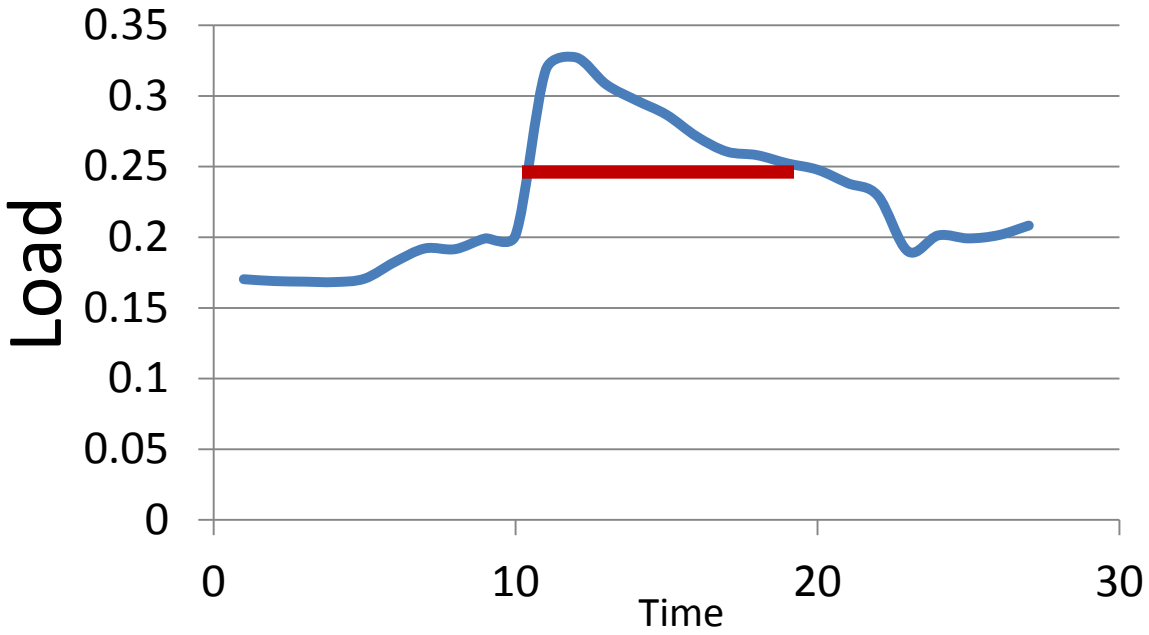
A First Look at Colocation Demand Response

Shaolei Ren and M. A. Islam

Florida International University

Demand response program

- Market-based program
  - Reduce peak energy usage



Demand response program

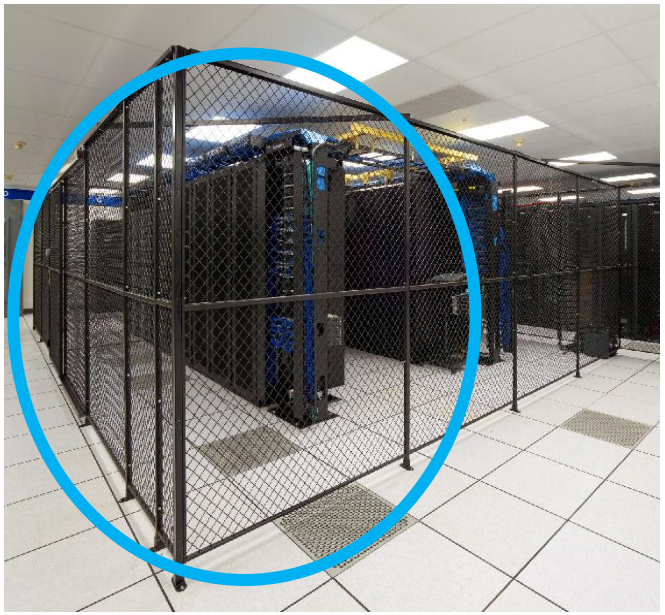
- Market-based program
  - Reduce peak energy usage
  - Increase adoption of renewables
    - e.g., encourage customers to reduce energy during low renewables
- Data centers are promising participants in demand reponse
  - Large yet ***flexible*** energy demands!

