Towards energy efficient computing via reversibility

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Background information

Born in Hrubieszów, finished Liceum im Stanisława Staszica w Lublinie, attended Handel Zagraniczny na SGPiS-ie w Warszawie.

Left for London in November 1981.

Attended Queen Mary College and Imperial College in London (1984-92). Awarded a PhD in concurrency theory in 1994.

Worket at University of North London, Kyoto University, and University of Leicester.

Research interests in concurrency theory and in revesible computation.

Physical reversible computation

Reversible computation allows computation to proceed not only in the standard, forward direction, but also in reverse, recovering past states.

- Landauer's principle: removing 1 bit of information costs $k_B T \ln$. Verified experimentally in 2012.
- Reversible universal logic gates: Fredkin and Toffoli.
- Some research on reversible hardware.
- More research on logical reversibility: how to make programs work in reverse as well as forwards.

Logical reversible computation

Background:

- Reversible Turing machines: Lecerf and Bennett. Require extra tape and more time.
- Janus: reversible imperative programming language. Also, Erlang, process calculi, Petri nets, ... have been reversed.
- Applications in debugging (Undo UDB), optimistic parallel discrete event simulation, error recovery in robot assembly operations, ...

Current and future research:

- Reversible or partially reversible general purpose algorithms.
- Reversing intermediate and lower-level PLs.
- Reversing concurrent PLs.
- ...

Improving energy efficiency of software

Question:

Can running reversible programs on irreversible hardware save energy?

- We think Yes, but need to do more research and experiments.
- Marie Skłodowska Cure Action (MSCA) Doctoral Network (DN) involving Bologna, Copenhagen, Manchester and AGH.
- 10 PhD studentships:
  - 7 on basic research developing reversible algorithms, reversible intermediate and lower-level PLs, simulation of reversible hardware.
  - 3 practical case study PhDs: fixed wings drones, blockchain, and one more application topic suitable for AGH.
- 2 PhD studentships at AGH:
  - reversible general purpouse algorithms,
  - a case study (currently) on Deep Neural Networks.

Deep Neural Network studentship

Aims at applying reversible computation techniques, as well as other energy saving approaches, to enhance energy efficiency in Deep Neural Networks (DNN).

We will re-design algorithms and re-develop software components used in the training phase layers of DNNs by applying reversibility and other energy saving approaches.

Expected results:

1. Development of reversible versions of DNN layer algorithms, and their implementations
2. Formulation of suitable models for estimation of energy consumption of software, called the energy models
3. Measurement of energy consumption of the developed software, and evaluation of the energy models
4. Analysis of the effect of reversible computation techniques on energy efficiency, as well as on time and space complexity.

Question:

Can we find an alternative case study software to apply the proposed energy saving techniques and to evaluate their outcomes?

Some characteristics of such software:

- KIS colleagues are experts,
- uses basic algorithms,
- repeats patterns of computation many times,
- calculations with lots of garbage,
- speed or space are not critical.

Any suggestions are welcome: room 320 today and on Thursday.

Or email irekulidowski@gmail.com .