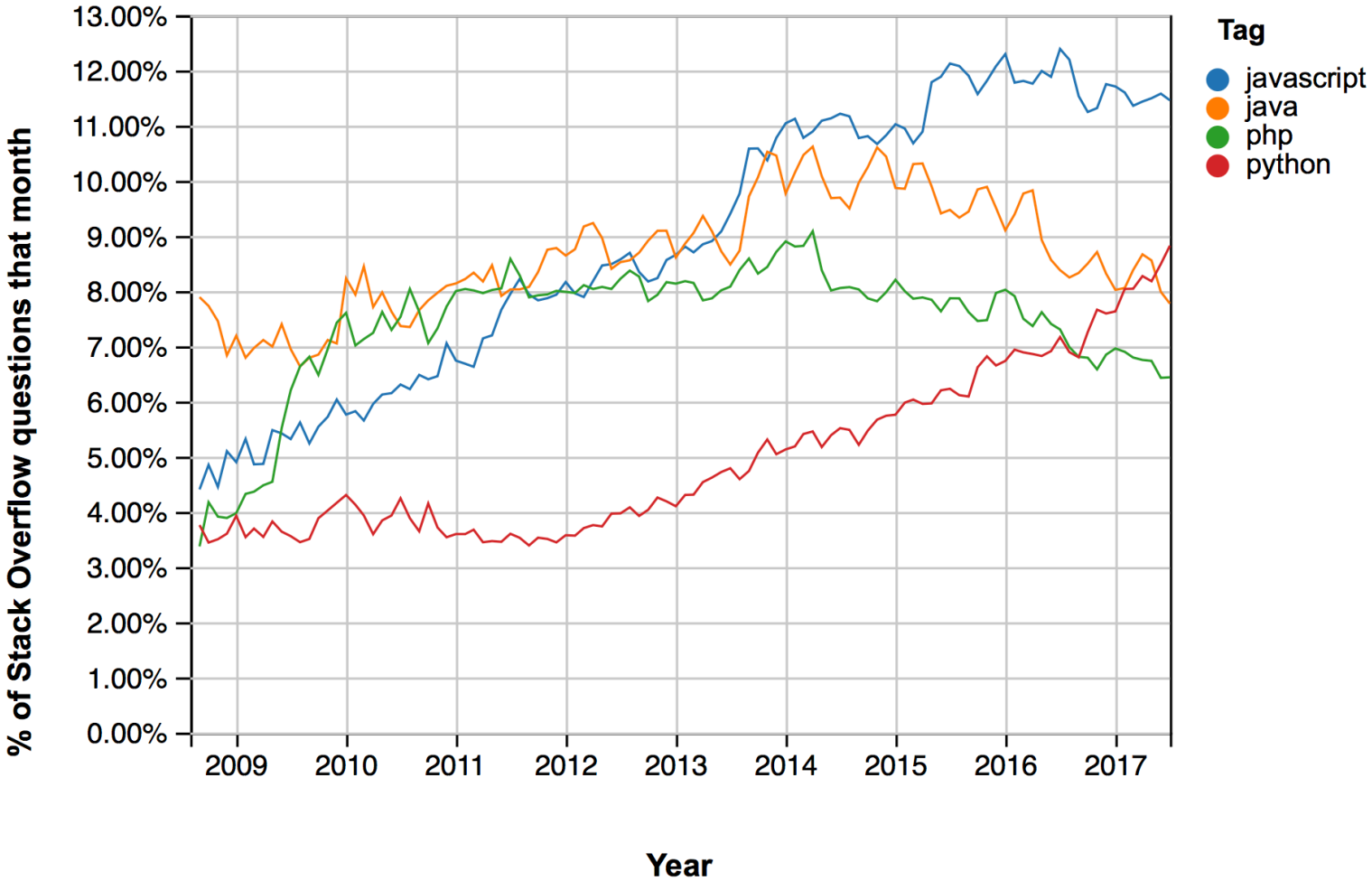
Trade-Offs


Productivity
Python
Python + NumPy + Numba
Ruby
MATLAB
Julia
C
assembly
Fortran
Machine speed

Summary: Why Python for Computational Economics?

- Elegant high level programming language
- High quality scientific libraries (NumPy, SciPy, pandas, Matplotlib)
- JIT compilation and parallelization
- Modern machine learning libraries (Tensorflow API, Scikit Learn)
- Vast array of free libraries in other fields (web, networks, natural language processing, etc.)
- Positive spillovers from popularity (Stack Overflow)

