Parallel Programming

Introduction

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High Performance and Automatic Computing

Motivation

Why Parallel Computing?

- Time: Sequentially, the problem cannot be solved fast enough
  - Real-time constraints, accuracy, . . .
- Space: The problem cannot be solved on a single node
  - Large datasets, large memory requirement.
- My computer is parallel, why not to take advantage of it?

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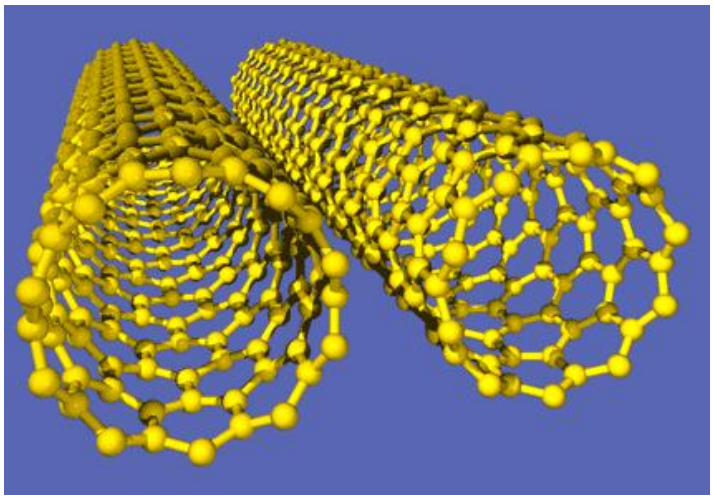
Main idea

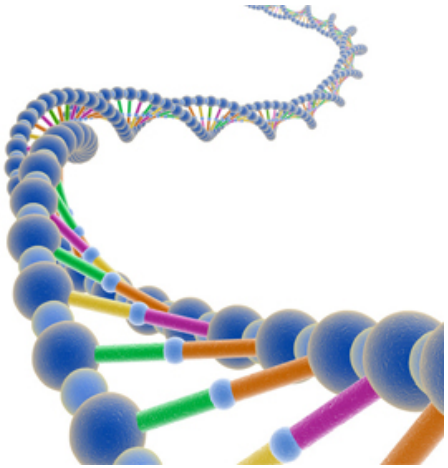
- Decompose large problems into subproblems ...
- ... that can be solved concurrently ... but ...
- beware of dependencies!

Motivation

Computational Science

- Genome analysis
- Drug development
- Materials science
- Weather forecast
- Climate

