The Data Furnace:

Heating Up with Cloud Computing

Jie Liu, Michel Goraczko,
Sean James, Christian Belady

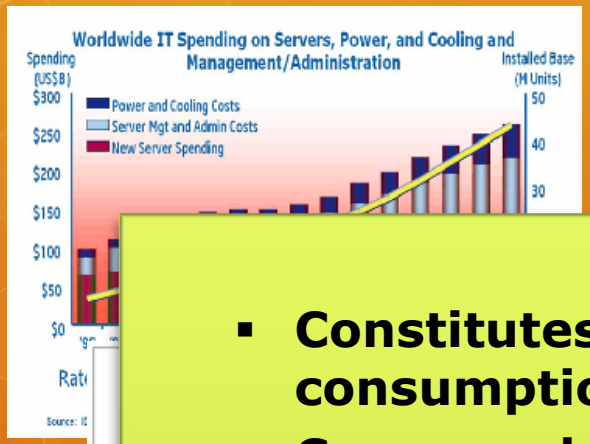
Microsoft

Jiakang Lu
Kamin Whitehouse

University of Virginia

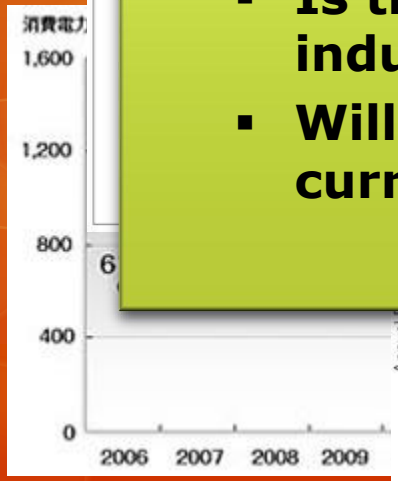
The Cloud Is Big!

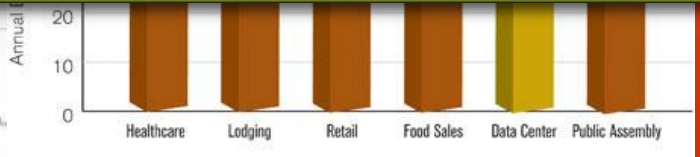
The Cloud Is Hot!

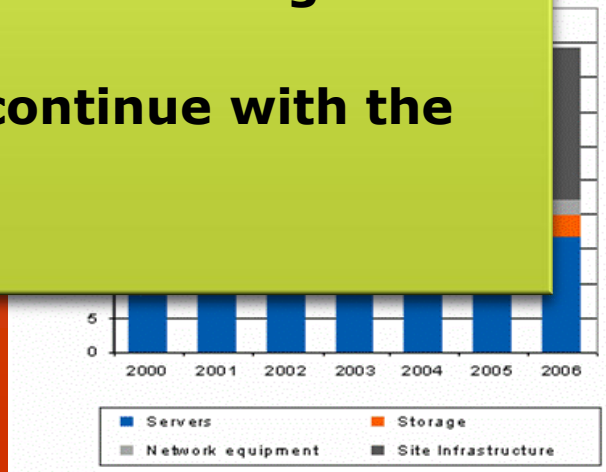


IT industry

- **Constitutes about 2% of total US energy consumption**
- **Consumed 61 Billion kWh in 2006, enough to power 5.8 Million average US households**
- **Paid $4.5 Billion power bill in 2006**
- **Is the fastest growing energy consuming industrial sector**
- **Will double again by 2011 if continue with the current trend**

