ITC/HPC Heat Re-use
a case study and perspectives

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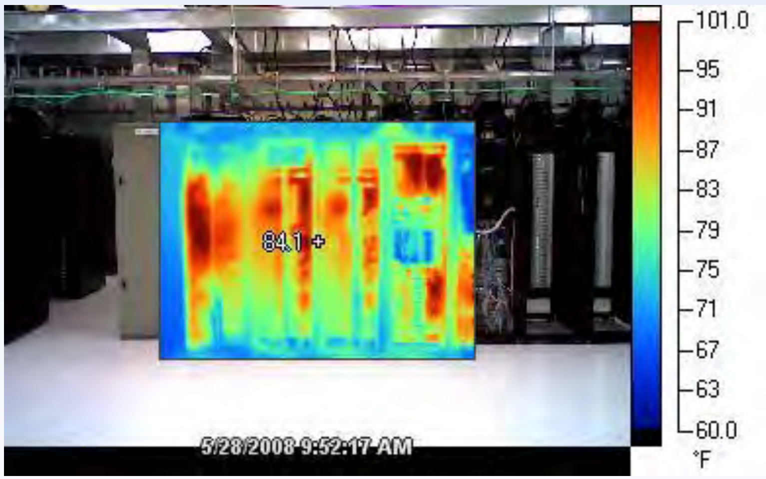
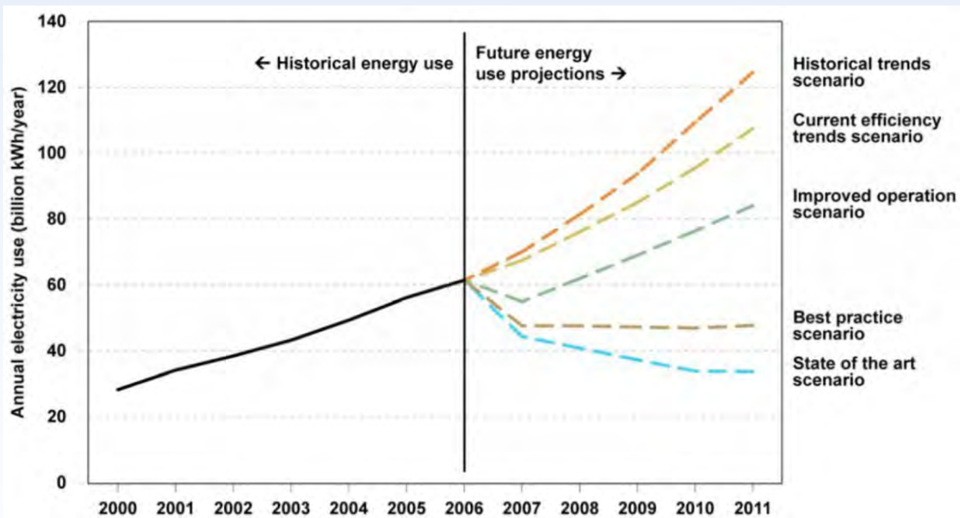
Motivation

Utility costs for US Servers to grow from $4.5 billion in 2006 to $7.4 billion in 2011





US EIA (billions)

- 2001 Residential Heating: Space $50.4 , Water $21
- 2002 Industry Heating: $8 Boilers , $20.5 Process

Ref: US EPA 2007

New Frameworks

- ***Environmentally Opportunistic Computing (EOC)***

EOC integrates ICT infrastructure with existing facilities to create heat where it is already needed, to exploit cooling where it is already available, to utilize energy where it is least expensive, and thus maximize the overall sustainability of an organization.

Two Examples:

– ***Grid Heating***
  - Design and deploy the IT infrastructure in correlation with target industrial and municipal heat sinks . ***"Bring the Heat"***

– ***Symbiotic Cooling***
  - The ICT resources are deployed inline with the host facility's available relief/exhaust air streams
  - *"Fresh air must come in, cool with the air stream headed out."*