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?

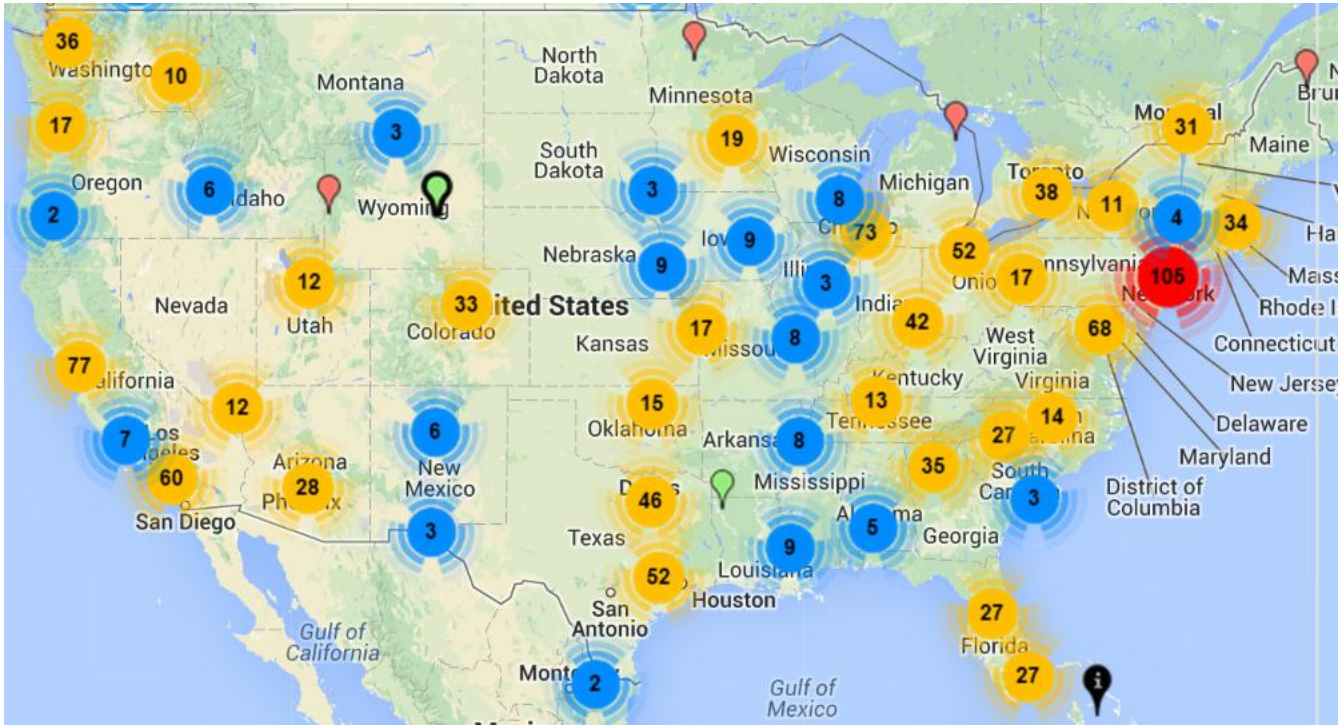
In reality…

“**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.com

- Even the largest ones
  - e.g., Microsoft and Amazon have many "edge" centers to realize global footprints



