Our Computing Habits Unaffordable soon, and: a Climate Disaster

Our Computer Models Too Optimistic?

Greenland’s Ice is Melting… Our Computer Models Too Optimistic?

The Solution: Reconfigurable Computing mainly an education issue

The Impact of Reconfigurable Computing

Dual-Rail Education

Conclusions

key issues

climate change faster than predicted: by carbon emission, primarily from power plants?

very high and growing computer energy cost - and growing number of power plants needed here

the manycore programming crisis stalls progress (from growth industry to replacement industry?)

the dominance of the von Neumann computer is the root of all these problems

Reconfigurable Computing is the highly effective alternative

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Our Computing Ecosystem

Visible and hidden computers everywhere:
- In PCs, laptops, and in their peripherals in offices, homes and elsewhere
- In entertainment equipment at home and elsewhere
- In data centers, server farms and supercomputers
- In base stations of wireless communication networks
- In all kinds of machines in industry, homes and more
- In all kinds of vehicles, airplanes, trains, ships and more
- In all kinds of portable equipment and more

This list is far from being complete.

Energy Cost of Computing

Immense energy consumption of the internet
- Amsterdam’s electricity consumption: 25% to server farms
- Google’s annual electricity bill: > 50,000,000 $ (in 2005*)
- Google, Microsoft ...: huge datacenters at Columbia River and ORNL benefits from Tennessee Valley Authority.
- Google: patent for a “water-based datacenter” using the ocean to provide power and cooling.

Using the Ocean?

Heating the Ocean to provide Cooling?

Energy consumption by the US total computing ecosystem:

Engineers Will Solve This Problem

... important role of programmers

Software to Configware migration is the key

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Climate protection policy
Much more effect than any other climate protection effort? factor 10? 50% - 5%? or even less?

Side effect: saving the affordability of our computing infrastructure

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Field-Programmable Gate Array FPGA
Xilinx (1984)
fine-grained reconfigurable

Note:
this is Programming in Space .... FPGA
.... instead of Programming in time CPU

Remark:
Programming in high level language FPGA

RAM-based interconnect
hidden RAM
configure code loaded before run time into "hidden RAM"

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Coarse-grained Reconfigurable

datatpath of a CPU

e. g. 16 bits, 32 bits, …

instruction fetch

state address computation

data address computation

data meet PU + other path,

1 to 1 from off-chip RAM

von Neumann Syndrome

Overview

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Massive Overhead Phenomena

von Neumann Syndrome

single core

von Neumann machine

overhead piling up to code sizes of astronomical dimensions

overhead (just not complete)

von Neumann Syndrome

2006 C.V. “RAM”

Rambunctious

von Neumann Syndrome

overhead

P3A DMA acceleration [Escadas 1996]

von Neumann Syndrome

Overhead

many-core von Neumann: arrays
of massive overhead phenomena

overhead

von Neumann machine

instruction fetch

instruction stream

state address computation

Instruction stream

data address computation

Instruction stream

data meet PU + other path,

1 to 1 from off-chip RAM

Instruction stream

message passing overhead

Instruction stream

transactional memory overhead

Instruction stream

multithreading overhead etc.

Instruction stream

Disproportionate to the number of processors

...a terrifying number of processes running in parallel, create sequential processing bottlenecks and losses in data locality

2008 David Callahan

September, 2008

DAAD


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Why a growth industry? The end of this free ride on the Gordon Moore curve! Stop in 2008!

The coming breakdown of the growth industry?

Programmer population ... not existing for the transition from:

<table>
<thead>
<tr>
<th>nor from:</th>
<th>von Neumann</th>
<th>single core</th>
<th>von Neumann</th>
<th>single core</th>
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<tbody>
<tr>
<td></td>
<td>Reconfigurable Computing</td>
<td>27</td>
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Reiteria, UnB, Brasilia

breakthrough or breakdown?

Industry is facing a disruptive turning point

The many core programming crisis

forcing a historic transition to a parallel programming model yet to be invented

It’s an education, qualification, and a R&D problem

I would be panicked if I were in industry

Outline

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Speed-up factors obtained by Software to Configware migration

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Energy saving factors obtained by software to configware migration

Demonstrating the intensive Impact

Reconfigurable Supercomputing

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We need to POIIP for:

- Software to Hardware Migration
- Software to Configurable Migration

2 simple key rules of thumb:

a) loop turns into pipeline

b) decision box turns into demultiplexer

VLSI Education Revolution
 avoiding specialization overload

VLSI design education spreading rapidly

Following the exemplar: our ideal:
The VLSI Revolution

We are discussing to hold a summer school for Professors
We have presented a road map

Software to Configware migration is the key

FPGA

rDPA

Conclusions

A von-Neumann-only strategy can never be the solution
We need a massive Software to Configware Migration
Established technologies are available and we can still use standard software and their tools
Configware skills and basic hardware knowledge are essential qualifications for programmers.

We urgently need a fundamental CS Education and Research Revolution for dual-rail-thinking

We need „une’ Levée en Masses“

• thank you for your patience

END

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US Energy Flow

US CO₂ emission

US energy in 2002:
- total: 29000 TWh
- electricity: 8207 TWh
distributed: 2323 TWh
- wasted: 6730 TWh
- carbon dioxide emissions:
  - total: 5.7 Gt
electricity: 2.5 Gt

quad ~30,000 TWh

US 2002 Carbon Dioxide Emissions from Energy Consumption – 5.682* Million Metric Tons of CO₂

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