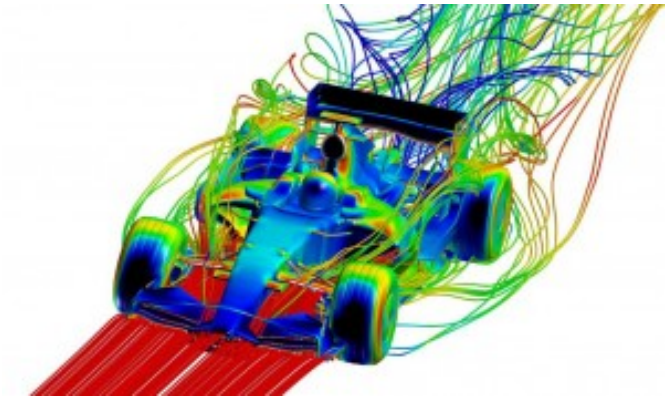


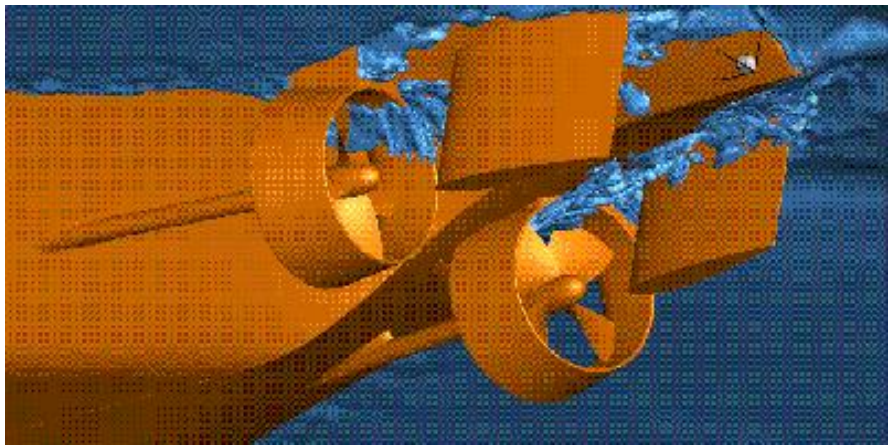


Motivation

Engineering

- Engine design
- Aerodynamics
- Fluid dynamics
- Crash simulations





Motivation

Finance

- Economics
- High-Frequency Trading

The Top500 List – Top500.org

- List of the 500 fastests supercomputers in the world
- Twice per year (ISC, June, Germany. SC, November, USA)
- Computers ranked based on the LINPACK benchmark
  - Solution of linear system of equations: $Ax = b$
  - Result measured in FLOPS/s[1] (in double precision)
- Established in 1993: 60 GFlop/s
- June 2016: 122,000,000 GFlop/s
- June 2018: 93,000,000 GFlop/s

[1] Floating Point Operations per Second

Examples of supercomputers

Sunway TaihuLight
Rank #1: June 2017 – Nov. 2017

Source: top500.org

Sunway TaihuLight

- Site: National Supercomputing Center in Wuxi, China
- 40,960 SW26010 processors, each
  - 256 processing cores
  - 4 auxiliary cores
- 10,649,600 cores
- 1,310,720 GB RAM
- 93,014.6 TFlop/s (125,435.9 TFlop/s)
- 15,371 kW

Examples of supercomputers

Hazel Hen
Rank #8: Nov. 15

Source: hlrs.de

Hazel Hen

- Site: HLRS - Höchstleistungsrechenzentrum Stuttgart
- 7,712 compute nodes
  - 2 Haswell 12-core CPUs
- 185,088 cores
- 987,136 GBs RAM
- 5,640.17 TFlop/s (7,403.52 TFlop/s)
- ~3200 kW

So...

are parallel computers restricted to supercomputing?

So...

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Not at all!!

Parallel Computers are everywhere!

