The Transdisciplinary Responsibility of CS Curricula

Reiner Hartenstein
TU Kaiserslautern
San Diego, CA, USA, June 25 - 30, 2006

The Basic Model Paradigm Trap

frustrates interdisciplinary education, in CS even between subdisciplines

High performance computing stalled for decades by the von Neuman paradigm trap: the wrong road map.

The right roadmap kept by another trap for decades!

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Transdisciplinary Education? 

Computer Science not prepared for decades: the Hardware / Software chasm turns into: the Configware / Software chasm

Lacking intradisciplinary cohesion between the mind sets of:

- Theoreticians (Math background)
- Hardware People \{ Computer Architects, Embedded Syst. Designers \}
- Software People (Application Development)

for decades: the Hardware / Software chasm turns into: the Configware / Software chasm

H. T. Kung paradigm (systolic array)

define: ... which data item at which time at which port

(introducing Data streams, no instruction streams needed)

CS Mathematicians' hobby, early 80ies

(pipe network) DPA* (*) DataPath Array (array of DPUs)

execution transport-triggered

input data stream

output data streams

1980

H. T. Kung paradigm (systolic array)

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Synthesis Method?
of course, algebraic!

Algebraic means linear projection, restricted to uniform arrays, only with linear pipes
useful only for applications with strictly regular data dependencies:

Mathematicians caught by their own paradigm trap for more than a decade

DPA:
Generalization by a transdisciplinary hardware guy:
Rainer Kress discarded their algebraic synthesis methods and replaced it by simulated annealing. 1995

The right road map to HPC: no memory wall
there ignored for decades
massively avoiding memory cycles
DPU operation is transport-triggered
no instruction streams
no message passing
nor thru common memory
where are the supercomputing people? (took >2 decades)

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The supercomputing paradigm trap

this did not prevent supercomputing from following the wrong roadmap for decades, imprisoned by the von Neumann paradigm trap

No technology transfer from Mathematics: caught by the algebraic paradigm trap (systolic array scene)

Monstrous Steam Engines of Computing

Crossbar weight: 220 t, 3000 km of cable, 5120 Processors, 5000 pins each

ES 20: TFLOPS peak or sustained?

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The Language and Tool Disaster

End of April a DARPA brainstorming conference

Software people do not speak VHDL

Hardware people do not speak MPI

Bad quality of the application development tools

A poll at FCCM’98 revealed, that
86% hardware designers hate their tools

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Escaping the Paradigm Trap

The underground success story of FPGAs

The fastest growing segment of the semiconductor market

Massive speed-up

Slashing the electricity bill

However, this is not supported by our education systems

The RC paradox

although the effective integration density of FPGAs is by 4 orders of magnitude behind the Moore curve

wiring overhead reconfigurability overhead routing congestion

The fastest growing segment of the semiconductor market

Massive speed-up

Slashing the electricity bill

However, this is not supported by our education systems
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Embedded Systems scene not imprisoned by the von Neumann paradigm trap

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The Pervasiveness of RC unqualified for RC ?
Math/SW-savvy scene

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Using FPGAs for scientific computation?
hiring a student from the EE dept.?

application disciplines use their own trick boxes:
transdisciplinary fragmentation of methodology

CS is responsible to provide a RC common model
• for transdisciplinary education
• and, to fix its intradisciplinary fragmentation

Joint Task Force for Computing Curricula 2004
fully ignores Reconfigurable Computing

Curricula?
FPGA & synonyma: 0 hits
(Google: 10 million hits)

Computing Curricula 2004

Overview Report
including
A Guide to Undergraduate Degree Programs in Computing

for undergraduate degree programs in
Computer Engineering
Computer Science
Information Systems
Information Technology
Software Engineering

Joint Task Force for Computing Curricula 2004
A cooperative project of
The Association for Computing Machinery
The Association for Information Systems
The Computing Society (IEEE-CS)
22 November 2004

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Curriculum Recommendations, v. 2005

Upon my complaints the only change: including to the last paragraph of the survey volume:

"programmable hardware (including FPGAs, PGAs, PALs, GALs, etc.)."

However, no structural changes at all v. 2005 intended to be the final version (?)

torpedoing the transdisciplinary responsibility of CS curricula

This is criminal!

We need a SIG on CS education and RC education

to identify intra-disciplinary communication gaps in CS

to send delegates to the Joint Task Force for Computing Curricula

to develop a roadmap for CS to assume intradisciplinary responsibility for education

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thank you
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Liaison to the Organic Computing Initiative

http://www.organic-computing.org

German section

http://www.organic-computing.de

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Illustrating the von Neumann paradigm trap

The watering pot model [Hartenstein]

The instruction-stream-based approach

many watering pots

The data-stream-based approach

has no von Neumann bottleneck

von Neumann bottleneck

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data meeting the processing unit (PU)

We have 2 choices

routing the data
instruction streams are memory-cycle-hungry
placement of the execution locality
optimize pipe network: place PU in data stream

by Software

by Configware

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Co-Compiler Enabling Technology

is available from academia
only a small team needed for commercial re-implementation
on the road map to the Personal Supercomputer

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Compilation: Software vs. Configware

Software Engineering

- source program
  - software compiler
  - software code

Configware Engineering

- placement & routing
  - mapper
  - configware compiler
  - configware code
  - data scheduler
  - flowware code

Nick Tredennick’s Paradigm Shifts explain the differences

Software Engineering

- CPU software
  - resources: fixed
  - algorithm: variable
  - 1 programming source needed

Configware Engineering

- configware
  - resources: variable
  - algorithm: variable
  - 2 programming sources needed

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Co-Compilation

C, FORTRAN, MATHLAB

automatic SW / CW partitioner

software compiler

software code

Software / Configware Co-Compiler

mapper

configware compiler

data scheduler

configware code

flowware code

Co-Compiler for Hardwired Kress/Kung Machine

[e.g. Brodersen]

source

automatic SW / CW partitioner

software compiler

software code

Software / Flowware Co-Compiler

flowware compiler

data scheduler

flowware code

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