Using Local Power Price to Manage Multi-Tenant Data Center Performance and Energy

Sulav Malla, Ken Christensen
sulavmalla@mail.usf.edu, christen@cse.usf.edu
Department of Computer Science and Engineering

Introduction

In US, data centers consumed about 70 billion kWh (1.8%) of electricity in 2014 [1]. About one third of this data center energy use is by multi-tenant data centers (MTDC), a data center where operator leases infrastructure to multiple tenants.

- MTDC have a maximum allowed power use
- To increase profit, it can host more servers than capacity as not all servers consume maximum power all the time
- Such power oversubscription can lead to rare power overload and has not been studied very well for MTDC

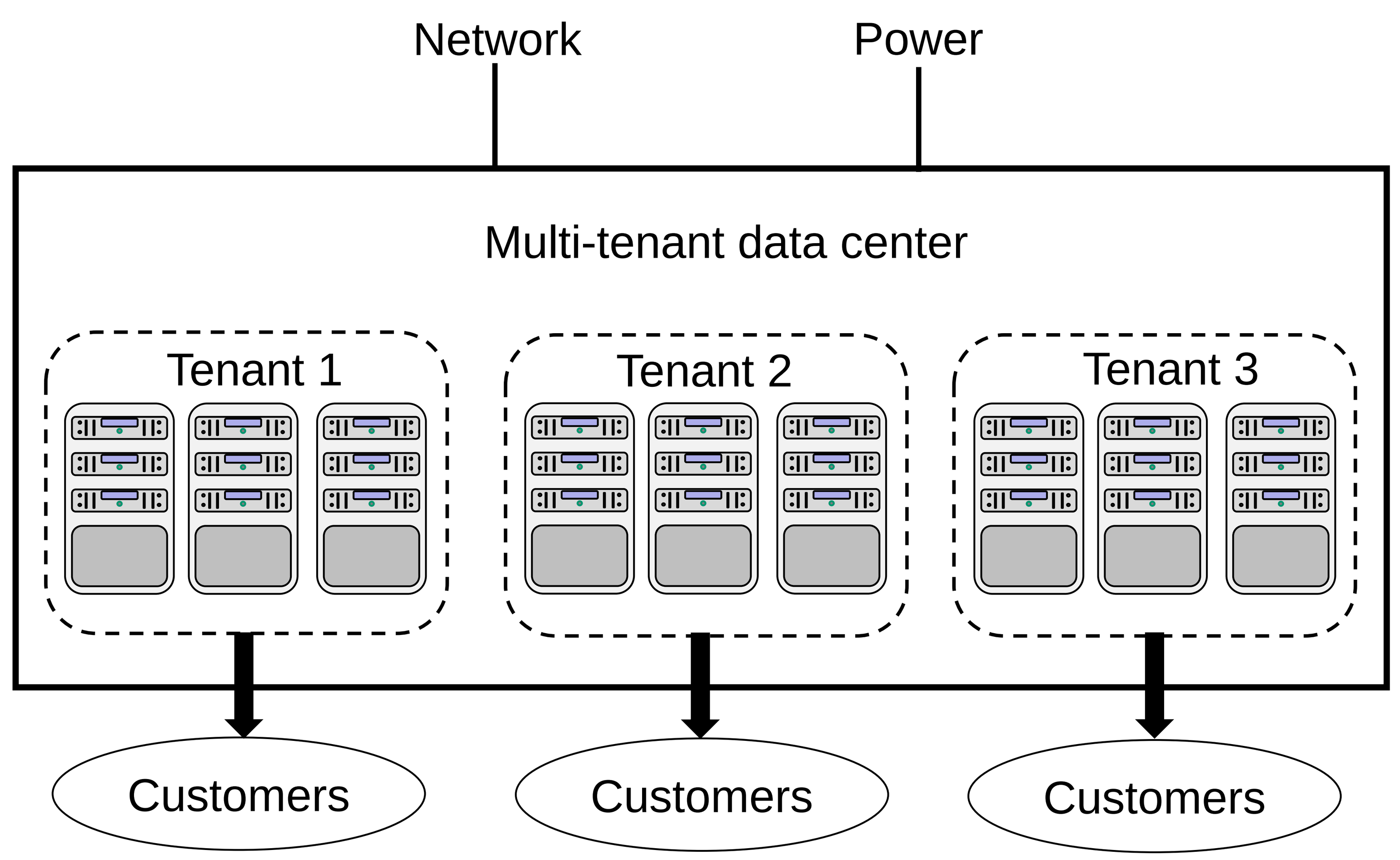

Fig. 1: A multi-tenant data center with 3 tenants. Operator leases space, cooling and power. Tenants own IT equipment and make profit by providing service to their customers.

