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Managing Distributed UPS Energy for Effective Power Capping in Data Centers

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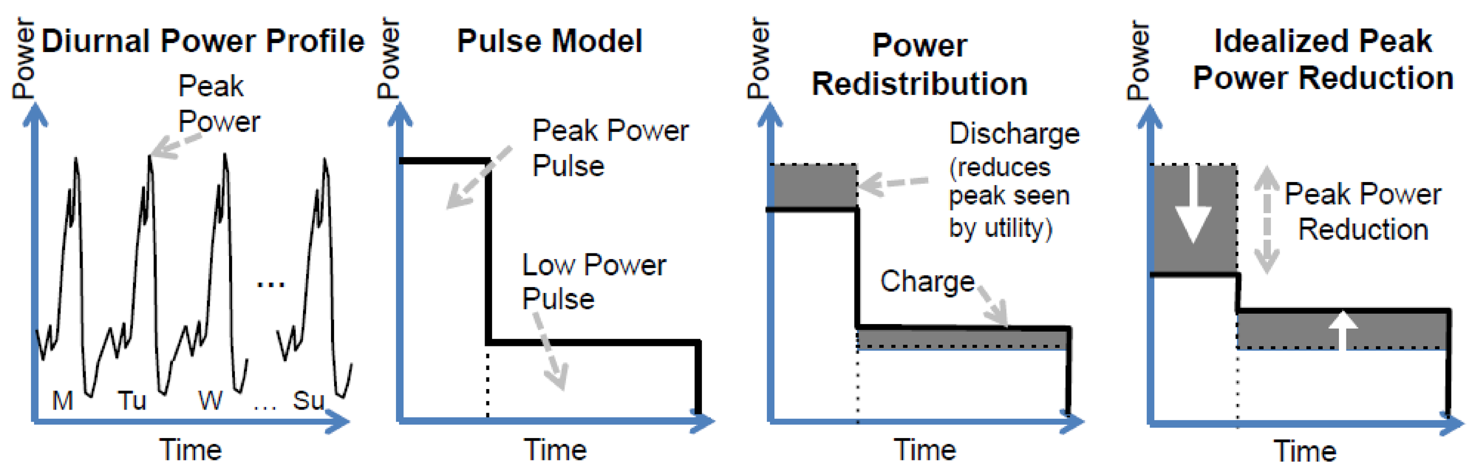
Goals

- ✓Reduce data center peak power using UPS-stored energy
- ✓Increase servers supported by power infrastructure
- ✓Decrease Total Cost of Ownership / Server

Idea

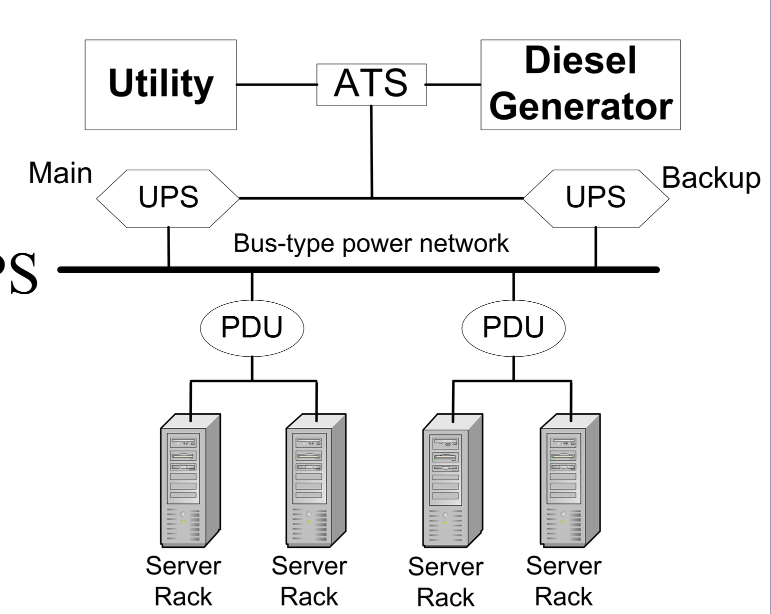


UPS topologies

Centralized

- ✓Small-medium data centers
- ✓Does not scale well
- ✓Highly over-provisioned UPS
- ✓Sufficient energy for power capping