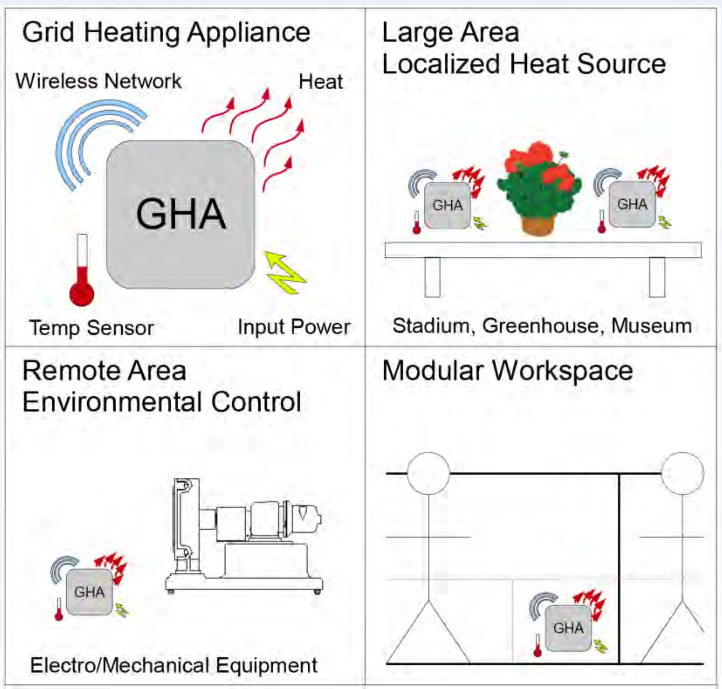
Deployment

- Must address operational IT considerations
  – Physical
    - Temperature, Humidity, Particulate
  – Practical
    - Security, Bandwidth, Access, Acoustics
    - Reliability/Redundancy/Disaster Recovery
- Utilization relative to hardware capital costs
  – 365 x 24 designs preferred
  – Minimize energy transformation/transport
  – Select granularity of grid distribution accordingly

