The Tunnel Vision Syndrome: Massively Delaying Progress

Outline (1)
- Preface
- History of Computing
- The Systolic Array
- The Kress Array
- The Xputer Paradigm
- The Twin Paradigm Approach
- More Tunnel Vision
- We must Reinvent Computing
- Conclusions

Power costs more than servers

Google's Electricity Bill
Cost of a data center determined by the monthly power bill

"The possibility of computer equipment power consumption spiraling out of control could have serious consequences for the overall affordability of computing."

[L. A. Barrosse, Google]

Google going to sell electricity
Patent for water-based data centers

Featured Invited Talk; The 24th IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP 2013), 5-7 June 2013, Washington, DC, USA
The end of evolution: we need a revolution!

Disruptive research is urgently required and we need by orders of magnitude more parallelism and power-efficiency. Fundamental issues have to be revisited. We must overcome the von Neumann syndrome and also the widespread Tunnel Vision dementia.

Too many terminals

I used this Museum Equipment. NATO ASI on VLSI 1981, SOGESTA, Urbino, Italy.

The History of Computing

The 1st electrical computer, ready prototyped for mass production?

Guess: which year, which company?

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The History of Computing

Prototype 1884: Herman Hollerith, the first reconfigurable computer.

The LUT (lookuptable) size: <3 refrigerators!

1989 US census use of datastream-based!

Non-volatile!!

Laura Pearlman, MIT: First Xilinx 1987! 100 years later.

The History of Computing
Not yet invented in 1884:
• magnetic tape (1898),
• the vacuum tube (1904),
• magnetic drum (1932),
• the transistor (1934),
• ferrite core memory (1949),
• hard disc (1956).

Speed-up Factors

What Parallelism?

Instruction Stream Parallelism

The Beauty and the Joy of Computing...

Great Principles of Computing?

Shifting to the Dominance of von Neumann caused an accumulated Damage of at least Trillions of Dollars, if not Quadrillions...

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You won’t get research grants and submitted papers will be rejected if Reasonable people adapt themselves to the world as it is. Breakthroughs of innovations can be achieved only by unreasonable people.

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Max Planck: Replacement of false doctrines by new insights needs 50 years not only for old professors but also their scholars to die off.

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Max Planck: Replacement of false doctrines by new insights needs 50 years waiting for not only old professors but also their scholars to die off.

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The ASAP series is an important forum to discuss cures for healing from the von Neumann syndrome.
Featured Invited Talk; The 24th IEEE International Conference on Application-specific Systems, Architectures and Processors (ASAP 2013), 5-7 June 2013, Washington, DC, USA
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A Clean Terminology, please

The Twin Paradigm Approach

The Systolic Array

The Kress Array

The Xputer Paradigm

More Tunnel Vision

We must Reinvent Computing

Conclusions

Software Languages

Flowware Languages

MoPL Languages

GNU C compiler

Analyzer / Profiler

X-C compiler

Partitioner

KressArray

Configware

Flowware

Supporting different platforms

Extended Lesley Lamport

Hyperplane Theorem

CoDeX 1996

X-C is C language

extended by MoPL
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More Tunnel Vision (1)

20 years ignored by TR scene

Specification: some rewrite rules:

\[ z = \frac{x}{y} \]
\[ \frac{a}{b} + \frac{c}{d} = \frac{ad + bc}{bd} \]

TR expert Prof. Mauricio Ayala-Rincón, Universidade de Brasilia in 2001: still the only top-down example - Term Rewriting (TR) use in EDA: only in verification: "is bottom-up."

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A huge design space

Programmability crisis solution impossible without mastering the entire design space

extending Flynn's taxonomy by going heterogeneous:

Mike Flynn's taxonomy

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<tr>
<th>SISD</th>
<th>MISD</th>
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<tbody>
<tr>
<td>SIMD</td>
<td>MIMD</td>
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Instruction set

Single vs. Multiple

Diana's Taxonomy

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<tr>
<th>SI</th>
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Reconfigurable or not

datastream-based (anti-machine)

The tunnel vision of the pre-manycore age

SISD
The extension into this huge design space is mainly ignored by curricula and even by most R&D scenes.

The Mead-And-Conway strategy: clearing out & intuitive models.

Removal of the education dilemma.

The new strategy: more connected thinking.

Removing Abstraction Layers hides critical sources of efficiency limits.

Hides issues to detect overhead and bottlenecks.

We must change how programmers think, also by...

...fusion of abstraction layers: challenging educators...

...opening the borders between paradigm domains.
You cannot teach Hardware to a Programmer efficiently. You have not efficiently taught procedural programming to a Hardware Guy who always can teach Programming.

**Conclusions**

We need by orders of magnitude more parallelism and power-efficiency. A reductionist attitude of most R&D areas massively delays the solution of urgent problems. Disruptive research is urgently required and fundamental issues have to be revisited. We must disruptively reinvent CS education. We must overcome the von Neumann Syndrome and the widespread Tunnel Vision dementia.

We need "une' Levée en Masses".

Thank you!
The spirit from the Mainframe Age is collapsing.

There is something fundamentally wrong.

The reason of this paradox?

Bad FPGA technology:

- Up to 4 orders of magnitude speedup + tremendously slashing the electricity bill by migration to FPGA
- The reason of this paradox?
- There is something fundamentally wrong in using the von Neumann paradigm
- The spirit from the Mainframe Age is collapsing under the von Neumann syndrome

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**The End of Evolution**

The end of evolutionary extension of current models.
Disruptive research is required in programmability.
Fundamental programming issues have to be revisited.
An entirely new software stack is needed.
Rethink all disciplines from circuit design and test, up to architecture, system design, storage behavior, compilers, run time systems, operating systems, and programming.
We need a much deeper integration between applications and data inside all kinds of memory.

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**What means zettaFLOP?**

- FLOPS
- petaFLOPS $10^{15}$
- zettaFLOPS $10^{21}$
- exaFLOPS $10^{18}$
- zetaFLOPS $10^{15}$
- petaFLOPS $10^{12}$
- teraFLOPS $10^{9}$
- gigaFLOPS $10^{6}$
- megaFLOPS $10^{3}$
- kiloFLOPS $10^{0}$

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**Following the exemplar: our ideal:**

Solving the VLSI design crisis: missing reply to Moore's Law
missing designer population, design tools (SW), HW for a design as a whole
Project has provided an educational framework to create a population of designers (and researchers) needed
Incubator of EDA industry, workstations...

The most influential research project in modern computer history.

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**JPEG zigzag scan pattern**

- Main program
- JPEG
- Scan pattern
- Flowware language example (MoPL)
- programming the datastream
- MoPL: no instruction streams!

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VLSI Design Education Spreading Rapidly
1980 - 1983 -
world-wide

The most effective project in the history of modern computer science

incubator of the EDA industry etc.

Carver Mead
Lynn Conway

Flowware Languages

specialized:

Brook: for modern graphics hardware
Streams-C: defines 1-D streams; generates VHDL
DSP-C: allows to describe key features of DSPs
StreaMIT

general purpose:

MoPL: fully supporting the anti machine paradigm
- the counterpart of the von Neumann paradigm