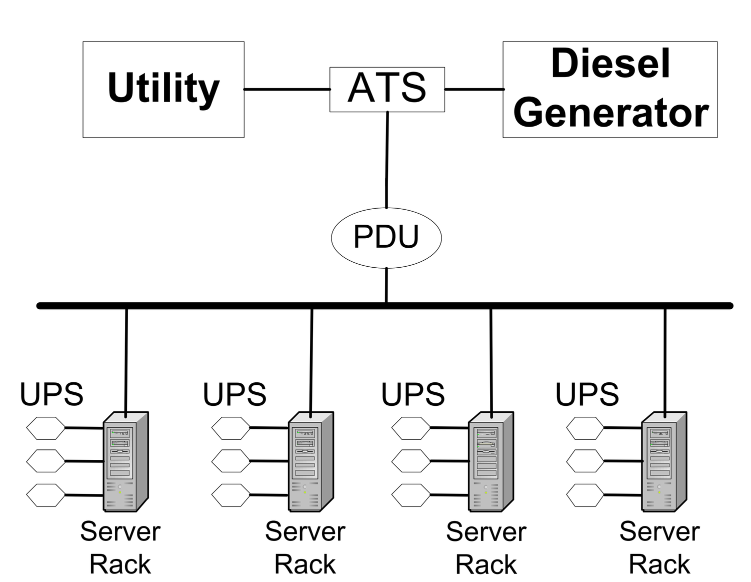
[Govindan el. al, ISCA 2011]



Distributed

- ✓ For large data centers
- ✓ Scales with number of servers
- ✓ Needs extra battery capacity for power capping
- ✓ Coordinate charge and discharge

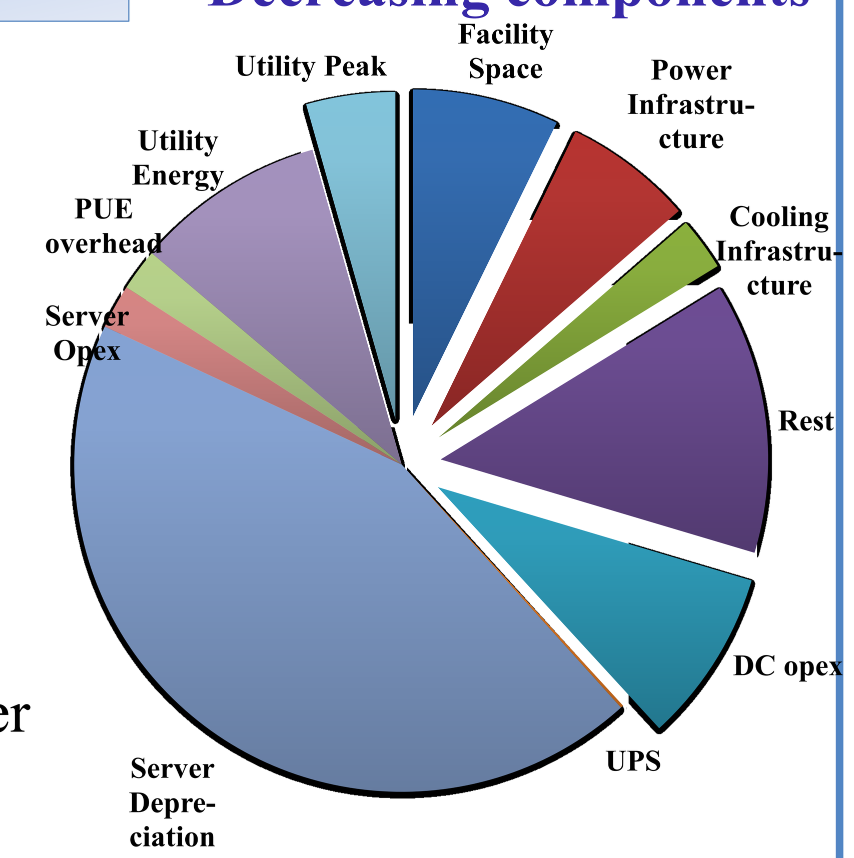
[Open problem]



TCO analysis

- ✓ Modern data centers power limited
- ✓ More servers amortize capex costs better
- ✓ We increase distributed UPS cost, add extra machines within provisioned power