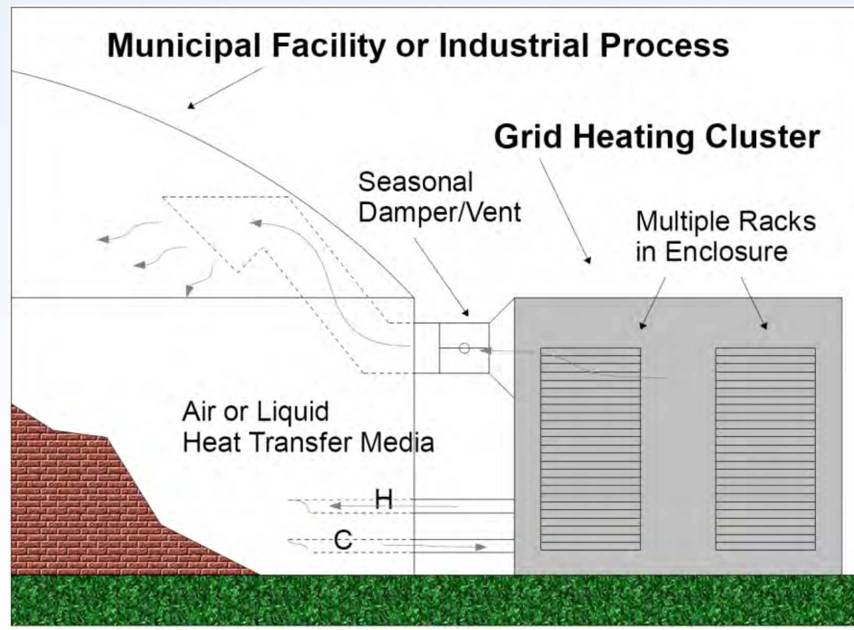
Early Concepts

- Continuum of granularity: server to rack to container

Appliances

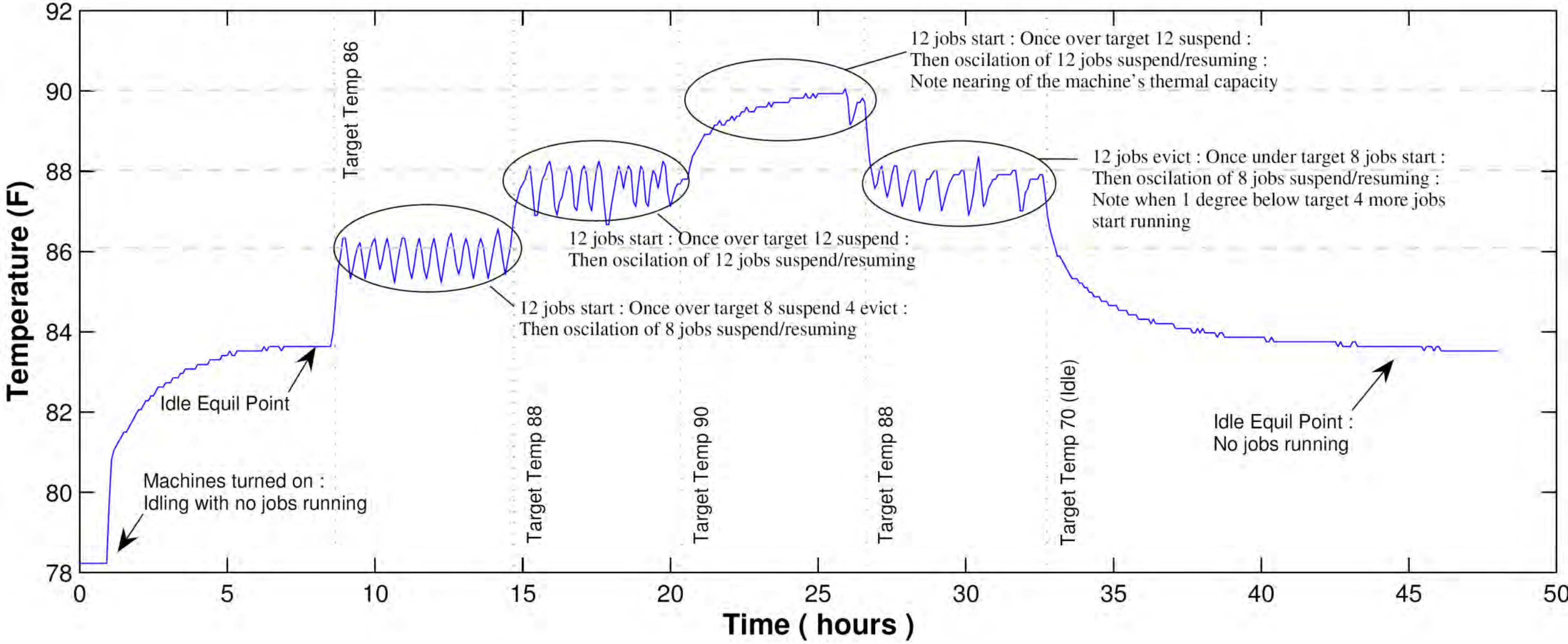


Clusters



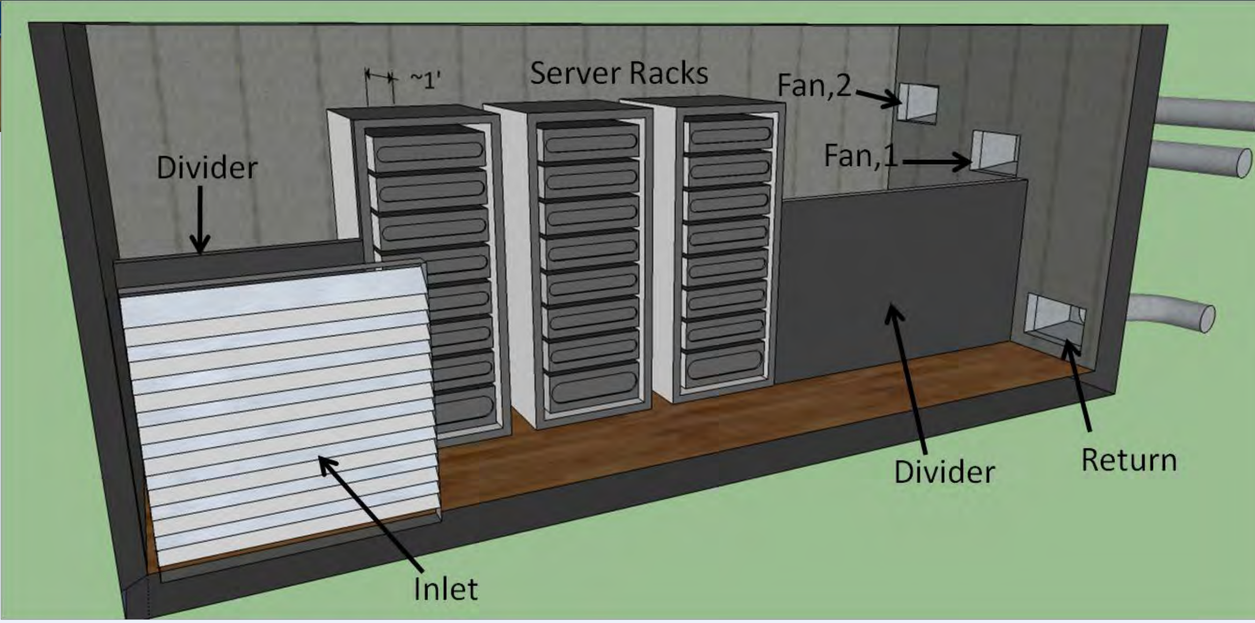
Controls Validation

- Fine Grained Temperature Control