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***

CIRCUITS	KW	RATE
20/120A	2.4	$ 350
30/120A	3.6	$ 525
20/208A	4.2	$ 610
30/208A	6.2	$ 910
50/208A	10.4	$ 1,520

http://www.terremark.com/

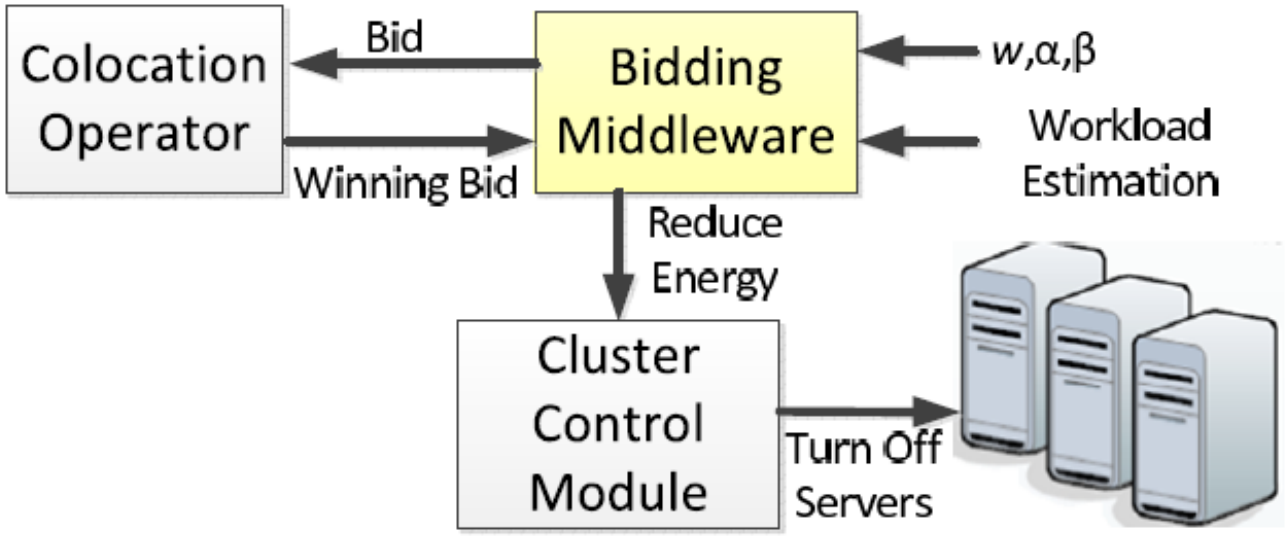
Why colocation demand response is challenging?

- 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
  - Δe_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

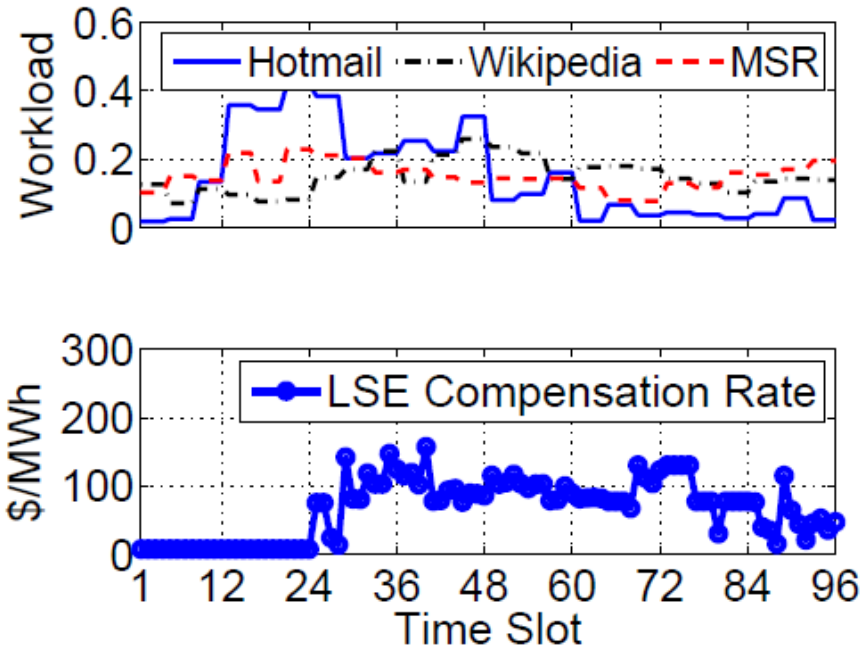
$$\underset{\text{bids}}{\text{maximize}}\ \gamma \cdot \sum \Delta e_i$$
$$\text{s.t.}\ \ \sum c_i \leq q \cdot \gamma \cdot \sum \Delta e_i$$