Decreasing components

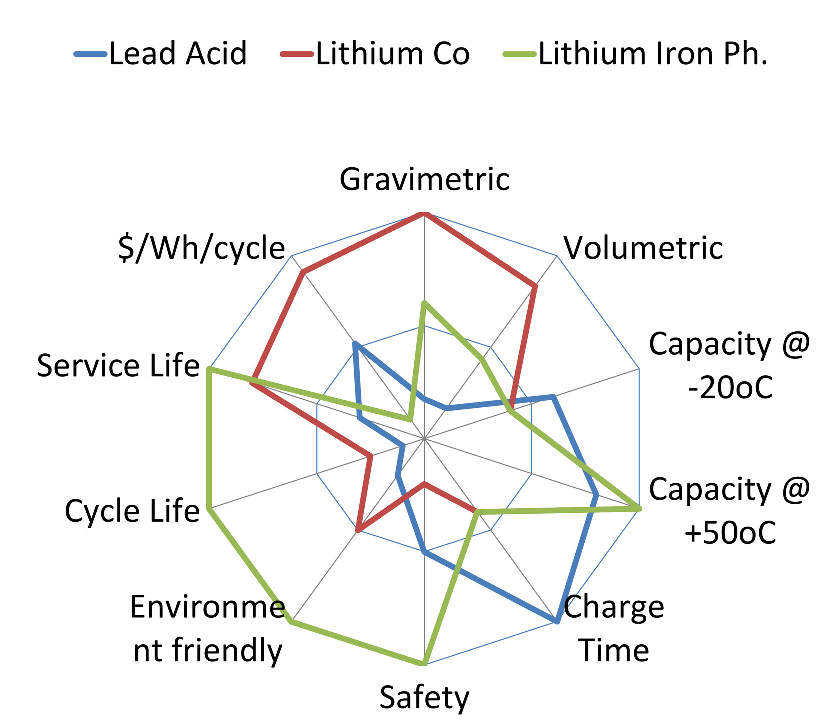


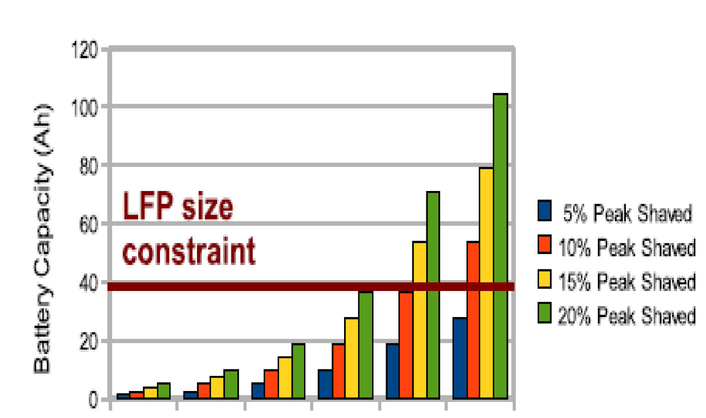
Constant components

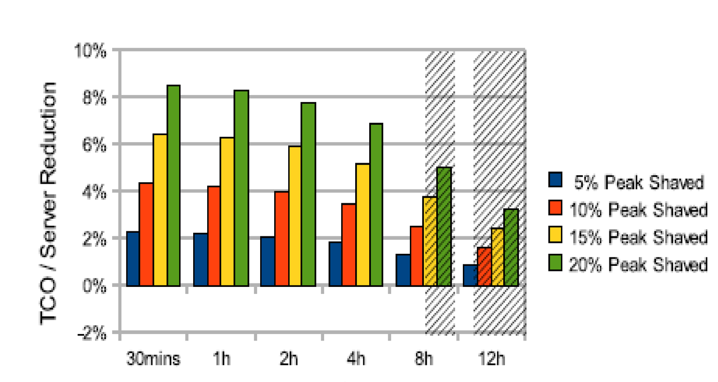
Batteries

- ✓We compare Lead Acid, Lithium Covaltium and Lithium Iron Phosphate battery technologies.
- ✓ Lithium Iron Phosphate:
  1) more recharge cycles
  2) longer lifetime
  3) higher energy density