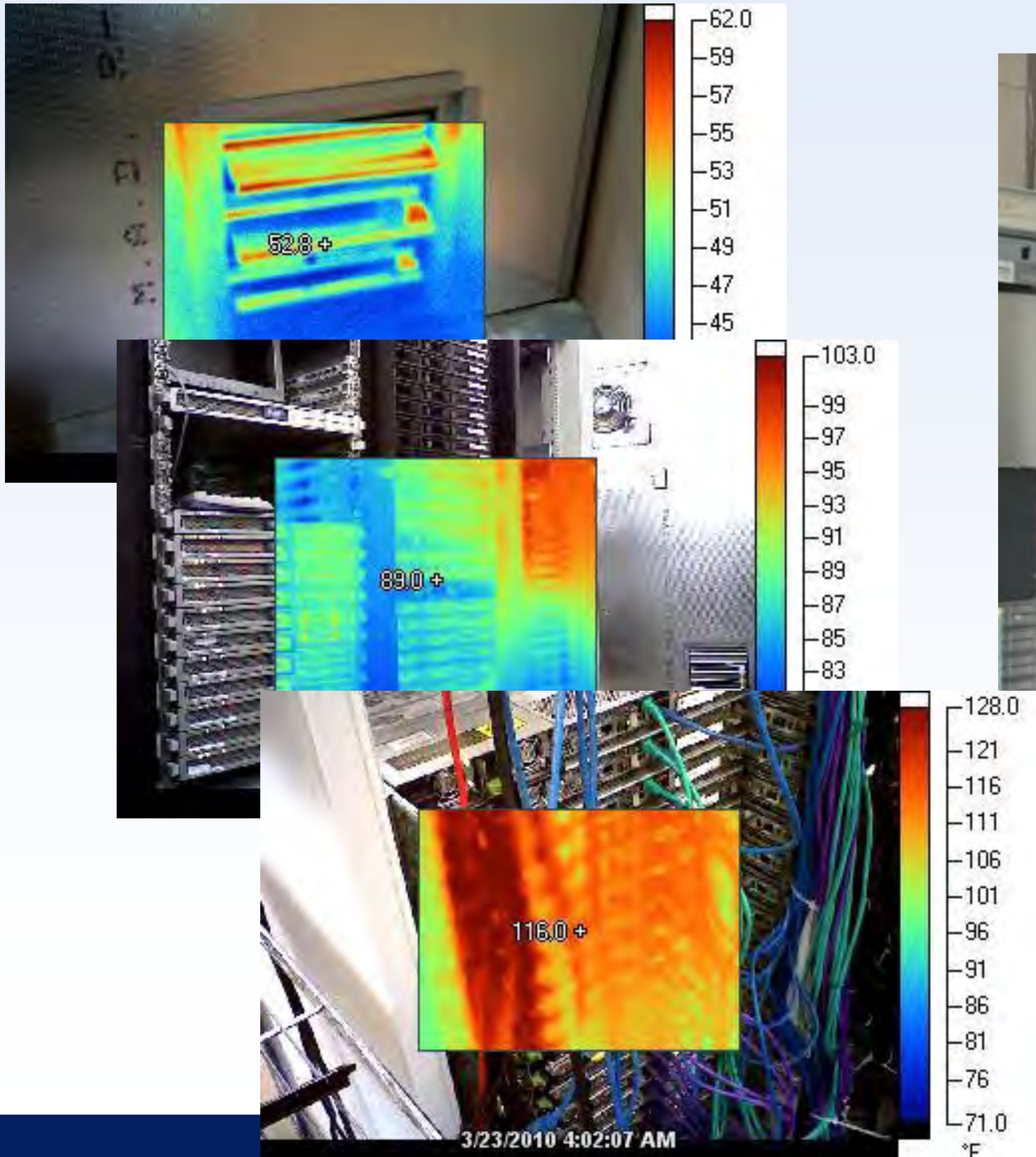
Green Cloud: an EOC Prototype

- South Bend Greenhouse and Botanical Conservatory
  - SBG struggles to retain sufficient funding. Annual heating costs are a primary funding factor (over 100K in 2005 & 2006, forced closure of some sections in 2007).



