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Energy-Efficient Computing: Hype or Science?

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The Perfect Storm

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- 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?

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- 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

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- 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

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- 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

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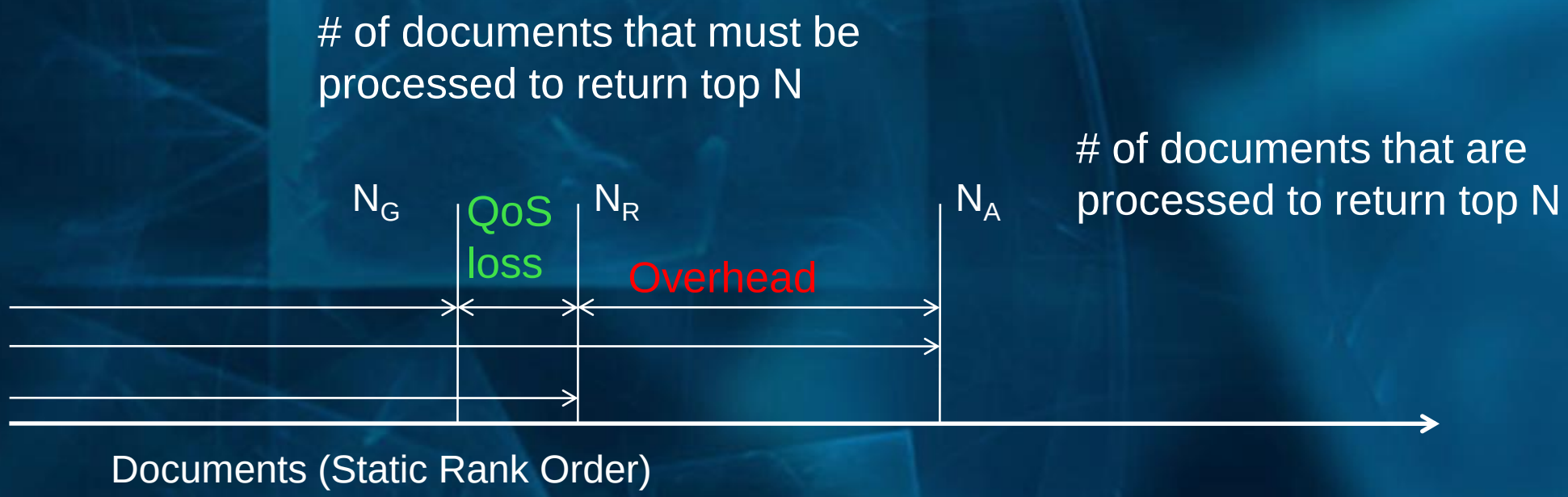

15-20% energy reduction with 0.2% QoS degradation

Energy-Efficient Computing

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- 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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