Warehouse Scale Power
Energy, Scaling, and the Future
OVERVIEW

- Quantifying Power
- Tangent: Green Servers (New)
- Scalable Systems
- Tangent: OpenPower (New)
QUANTIFYING EFFICIENCY

- Why?
  - Efficiency = Money

- Benchmarks
  - Issues
  - Usefulness

- PUE
  - Power Usage Effectiveness
  - Facility Efficiency

\[ \text{Total Building Power} = \frac{\text{IT Power}}{} \]
PUE

- Evolution of PUE
  - At one time a PUE of 3.0 was the norm
  - Accounting for the range of PUEs

- Pitfalls of PUE
  - Unclear methodology
  - Account for overheads
PUTTING IT TOGETHER

SPUE

\[ \frac{\text{Total Server Input}}{\text{Useful Power}} \]

Efficiency = \( \frac{\text{Computation}}{\text{Total Energy}} = \left( \frac{1}{\text{PUE}} \right)^{(a)} \times \left( \frac{1}{\text{SPUE}} \right)^{(b)} \times \left( \frac{\text{Computation}}{\text{Total Energy to Electronic Components}} \right)^{(c)} \)

How can we use it?
DESIGNING GREEN SERVERS

- Jevon’s Paradox
- Information technology industry uses about 2% of global carbon emissions
- Alternative measurements of efficiency
A TALE OF THREES

• Reduce, Recycle, Reuse
  – Drawing parallels to WSC and servers

• Energy, Entropy, and Exergy
  – Sustainable development
HP Labs

- Disaggregate, Dematerialization, and Dedensify
INTERESTING PAPER

**Usage and Scalability**

- On the right is the activity distribution of a Google WSC
- On the left is a shared WSC
- What’s the difference?
POWER SCALING

- CPU’s have a dynamic power range
- Memory: 2x | Disk: 1.2x A meaningful metric of the energy proportionality of a server for a WSC is the ratio between the energy efficiency at 30% and 100% utilizations. A perfectly proportional system will be as efficient at 30% as it is at 100%.
SCALING METRICS

- DVFS is *not* enough
AMHALS LAW

- \( S(N) = \frac{1}{(1-P)+\frac{P}{N}} \)
- \( P(u) = P_i + u(1 - p_i) \)
  - Assume system has linear power usage as a function of utilization
- \( E(u) = \frac{1}{(1-P_i)+\frac{P_i}{N}} \)
  - \( P_i \) is idle system and peak power is 1.0
  - Any subsystem that isn’t optimized brings down entire system
OpenPower Foundation

- Utilize IBM’s Vertical Stack
- Customized servers
- Unique architectural alternatives
Power8

- 22nm SOI
- 12 core (96 Thread)
- Scale Out Clusters

Energy Usage
- Dependent on memory technologies (on-chip eDRAM)
- 250W
CLAIMS

- “Power8 is capable of analyzing Big Data workloads between 50 and 1,000 times faster than comparable x86 systems”
- CAPI: Coherent Accelerator Processor Interface
  - Direct link to CPU
  - Bypass communication overheads
  - Attach Co-Processors
  - Workload specific boost are tremendous, 1000x over x86 system
What’s Google Up To

- Moving away from commodity
- More efficiency gains from switch-off/switch-on co-processors
- Dark Silicon
- Controlling *everything*