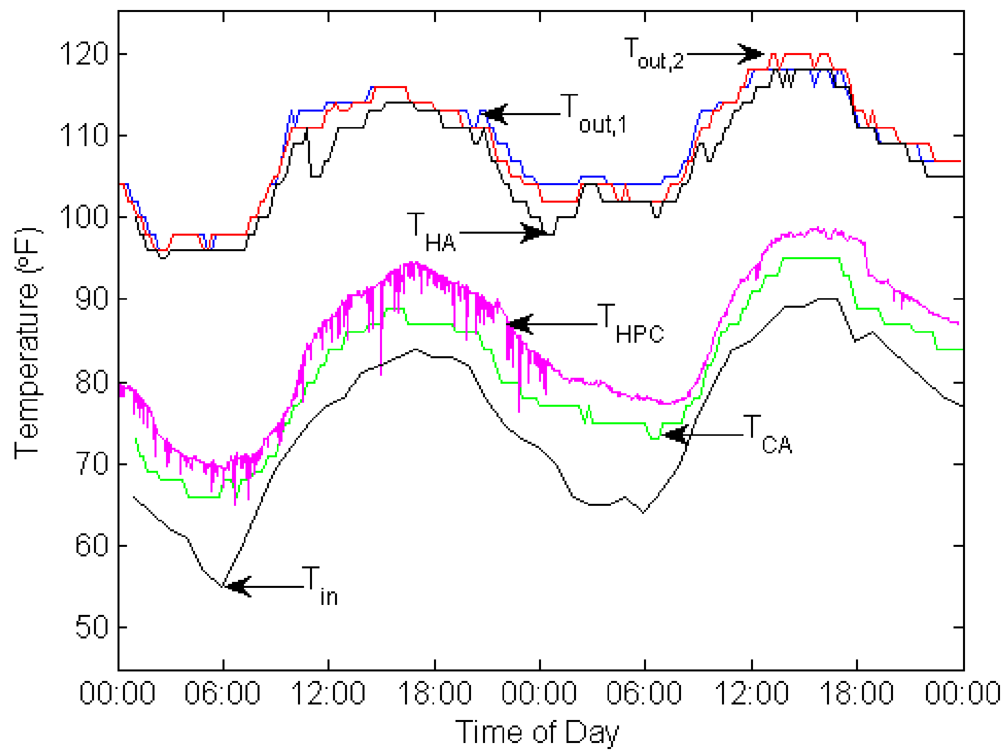
SDDC
Sustainable
Distributed
Data Center

Perpetually Evolving Production Prototype



Energy Targets

- Optimization Problem
  - Maximize
    - * *Job Throughput*
    - * $T_{in} - T_{out}$
  - Minimize
    - * *Mean Time to Failure*