Using Local Power Price

- We show that a real time local power price can enable safe oversubscription in MTDC to increase operator profit and decrease lease cost to tenants
- Operator profit = Lease income – Energy bill
- Tenant profit = Income from customer – Leasing cost
- Tenants pay back customers if cannot meet SLA

Implementation

- Tenants can reduce their power use by putting servers to sleep at loss of performance
- They only need enough servers powered-on to meet SLA
- Rare events when workload of tenants simultaneously peak, power demand exceeds capacity which leads to power overload and potentially downtimes (power outages)
- Operator increases local price to manage tenant demand

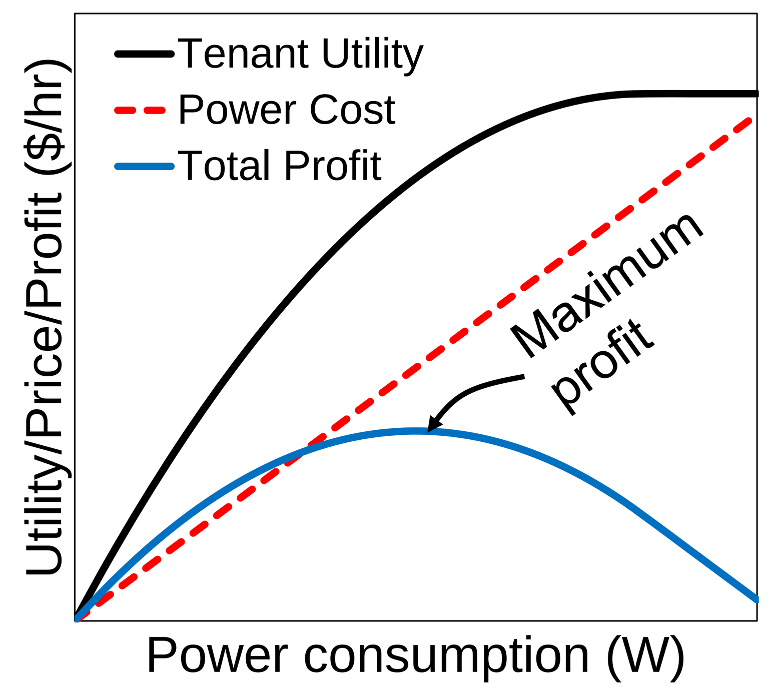

Fig. 2: Utility function U(x), power cost and profit of tenant.

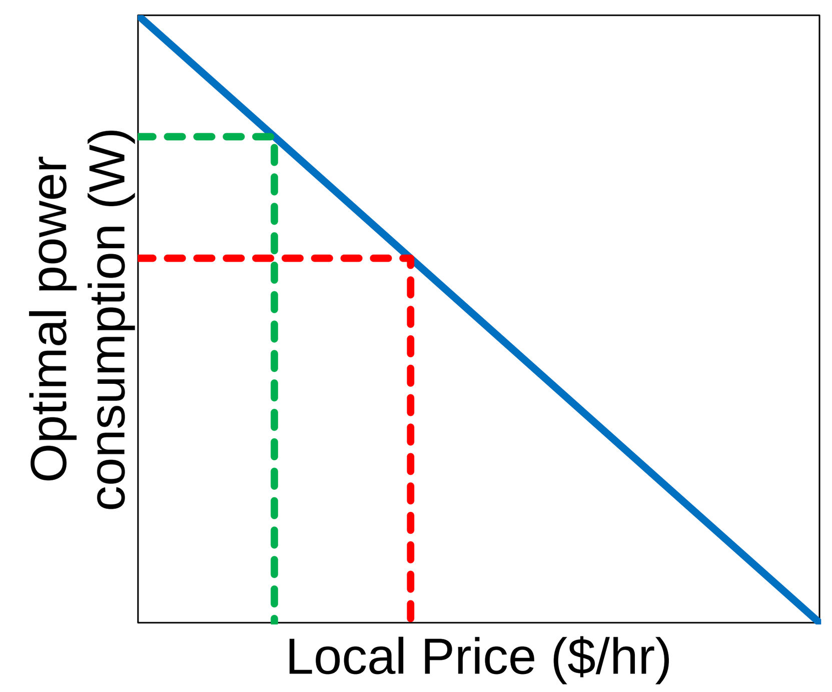

Fig. 3: Tenant's optimal power demand function $U'^{-1}(p)$.

