Motivations

Rethinking the nature of Computing: for drastically better supporting Massive ICT Systems

- Computing power
- Physical dimension
- Storage capacity
- Bandwidth
- Cost/unit

\[ \Rightarrow \text{Number & density of embedded devices} \]

Prof. Imrich Chlamtac

“Infinite” Resources by a Paradigm Shift

Empower user with context by:
- “infinite” bandwidth: users do not have to wait until they get something faster or interactive
- “infinite” storage: making all personal data (emails, pictures, video, docs) accessible from everywhere; the online copy becomes the Master Copy, local-machine copy as a cache
- “infinite” computing power: enabling to build personalized services and proactive environments to optimize user’s experience

Prof. Imrich Chlamtac

HPC for SMEs by “Infinite” Resources

- under affordable cost
- affordable energy consumption

“Infinite” Resources also for SMEs: The desktop supercomputer is near - by Reconfigurable Computing via FET

The von Neumann Syndrome

Outline
Computing affordable in the Future?

Pervasive ICT with “infinite resources” cannot be feasible without a massive reduction of power consumption
Stressing the von Neumann Paradigm makes it impossible
Reconfigurable Computing methodology is the way to go
Its progress is blocked by severe educational problems
A qualified implementer population of sufficient size is far from being available
The methodology fundamentals are ready, but managers, researchers, and even engineers are not

The History of Computing

The first reconfigurable computer

ee-non-volatile: a task for FET?

Non-volatile configuration memory

The History of von Neumann Computing

Algorithms reside as “instruction” schedule in RAM
Program sequencer piecewise mimics reading tapes

The introduction of the microprocessor in 1971 introduced a >20-year stall in design methods for electronic systems.

The Electricity consumption of all visible and hidden computers reaches more than 20% of our total electricity consumption. 35 - 50% predicted for the US by the year 2020. (Mark P. Miller)

$200 Minimum oil price in 2010, in a bet by investment banker Matthew Simmons [BusinessWeek, January 29, 2007]

Dijkstra 1968: The Goto considered harmful
R.H. & Koch 1975: The universal Bus considered harmful
Backus, 1978: Can programming be liberated from the von Neumann style?
arvind et al., 1983: A critique of Multiprocessing the von Neumann Style

A List of Massive Overhead Phenomena

overhead
von Neumann machine
instruction fetch
instruction stream
data address computation
instruction stream
data address computation
instruction stream
data meet PU + other overh.
instruction stream
l/c to/from off-chip RAM
instruction stream

the law of Bill Gates?
or, “von Neumann’s law”?
von Neumann Syndrome
[C.V. “RAM” Ramamoorthy]

Code sizes of astronomic dimensions

Fast on-chip memory cannot store such huge instruction code sizes
... no way around von Neumann bottlenecks

Outline

Why Reconfigurable Computing (RC) ?
Reconfigurable Computing: locality of operation (assignment of rDPU) moved at compile time … into the paths of the data streams:

- placement and routing by configware compiler
- by coarse-grained Reconfigurable Computing - also a solution for the manycore crisis

von Neumann: data moved to CPU at run time .... by power-hungry instruction streams

Reconfigurable Computing: locality of operation (assignment of rDPU) moved at compile time ...

... into the paths of the data streams:

by Software

by Configware

The Method of Communication

and Data Transport

the von Neumann syndrome

complex pipe network on rDPA

by Software

by Configware

Software-to-Configware (FPGA*) Migration: some published speed-up factors

Slashing the Electricity Bill

Only one of these speed-up publications reports the electricity consumption (this will change soon)

What about higher speed-ups reported so far? (more expected)

Bioinformatics: up to x 288 ?

Communication: up to x 2,400 ?

Image Processing: up to x 6,000 ?

Encryption: up to x 36,514 ?

We expect also higher electricity savings ... down to substantially less than 10%

Areas of success, from high-end systems on earth to mission-critical systems in space.

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Outline

Why coarse-grained RC and not FPGA?

Coarse-grained vs. FPGAs

Coarse-grained is much more efficient, also energy-efficient
Coarse-grained is the better treatment of the manycore crisis
Raising the abstraction level it comes closer to the mindset of the programmer population as available now

Conclusions

Pervasive ICT with “infinite resources” is not feasible without massively using Reconfigurable Computing
The Reconfigurable Computing paradigm should be the basis also with future technologies – not only CMOS
the von Neumann part should be kept as small as possible
The twin paradigm approach including RC is inevitable
We need a disruptive solution of the educational dilemma, also to recruit more researchers qualified for FET
We need a task force like ARTIST – but interlaced with FET research

Final Conclusion

FET projects should favor the RC paradigm to cope with the von Neumann Syndrome

thank you
END

Inefficient von Neumann Paradigm

Instruction-stream-based processing, isn’t sufficiently efficient for portable, pocket-size, or much smaller untethered systems.

Performance is measured by MIPS/mWatt instead of MIPS/€

Accelerators (ASICs) needed*, due to the von Neumann syndrome.

* Application-specific Integrated Circuit

not only for portables: also for PC (e.g., graphics accelerators) and other systems

but it’s data-stream-based

von Neumann paradigm

extremely inefficient and very power-hungry