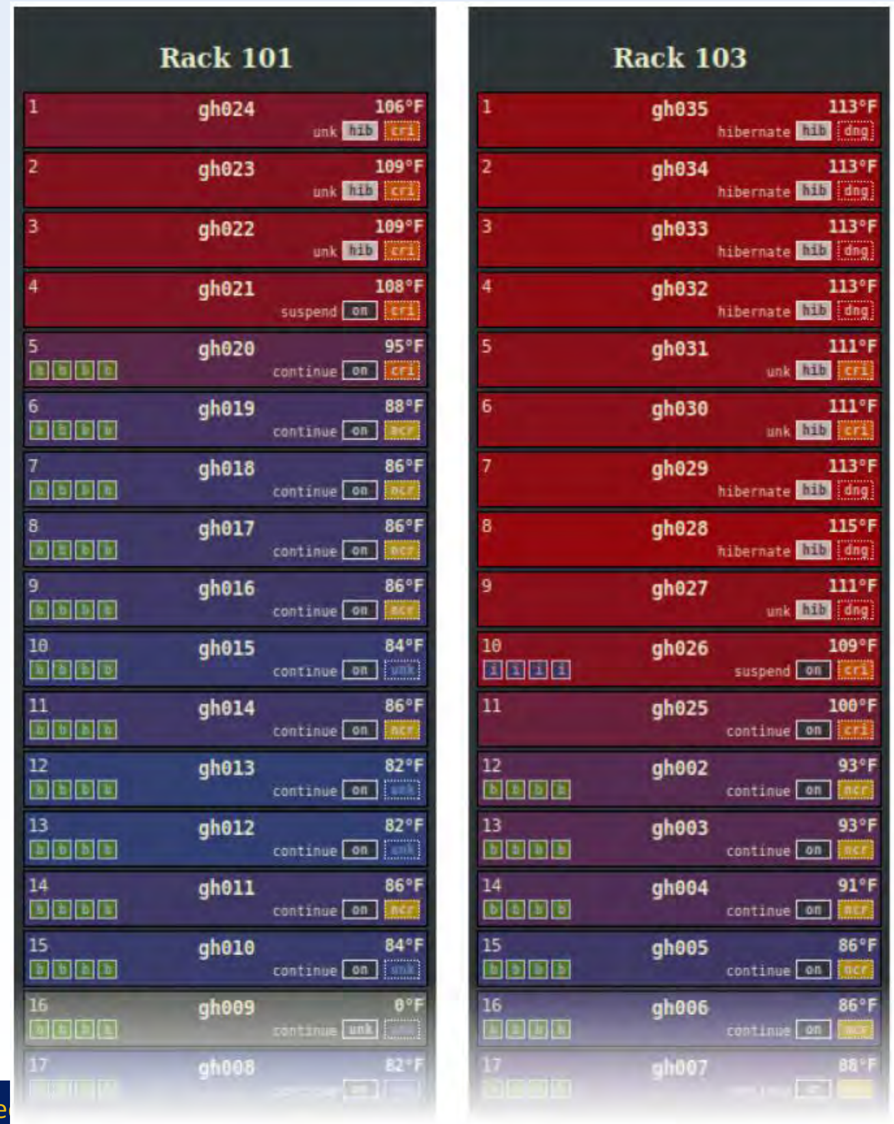


- Summer 2010
  - Operating between 30-60 servers ~9.75kW average
  - $702/month at $0.10 per kW-h
- With cooler fall temperatures
  - Operate more machines and recover ~30kW

Real-time Logic and Visualization

Algorithm 1 Pseudo Logic for Macro Thermal Control

```
repeat

    Read all temperatures

    if machine is in the dangerous threshold range then
        Lower target temperature by 2 degrees
    else if machine is in the critical threshold range then
        Lower target temperature by 1 degree
    else
        Raise target temperature by 1 degree
    end if

    for all machines do
        Rewrite machine configuration file with updated
        inlet temperature and target temperature:
        Start if temp <target - start_offset
        Suspend if temp >target
        Continue if temp <target
        Preempt if temp >target + 1 - evict_offset
        Hibernate if temp >danger temp {Hibernate not
        currently automated}
        Unhibernate if temp <target + 1
    end for

    Send reconfigure command to all machines

until Incrementally update controls for the period of
operation
```



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- The eBay corporation
- DOE NWICG Grant

Re-Use Discussion Topics:

- Air Cooled versus Water Cooled
  - How does this impact mapping reuse to your facility?
- Maximum Inlet Operating Temperature
  - This increases the applicability for free cooling; is the case equally true for better heat reuse?
- Remote Isolated Data Centers
  - What are the reuse options?

ERE

A Metric for Measuring the Benefit of Reuse Energy From a Data Center

Green Grid - White Paper #29

Editor: Mike Patterson, INTEL

Questions?

http://greencloud.crc.nd.edu