Green Bytes: Sustainable Approaches to Digital Stewardship, A Practitioner’s Perspective
There Are Limits...
Existing “Green” Preservation Practices

Tape Archives
“Virtual stacks” in...
- Berms
- Mountain vaults
- Leased salt mines and stone quarries

Upside:
- Cost of storage is often lower

Downside:
- Cost of access is often higher

Src: Myrbakk, Mountain Vaults: A Thousand Year’s Perspective

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"Protect our dead and our living Against the persistent Sunshine and rain called time"

From "The heart of the mountain" by Asbjørn I. Straumfors
Leading “Green” Commercial Practices

Innovative physical infrastructure/cooling
Geographic distribution of facilities
High/er storage density
High/er temps

GreenGrid Key Metrics:
PUE, DCcE, ScE…

www.thegreengrid.org
Case Study: Internet Archive
www.archive.org
Challenges to Sustainability: OpEx

Initial Goal: Lower operational expenses by reducing power consumption

Base Metrics:
- Power Usage Efficiency (PUE)
- KiloWatt per PetaByte (KW/PB)

Source: [Reduce OPEX](http://racktivityblog.files.wordpress.com/2013/03/reduceopex.jpg?w=282)
Power Usage Efficiency

\[ PUE = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}} \]

- Industry average for typical data center in 2008: PUE 1.5 – 2
  - Meaning: 100W of computing takes 50-100W of cooling
The “Old” Days (2004 - 2010)

- Traditional, air conditioned, data center facilities
- Rented - NOT easy to modify
- No separation between hot & cold air
- PUE (2010):
  - est. $\sim1.8$

- 2004: 117 KW/PB
- 2010: 39 KW/PB
  - not including cooling
Container Experiment (2008-2012)

- Density made cooling more important/complicated
- Needed cold water, not air
- PUE: varies (est. ~2)
- 67 KW/PB
  - not including cooling

Cheaper and faster to deploy than a traditional data center
The Latest Chapter (2010 – present)

Reduce power consumption even further/increase server efficiency

Racks should co-exist with humans, don't hide them…

Do not ruin buildings with ducts, A/C plant (in SF, 2 miles from the ocean w/49 wks per yr of natural cooling…)

Make it as “pretty” as… the Jedi Library from Star Wars
Challenges Along the Way

Our new data center is complete. The only wrinkle is that the power company won't give us the kilowatts we need. What are our options? Well, we can run the servers without air conditioning. Until they melt into a toxic blob. Then we can turn the building into a museum that celebrates poor planning. Or we could all quit our jobs and eat bugs to survive. Let's go with the toxic blob, but we need to call it something else.

Convergence!

No support from the power company and no $$ to “buy” solutions to measure usage… So, we built a whole-data-center, real-time, networked power meter for < $500…
Ongoing Engineering:
Data Driven Optimization

- Measure
- A/B tests
- Correlate power, temperatures, compute jobs
- Shift big compute jobs to avoid noon heat (and peak utility pricing)
Ongoing Engineering: Software + Networked Devices

if (temperature > 97F)  # it's hot
  or (current(fan1) < 7A)  # fan1 has failed
  then power_up(fan2)
  and alert(humans)
For Now…Success!

- **PUE < 1** (heat gets reused)
- **2010: 8.5 KW/PB**
- **2013: 2.8 KW/PB**
  (+1 KW, if running compute VMs)
- **Quiet(ish)**

Most photographed data center in SF…
Solar cell
15 cm (6 in) diameter
100um thick
wire routing on back side

Processor, RAM, Flash, Control and Power switching
Optical Thruster
Clear or Reflective
Radio

20 cm
~8 inches

(Image credit: ServerSky)