

SUSTAINABLE STORAGE: OPPORTUNITIES AND RESEARCH CHALLENGES

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SUSTAINABLE IT TRADEOFFS

–Sustainable IT must be:

- Environmentally sustainable
- Economical
- and*
- Efficient (perform adequately)

–Result: tradeoffs

- Optimization and feedback control can manage *quantifiable* tradeoffs

EXAMPLE: STORAGE SYSTEM

- Storage systems consume 37% of data center power
[Michael Bell, Gartner]
- Possible solutions and issues
 - Use slower disks: performance
 - Spin down disks: spin-up time
 - Use solid state disks (flash, etc.): cost
 - Consolidate workloads: interference
- Which to pick, and how to control?
 - Need quantitative tradeoffs

MANAGING THE TRADEOFFS

- Design objectives: quantify tradeoffs
 - E.g.: minimize costs where 1 hour's data loss costs \$500K
- Usual metrics: performance and cost
 - But energy consumption can be added!
 - E.g.: ... and a backup uses 0.5KWH/TB @ \$0.15/KWH in daytime and \$0.11/KWH at night
- Feedback control & optimization can do
 - Automatic configuration
 - Dynamic adjustment to workload

NEW STORAGE TECHNOLOGIES

–Solid state devices: flash, PCM

- Lower power, higher performance, higher cost
- New opportunities for sustainability, new dimensions for control

–Uses in sustainable IT:

- Cache/relocate data from disk to SSD
 - Disks can be reduced or spun down
 - Higher performance -> fewer machines needed

–How to use available SSD optimally?

- Use feedback control to adjust dynamically

SYSTEM CONTROL CHALLENGES

–Defining objectives/tradeoffs is hard

- Too many corner/pathological cases
- Must be robust to infeasible QoS targets, buggy systems, failure/recovery conditions, ...
- Requirements are often unknown
- Measurement hooks unavailable
- Control hooks unavailable
- Models are lacking
- Testing control system adequately

ANOTHER ANGLE

- Design easier-to-control systems
 - Support end-to-end objectives
 - 250ms user response, not 30ms IO response time
 - Combine with cost, power, space, ...
 - Build applications with measurement and control hooks
 - Build facilities to test control solutions
 - Build robust feedback control methods for complex systems