➔ More cost-effective

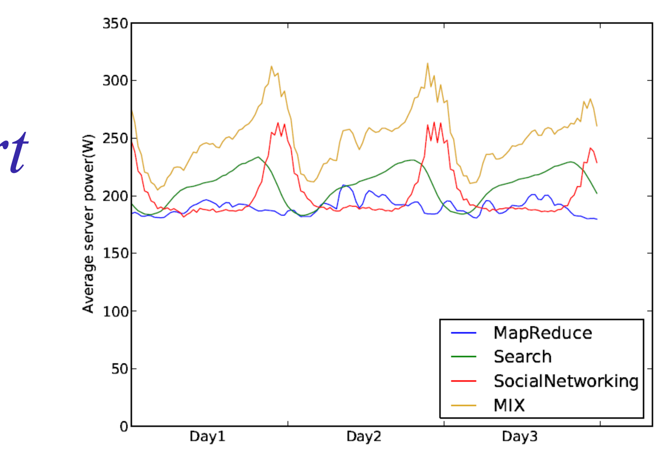






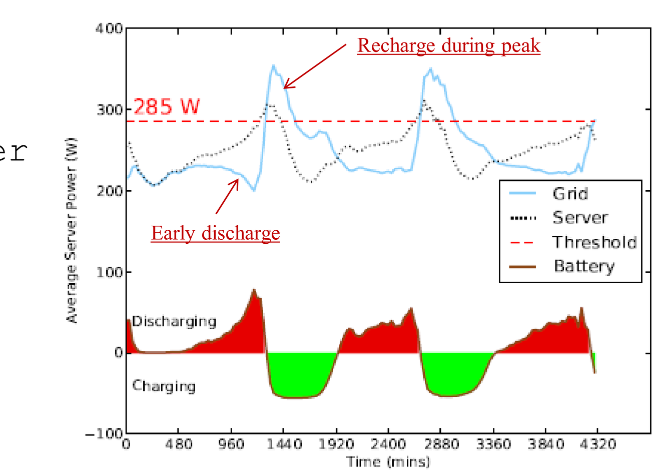
Results

Real traffic traces from Google Transparency Report



Uncoordinated control

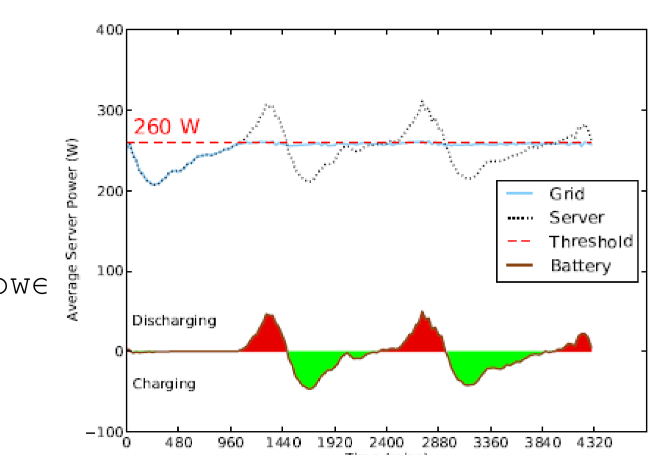
```
   On every server:
if (serverPower > Threshold)
     {Discharge serv.battery }
if (serverPower < Threshold)
     {Stop discharging  }
if (serverPower < Threshold-chargePower
   and  battery discharged)
      {Recharge}
```



- X Untimely charge/discharge
- X Use more energy than necessary

Coordinated control

```
   On every cluster:
if (clusterPower > Threshold)
   {Discharge deltaPower/ServPower
                  batteries}
if (clusterPower < Threshold)
   {Stop discharging deltaPower/ServPowe
                  batteries}
if (clusterPower < Threshold and
    no battery discharging)
   {Recharge deltaPower/ServPower
                  batteries}
```



- ✓ Proportional use of batteries, only during peak load
- ✓ Close to ideal scenario of flat, power profile (average equals peak)

➔19% shaved peak power with no performance loss
➔23.5% more servers within same power infrastructure
➔ 6.2% reduction in TotalCostofOwnership / server

MuSyC NSF Google cns GreenLight UCSD Microsoft

This work was sponsored in part by the Multiscale Systems Center (MuSyC), National Science Foundation (NSF) Project GreenLight, CNS, Microsoft and Google.