Source: hp.com

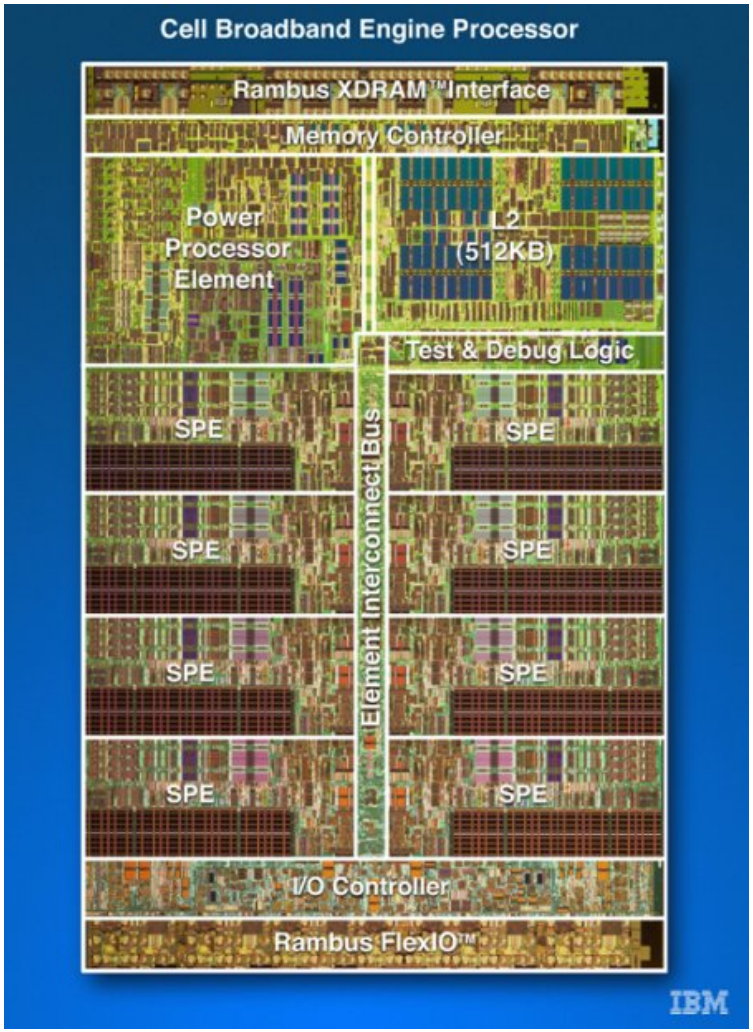
Source: indiatimes.com

Source: bq.com

Source: wearabledevices.es

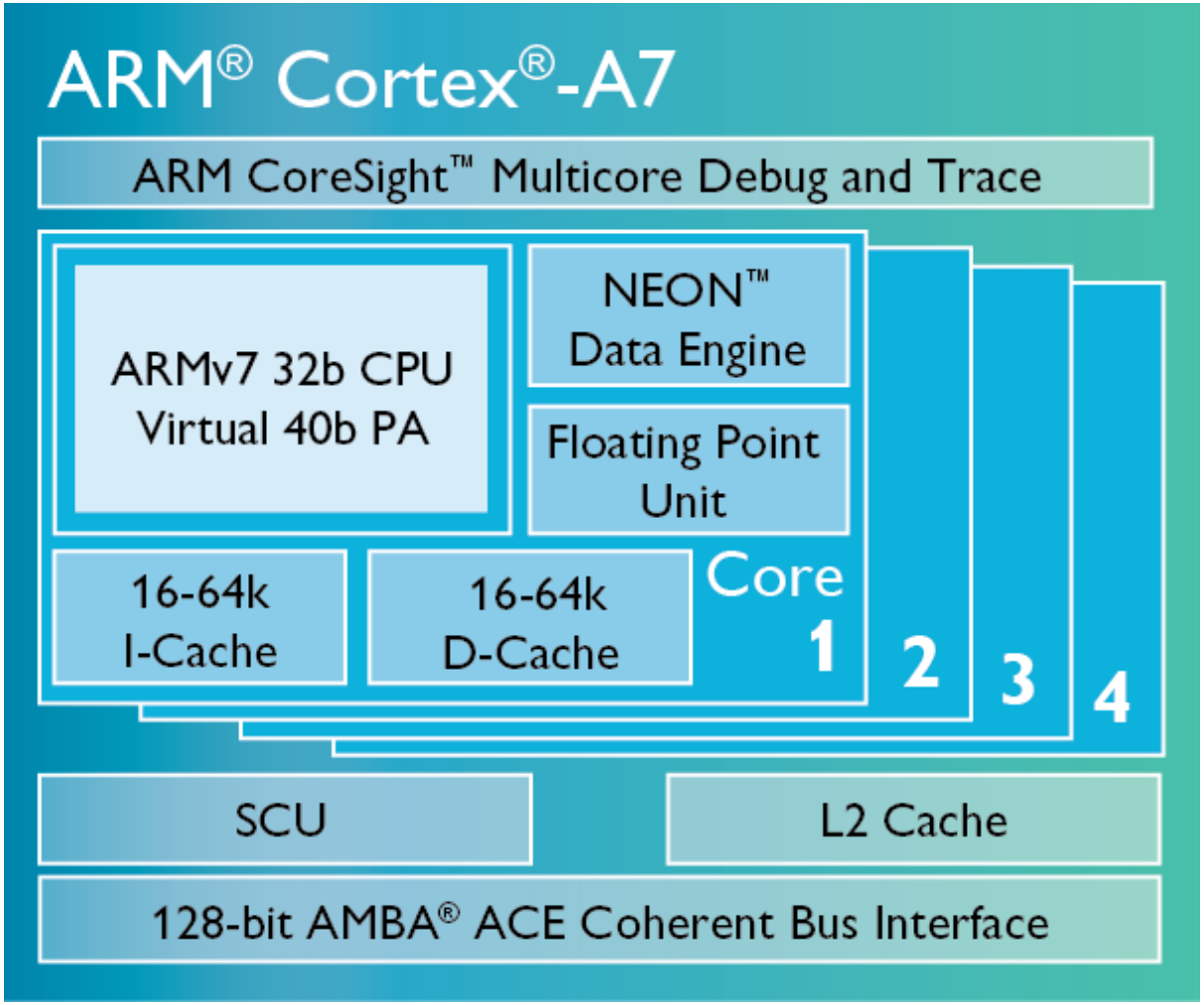
Parallel Computers are everywhere!

Play Station 3



Parallel Computers are everywhere!

Cell phones



Source: arm.com

Summarizing

- Parallel programming is critical in science and engineering
- Not only supercomputers, but in every workstation/laptop
  - Parallel computers are here to stay
  - The burden is and will be on the programmer
  - Let's roll up our sleeves and do our best :-)