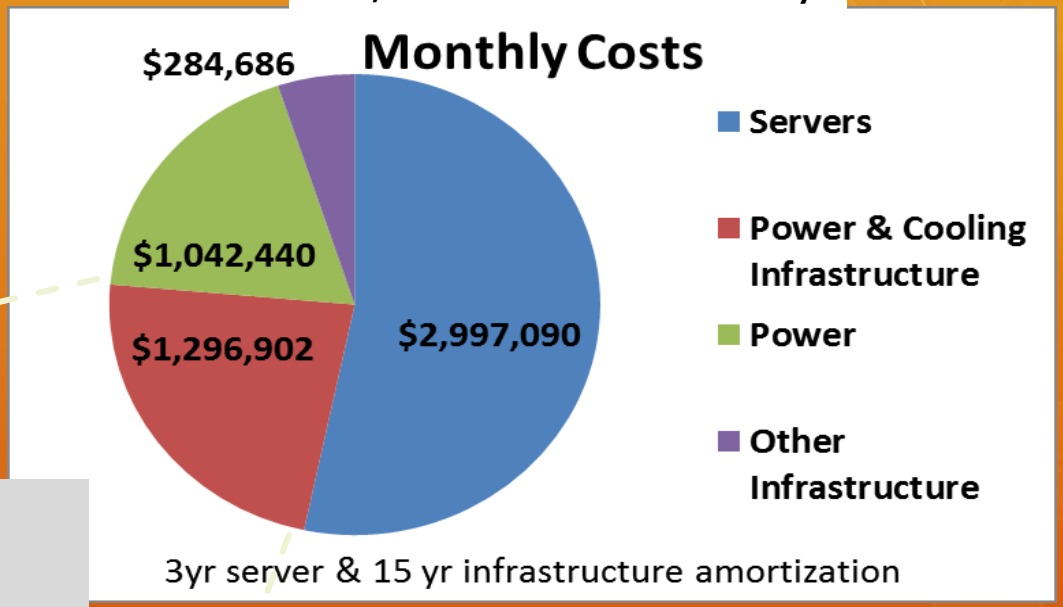




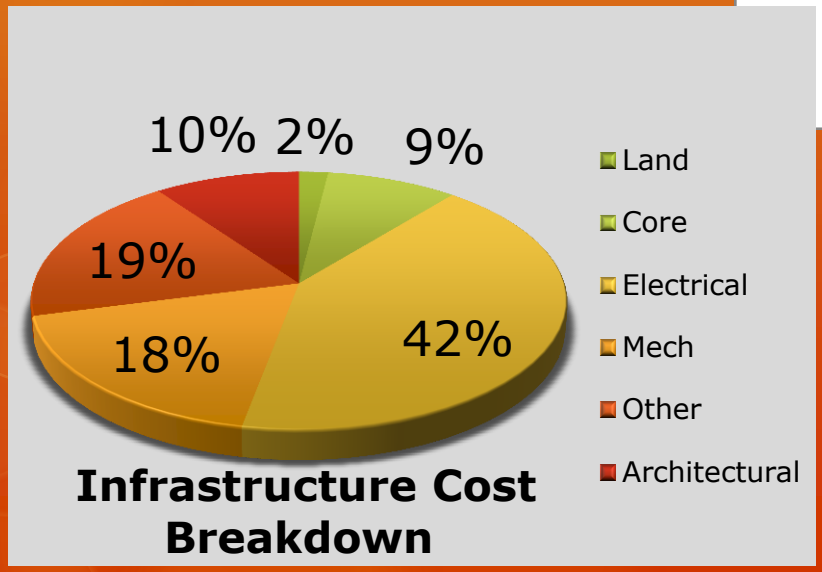


The Cloud Is Expensive!