Utility function to model tenant's revenue such that optimal demand function is linear. Tenants try to maximize their profit.

Price Update Algorithm

Operator: At the end of time intervals $t = 1, 2, \cdots, T$:
1: Monitor power consumption $x_{i,t}$ of each tenant, $i \in N$
2: Compute new price, $p_{t+1} = \max\{p_t + \gamma\left(\sum_{i \in N} x_{i,t} - C\right), p_{min}\}$
3: Communicate new price to all tenants

Local price, p_t Power consumption, $x_{i,t}$

Tenant: At the beginning of time intervals $t = 1, 2, \cdots, T$:
1: **For each** tenant, $i \in N$
2: Receive local price p_t
3: Update power consumption level to $x_{i,t} = [U'^{-1}(p)]_{m_x}^{M_x}$
4: **End for**

Experimental Evaluation

We simulated 8MW data center with 3 tenants having 10,000 servers and 25% oversubscription for following scenarios

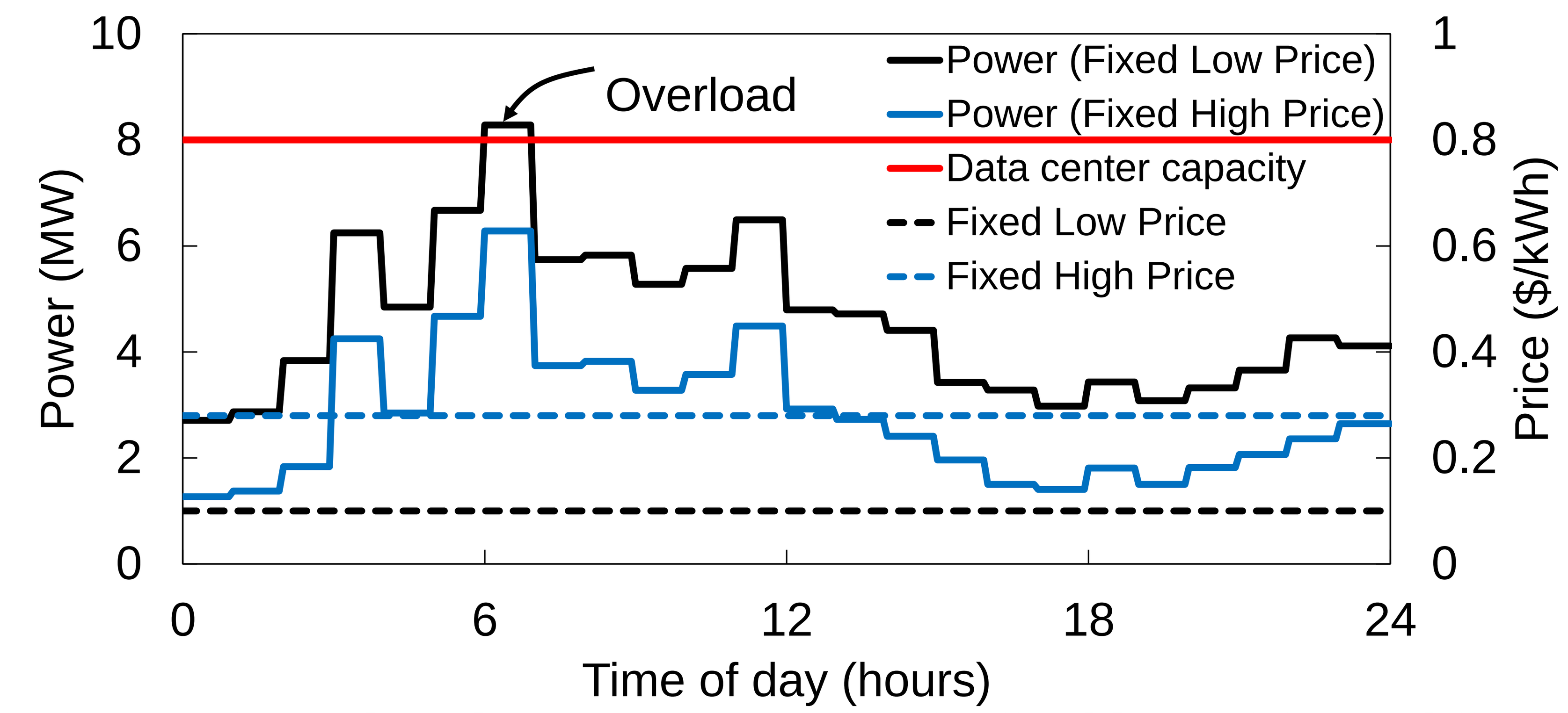

Fig. 4: Price and total power consumption for fixed low pricing and fixed high pricing. Fixed low pricing is profitable to tenant (SLA met) and operator but can lead to expensive downtimes. Fixed high pricing is much less profitable to tenants (SLA never met).

