A First Look at Colocation Demand Response

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Demand response program

• Market-based program
  – Reduce peak energy usage
Demand response program

• Market-based program
  – Reduce peak energy usage
  – Increase adoption of renewables
    • e.g., encourage customers to reduce energy during low renewables
• Data centers are promising participants in demand response
  – Large yet flexible energy demands!
Multi-tenant colocation data center

• Multiple tenants house their own servers in one *shared* space and manage their equipment independently.

• Data center operator is only responsible for facility management (e.g., power distribution, cooling).

Verizon Terremark in downtown Miami
Why colocation demand response?
In reality...

“Most large data centers are built to host servers from multiple companies (often called colocation data centers, or "colos").”

--- The Datacenter as a Computer, a study by Google Research in 2013
Colocation is growing

• There’re over **1,000** colocation data centers in the U.S.
• Projected to grow to **US$ 43 billion** by 2018
  – Annual compound growth rate of 11%

http://www.datacentermap.com/
Who are using colocations, and why?

• “Small and medium” businesses
  – Building self-owned data centers is out of the question
  – Public cloud is not a one-size-fits-all solution

• But, they’re not really small...
  – Wikipedia, Twitter, etc.
  – 62% of Facebook’s servers were housed in colocations as of 2012
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Are colocations competing with cloud?
Many **clouds** live in colocations!

- Medium-scale cloud operators
  - Box
  - Salesforce
- Even the largest ones
  - e.g., Microsoft and Amazon have many “**edge**” centers to realize global footprints

[Link to AWS Amazon](https://aws.amazon.com)
Colocation is ideal for demand response

• Most large data centers are colocations
• Colocations are mostly in metropolitan areas
  – Downtown Los Angeles, New York, Silicon Valley, etc.
  – This is where demand response is mostly wanted!

Google’s data center in Mayes County, Oklahoma

Verizon Terremark in downtown Miami
It’s not **easy** to enable colocation demand response...
Why colocation demand response is challenging?

- A commonly used pricing model is based on *Power Subscriptions*

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http://www.terremark.com/
Why colocation demand response is challenging?

• A commonly used pricing model is based on *Power Subscriptions*
• “Split incentive”
  – Colocation operator desires demand response but has no control over tenants’ servers
  – Tenants manage servers but have no incentive for demand response
We need to incentivize tenants for colocation demand response...
iCODE

• Incentive mechanism based on “negotiation”
  – **Step 1:** Each participating tenant decides its bid, including planned energy reduction and desired payment
  – **Step 2:** Colocation operator chooses winning bids
Model

• Tenant
  – $\Delta e_i$: energy reduction (by turning off unused servers)
  – $c_i$: requested payment is a non-decreasing function of energy reduction
    • Switching cost + delay cost

• Colocation operator
  – $q$: incentive rate provided by load serving entity for each unit energy reduction
Problem formulation

• Decide winning bids to maximize energy reduction subject to “no profit loss” constraint

\[
\text{maximize } \gamma \cdot \sum \Delta e_i \\
\text{s.t. } \sum c_i \leq q \cdot \gamma \cdot \sum \Delta e_i
\]

– LSE benefits from peak energy reduction
– Colocation operator reduces energy at no additional cost
– Tenants receive financial compensation without affecting application performance
Case study
How to evaluate iCODE?

• Consider a real-life trace simulation

   – Three different tenants
   – A multi-tenant colocation data center in New York, NY, with a PUE of 1.6
Colocation demand response

- **iCODE** can reduce over 4 MWh when requested by utility
  - Equivalent to completely shutting electricity for thousands of households
Three messages

• Multi-tenant colocation data center supports our Internet and is the physical home of many clouds
• “Most large data centers” are colocations
• Colocation has a huge potential for demand response
Thanks!