50,000 server facility



3yr server & 15 yr infrastructure amortization



Data from James Hamilton and Mike Manos

Improving Efficiency

REDUCE

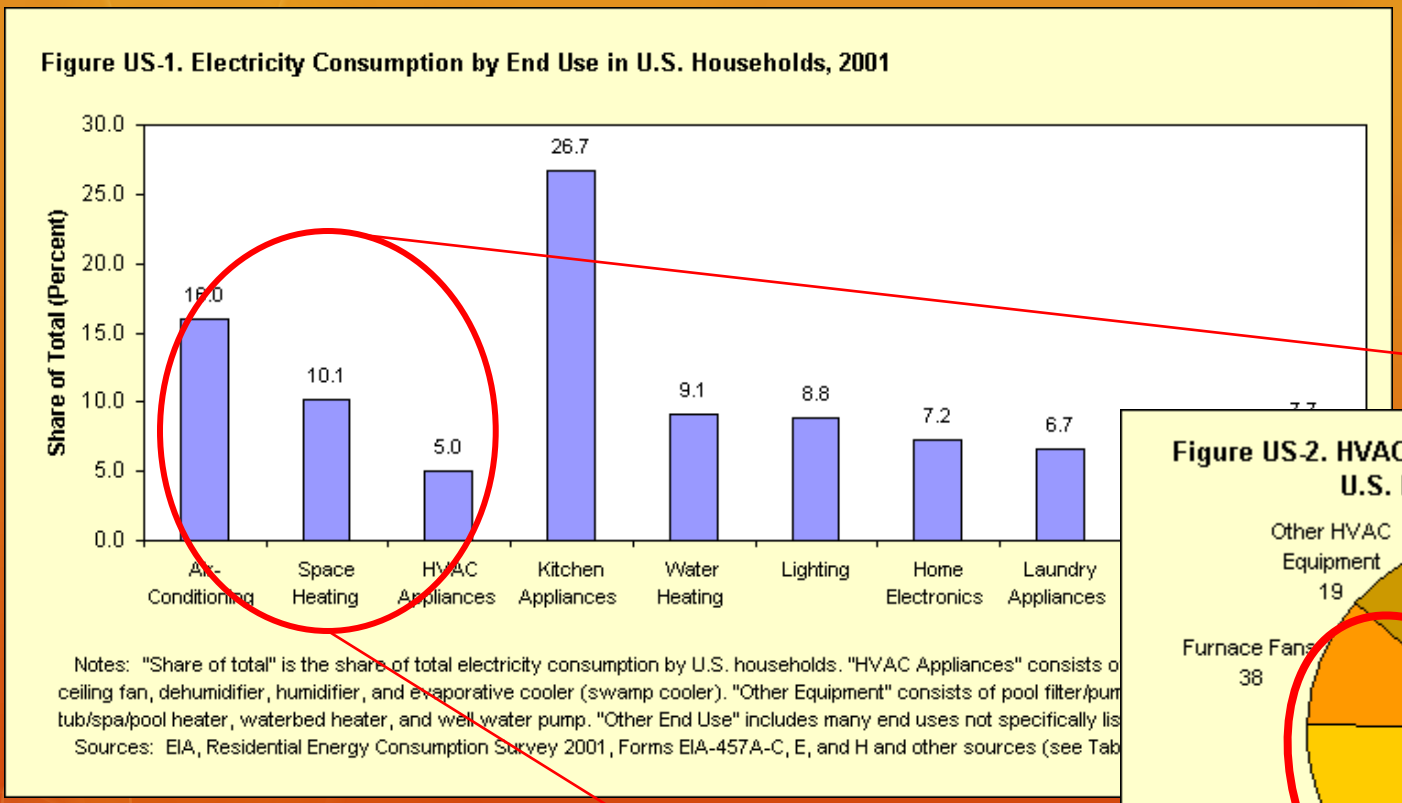
RENEW

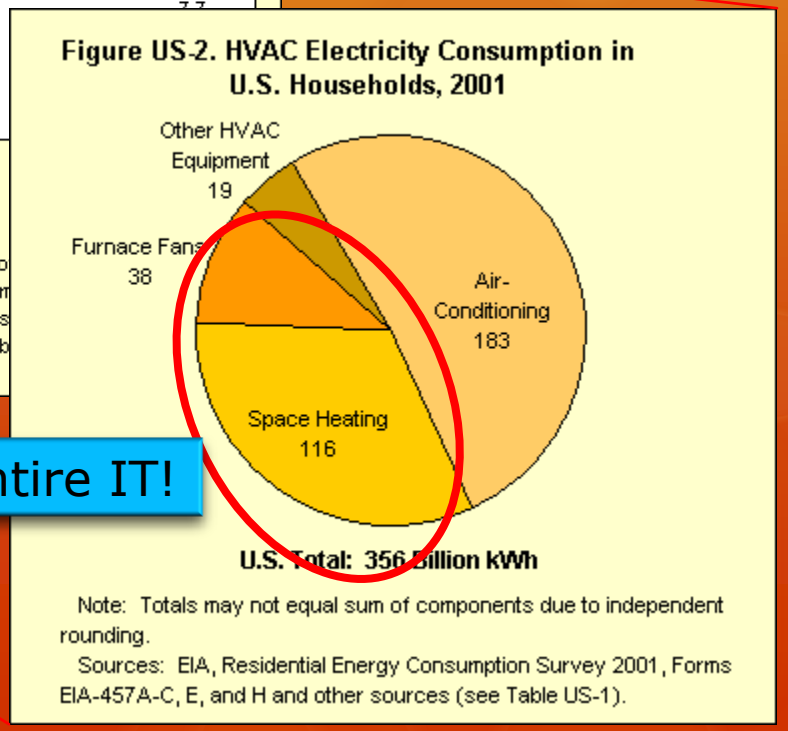
REUSE

Home Power Provision

12% provisioned power (30kW)

