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Energy-Efficient Computing: Hype or Science?

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The Perfect Storm



Lots of hype but much of it is justified

- Technology: Power wall
- Business: Data center operating costs, handheld battery life
- Environment: EPA Report, fastest growing carbon production segment

How did We Get Here?



Moore's law: 2x transistors every 2 years

- Hardware has focused on performance at high power cost
 - OOO execution, non-blocking caches, branch prediction
- Software has mostly ignored performance
 - Complex performance model, hardware gains
- Opportunity for better hardware/software co-design

Energy-Efficient Software



Can we build energy-efficient computing systems using existing software as is?

Can we automatically parallelize sequential software?

What are the right abstractions for programmers to communicate high-level intent and domain knowledge to the rest of the system?

nanoJoules/instruction is probably not the right level

Some Preliminary Ideas



Expose Quality-of-Service requirements

- Rest of system can leverage this
- But need to guarantee the QoS is met
- Signaling intention
 - Hardware/Software communication (e.g. better branch prediction)
- Specialization
 - Support for offloading computation to GPUs, FPGAs

QoS Opportunity



of documents that must be processed to return top N

Documents (Static Rank Order)

15-20% energy reduction with 0.2% QoS degradation

Energy-Efficient Computing



Need to rethink/reexamine all parts of computing systems

- Software: programming models, applications, compilers, runtime systems, operating systems
- Hardware: processors, memory, storage, networking
- Infrastructure: packaging, power delivery and cooling
- Better measurement tools for attributing energy usage
 - Tend to ignore what we cannot accurately quantify



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