Computers in the Past, at Present, and in the Future

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ENIAC – 70 years ago

- 20,000 vacuum tubes
- 100 m²
- 200 KW
- 1000 ops/sec
- Hours of up time
Microprocessors - Today

- >1 billion transistors
- 0.0001 m
- 100 W
- 1 billion ops/sec
- Years of up time
Moore’s Law

40 Years of Microprocessor Trend Data

Transistors (thousands)
Single-Thread Performance (SpecINT x 10^3)
Frequency (MHz)
Typical Power (Watts)
Number of Logical Cores

Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2015 by K. Rupp
What is Computer Architecture?

- Problem
- Algorithm
- Program
- Computer Architecture
- Electronic Circuits
- Switching elements - transistors

Software

Hardware
Program Execution

- Processor
- Memory
- Fetch Instructions & Data
- Store Results

Speed: ~1 GHz

Speed: ~10 MHz
Two Fundamental Concepts

Parallel Computing

Memory Locality
Why Does Compute Performance Matter?

- **Problem**
  - Algorithm
  - Program
  - Computer Architecture
  - Electronic Circuits
  - Switching elements - transistors

**Software Innovation Slows Down the Computer**

**Hardware has Compensated by becoming ~2X faster biannually**
The Free Lunch is Over

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What Does it Mean?

Compute performance will slow down software innovation.

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What Do We Do About It?

- Algorithm
- Program
- Computer Architecture
- Electronic Circuits
  - Switching elements - transistors

Efficiency Measures Across the Entire Compute Stack
My Own Contribution – Memory Data Compression

Inefficiency

Processor → Cache Memory Hierarchy → Memory
Memory Data Compression – A Chalmers Contribution

Processor ➔ Cache Memory Hierarchy ➔ Compress/Decomp. ➔ Memory 3X Capacity

ZeroPoint Technologies

Chalmers Initiative seminar on Digitalisation, Gothenburg, March 15-16, 2017
Thank you!

Questions?