Home Energy Usage





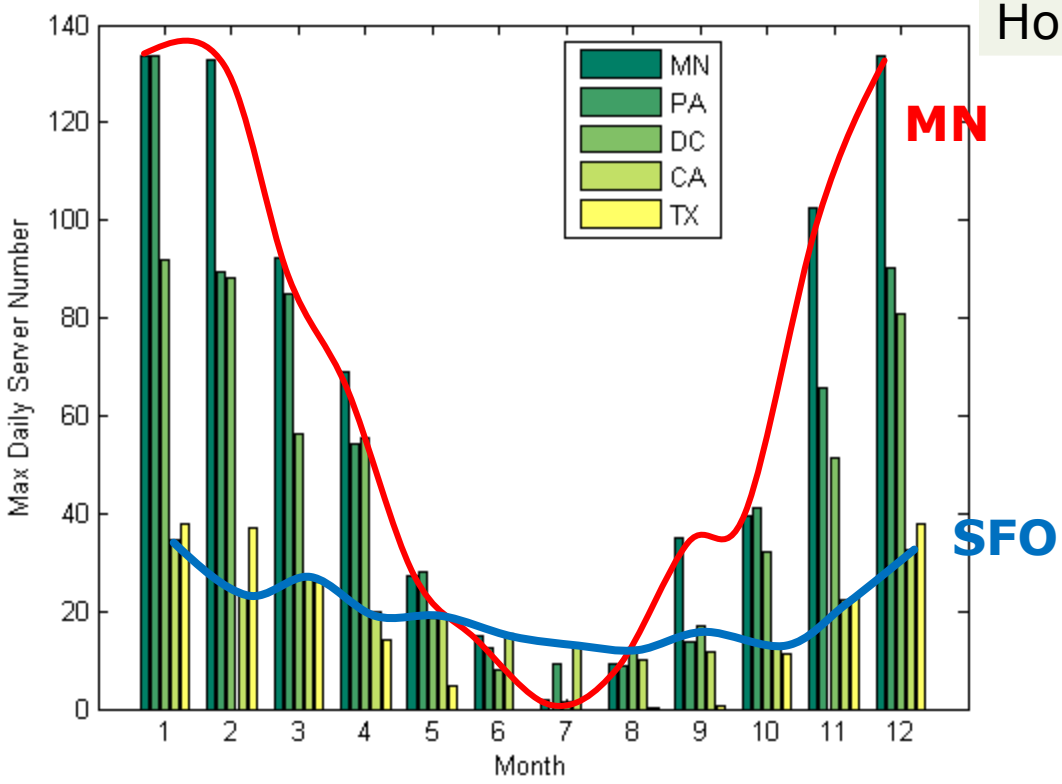
Twice the entire IT!

US Energy Information Administration

The Data Furnace

- DOE EnergyPlus simulator
- 1700 sqft single family house
- 70F set point
- 5 climate zones

	Outdoor Temp.	
	< 70F	> 95F
Minneapolis	82%	0.11%
Pittsburgh	82%	0
DC	77%	0.13%
San Francisco	96%	0
Houston	46.5%	0.15%



- 1 min time granularity.
- Max power required.
- Assume 300W servers.

Ideal Cost Benefits

- **Amortized cost in conventional DC: $400/server/year**
- **Urban electricity price overhead: $0.05/kWh**
- **Possible T1 network cost: $2640/year**

	MN	PA	DC	CA	TX
Provisioned server #	112	114	101	46	37
Current heating exp. ($/year)	3K	2K	2.5K		700
Elec. price overhead heating use ($/year)	9525				1666
Elec. price overhead full use ($/year)	14		13.3K	6K	4.9K
Current host cost ($/year)	44.8K	45.6K	40.4K	18.4K	14.8K

Cost Saving : 60%~80%!

FAQ#1: Useful?

- **Low-Cost Seasonal Data Centers**
  - Opportunistic cycles (SETI)
  - Developing communities
  - hobbyists
- **Low-Bandwidth Neighborhood Data Centers**
  - Email serving
  - Ultra-local web services
  - Neighborhood content sharing
  - Delay-tolerance jobs
- **Eco-Friendly Urban Data Centers**
  - Small scale cloud computing
  - Content caching
  - Casual collaborations/games

FAQ#2: Hidden Cost?

- Hardware reliability (Vishwanath et al. SOCC10)
  - 92% servers never need touch
  - 8% servers failed (repeatedly)
  - Average touches per failed server: 3~4/14months
  - Predominantly HDD failures
- Run a service truck: $100/visit/house

- **Technical Challenges – System Design & Management:**
  - Improve reliability by hardware design (low power density, low vibration)
  - Increase replication
  - Fail gracefully

FAQ#3: Residential Power?

- Home circuit capacity
- Usage is increasing with electrical cars
- Consumer power generators are emerging
- Residential power quality challenges

- **Technical Challenges – Power Management:**
  - Close monitoring and control are critical
  - Power availability prediction
  - Power capping and tracking
  - Local energy storage

FAQ#4: Secure?

- Physical security:
- Storage and communication security:
- Computing security:

- **Technical Challenges – Security**:
  - Embedded sensors for anti-tampering.
  - Isolation and encryption.
  - Secure execution.

FAQ#5: Performance?

- Not to replace centralized data centers.
- The services can be close to end user physically

- **Technical challenges – performance:**
  - Networking
  - Placement
  - Elasticity
  - Opportunistic processing

Conclusion

- **Data Furnace**
  - Reuse existing power infrastructure
  - Reuse heating energy for computing
  - Be close to end users
- **Other forms of heat reuse:**
  - Water pre-heating
  - Apartments/office buildings
  - Agriculture
- **Many, many challenges**

Hedging The Cloud