  - LSE benefits from peak energy reduction
  - Colocation operator reduces energy at **no** additional cost
  - Tenants receives financial compensation without affecting application performance

Case study

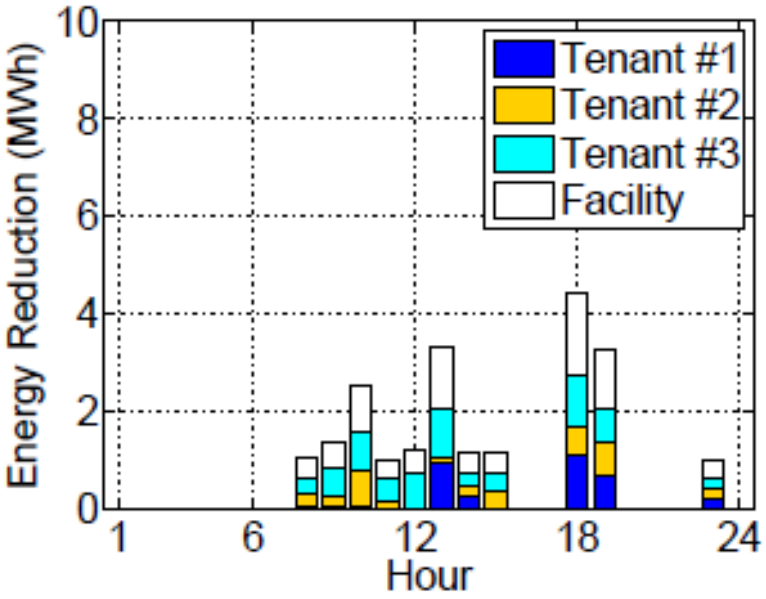
How to evaluate iCODE?

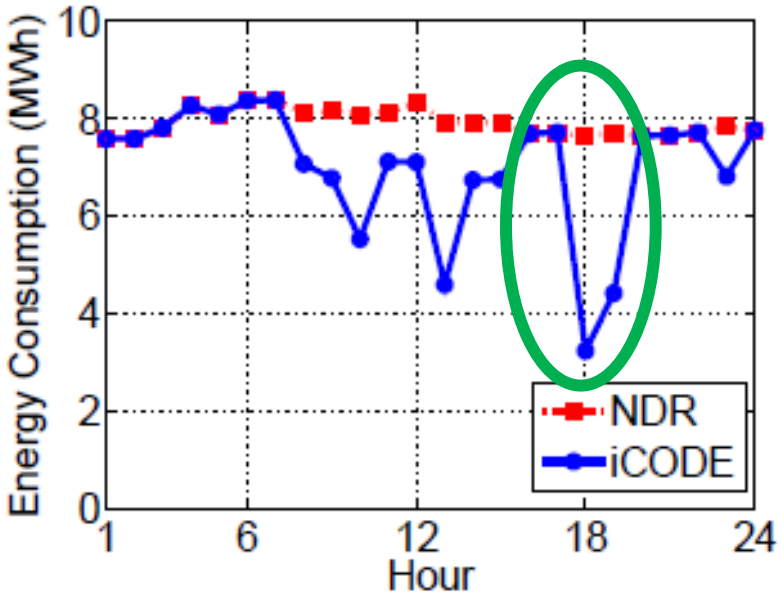
- Consider a real-life trace simulation



  - 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!
RagingWire guarantees 100% uptime with CA at the center.
Today, every data center customer demands "always on." CA management software gives RagingWire the power to put it in writing. Guaranteed. CA.com/AtTheCenter
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