Python vs other popular high level languages

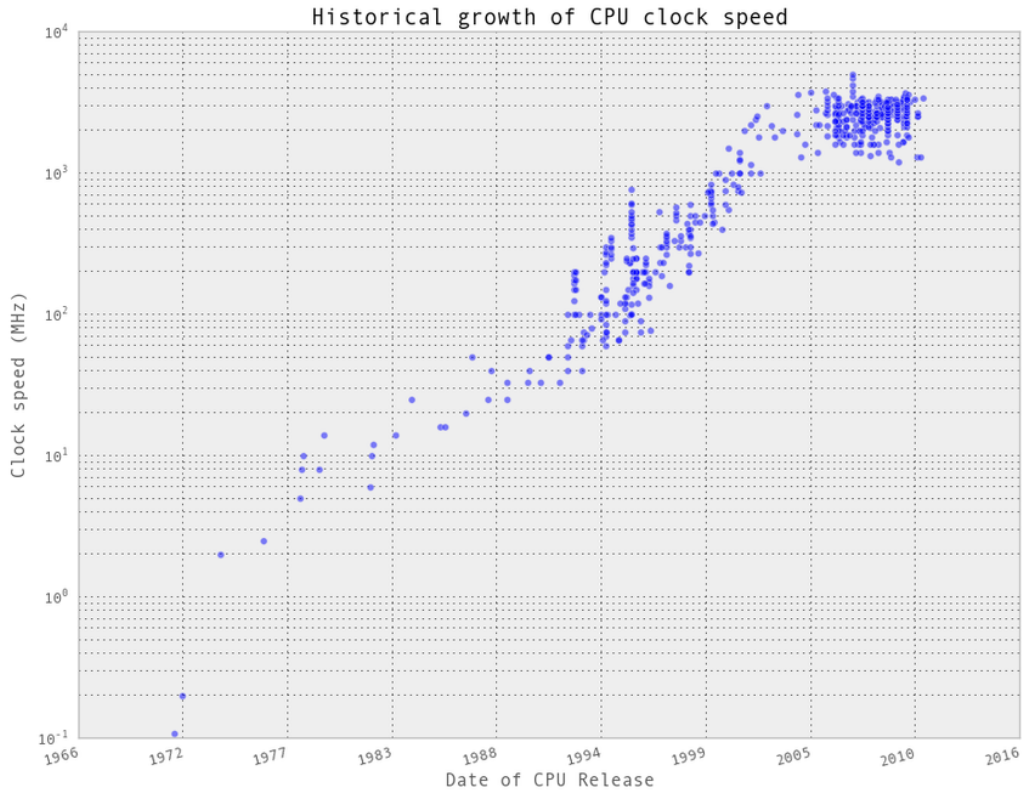


Disadvantages of Python

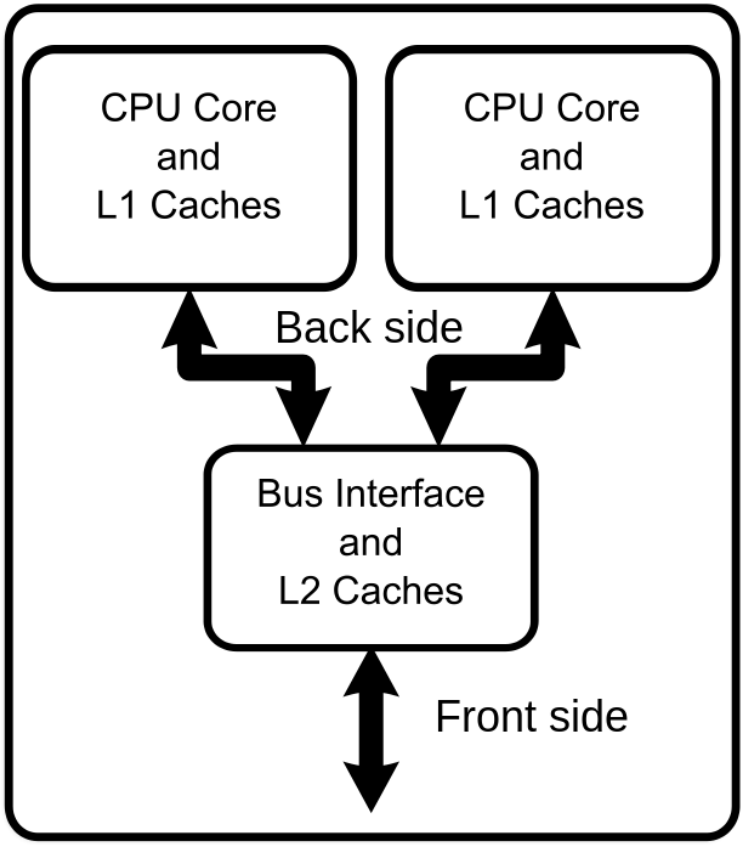
- Limited implementation of traditional econometric methods / tests
- Traditional scientific libraries are not JIT compiled

Programming Background — Hardware

CPU frequency (clock speed) growth is slowing



Chip makers have responded by developing multi-core processors



Source: Wikipedia

Exploiting multiple cores / threads is nontrivial

Sometimes we need to redesign algorithms

Sometimes we can use tools that **automate** exploitation of multiple cores

Distributed/Cloud Computing

Advantages: run computationally intensive code on big machines we didn't have to buy

Options:

- University machines
- AWS and other commercial services

Jupyter notebooks

A browser based interface to Python / Julia / R / etc.

Can be opened through `Anaconda navigator`

Or via a terminal:

Step 1: Open a terminal

- on Windows, use `Anaconda Command Prompt`

Step 2: type `jupyter notebook`

- opening a notebook
- executing code
- edit / command mode
- everything's an object (lists, strings)
- installing `quantecon`
- getting help
- introspection
- math and rich text
- Jupyter lab

Notebooks

- `lecture_1/python_by_example.ipynb`
- `lecture_1/python_essentials.ipynb`
- `lecture_1/python_foundations.ipynb`