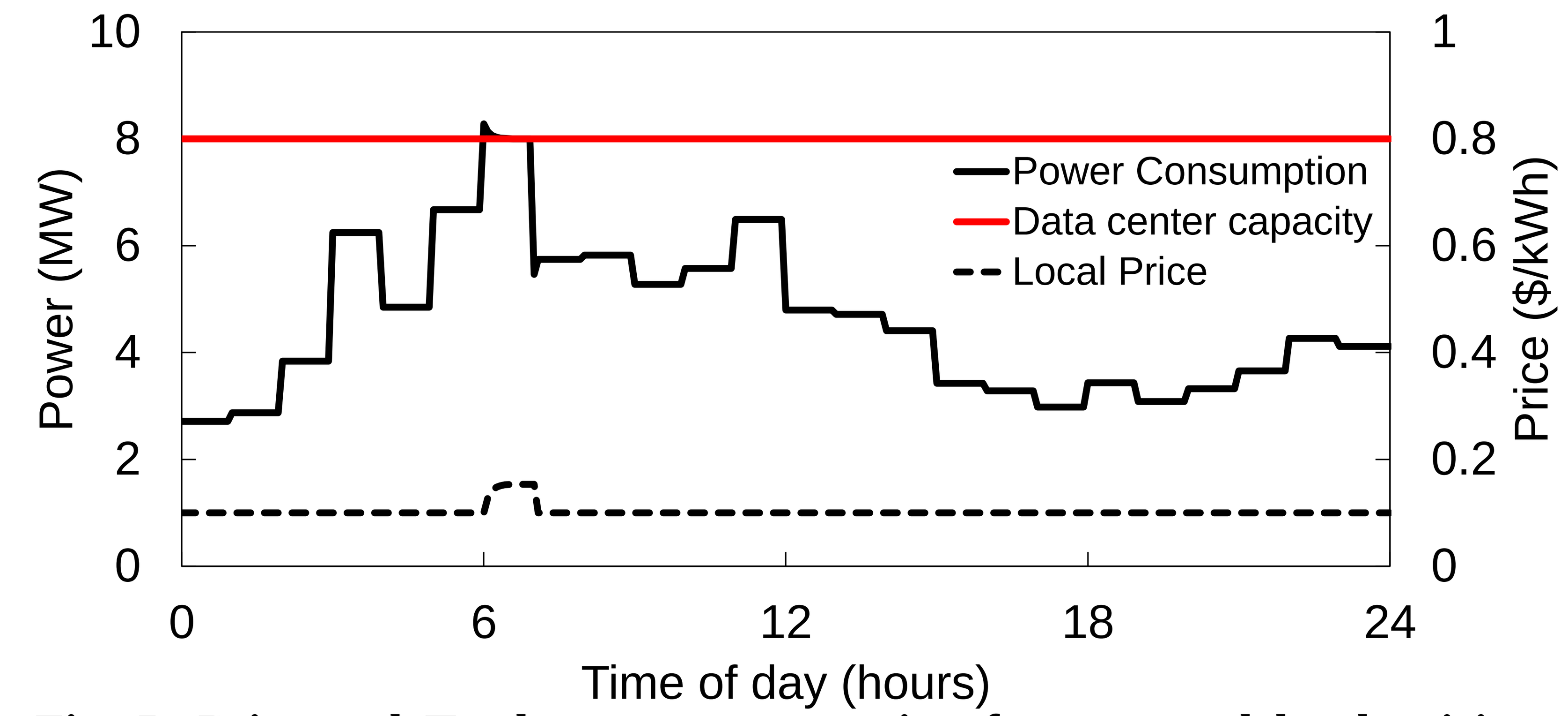

Fig. 5: Price and Total power consumption for proposed local pricing. Profitable to tenant (SLA met except when demand exceeds capacity) and operator while avoiding power overload.

Result and Summary

Compared to flat pricing used currently, use of local power price

- Enables oversubscription of multi-tenant data center
- Operator yearly revenue increases by $2.9B (11%) globally
- Tenant's yearly bill decreases by $108K (6%) per MW

Selected Reference
[1] Shehabi, A., et al. "United States Data Center Energy Usage Report." Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-1005775 Page 4 (2016).