Power Capping and Scheduling on Racks with Flexible Power Supply

Justin Song, Chief Power Architect, Alibaba Cloud
Agenda

• Rack power capping
• Scheduling on racks with flexible power supply
• Summary & recommendation
Rack Power Capping

Auto detected servers list
Or confirmed to-cap servers list

Perf impact

PSU / HSC / VR

Memory

PCH

FPGA

ASIC

IO

Network

Storage

Green: h/w or f/w; red: s/w

Top 5 reasons
- Save energy & costs
- DC power limiting
- Power exceeds rack quota
- Cooling fault
- Power supply failure

Conditions

Entities

Actions

0 P E N. F O R B U S I N E S S.
# Capping Helps and Hurts

## Mapped to 12 nodes @ 4 racks

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<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
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<tr>
<td>I</td>
<td>J</td>
<td>K</td>
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<tr>
<td>M</td>
<td>N</td>
<td>O</td>
<td>P</td>
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- J @ rack_3.node_5, 2.5GHz+
- K @ rack_4.node_7, 2.5GHz+
- A through I @ rack_11.node_6 through 10, 2.5GHz
- L through P @ rack_15.node_11 through 15, 2.5GHz

## Power capping happens

- Rack 3 in failsafe mode (S5)
- Rack 4 @ 1.2GHz
- Rack 11 @ 2.0GHz
- L through P @ rack_15.node_11 through 15 @ 2.0GHz

## Consequence T

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## Consequence T+1

- Pause, shutdown, migrate and resume

## Consequence T+2

- Service as normal
- Service stopped
- Surprise to customer
- Avalanche!
Another Challenge: Apps Deployment

We need to increase density and simply apps deployment without compromising SLA

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**Scheduling with Flexible Power Supply**

Use on-rack battery as an example; may use other distributed or central energy backup system.

Scheduler + Data Analytics → Use Battery Smartly
Manage Timing

Charging
- Avoid peak usage of server loads
- Charge when energy is cheap

Discharging
- To accommodate max usage (Rack Turbo)
- Use as a UPS (power shortage or outage)
- Predict duration of high demand
Algorithm

Power outage?

- yes: Power cap servers @low performance mode
  - yes: Discharge @ low current rate BUM (Back Up Mode)
  - no: Rack power level high?

- no: Rack power level high?
  - yes: Discharge @ high current rate RBM (Rack Boost Mode)
  - no: Predicted level high?

- no: Predicted level high?
  - yes: Charge at high current Predicted Boost Mode (PBM)
    - yes: High level phase comes or time out?
    - no: Healthiness Maintenance

- no: Healthiness Maintenance
  - yes: Energy is cheap?
    - yes: Charge batteries at high rate
    - no: Charge batteries at low rate
Summary and Recommendation

Use backup energy source to boost performance or enable higher deployment density

Nimble, flexible and cost effective deployment in data center

Software coordination, scheduling and application awareness is key
Intel Rack Power Optimization Technology

Nishi Ahuja, Principal Engineer, Intel
Rack Density Decreasing vs. Rack Power Under-utilization

Rack Density is limited by Power

**Life Cycle**
- Rack lifecycle is 10~15 years, server 3~5 years in datacenter
- 3 Server generation per rack generation

**Stalled**
- Rack Power Density can’t be easily increased and **stalled at design target** (in PRC cloud datacenter, mostly 5-7KW)

**Critical**
- Server Node Density in Rack is important TCO factor

Problem Statement – Rack density kept decreasing due to unmatched refresh cycle between infrastructure and IT equipment. The power usage analysis with top cloud service providers also showed the power utilization ratio is is lower than then planned due to dynamic range of peak to average.

[1] The evaluation is based on specific CSP workload and Intel Xeon Processors.
Node Manager Telemetry on Intel Xeon Scalable Processor

Power Telemetry
- Total platform power
- Individual CPU, Memory and Xeon Phi power domains

Thermal Telemetry
- Inlet & Outlet Airflow temperature
- Volumetric Airflow

Utilization Telemetry
- Aggregate Compute Utilization per sec
- CPU, Memory and I/O Utilization Metrics

Power Controls
- Power limiting during normal operation
- Power limit during boot

Intel® Node Manager
Firmware embedded in PCH’s

Intel Node Manager is widely adopted by Server OEMs and supports IPMI and DCMI API calls
## Intel Rack Power Optimization Technology

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<th>Options</th>
<th>Description</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Static Power Capping</td>
<td>Configure power budget for each server node to avoid power violations</td>
<td>Rack Power Safety</td>
</tr>
<tr>
<td>Group Level Power Capping</td>
<td>Dynamically adjust rack power allocation among servers to enforce rack wide power consumption is within power budget line</td>
<td>Rack Density and Power Utilization</td>
</tr>
<tr>
<td>Dynamic Rack Power Provision (DRPP)</td>
<td>Leverage rack battery backup system to shave those sporadic power spikes or peaks over budget line</td>
<td>Rack Density and Service Reliability</td>
</tr>
<tr>
<td>Intelligent Orchestration – Power Awareness Scheduling</td>
<td>Schedule workload according to telemetry intelligence, e.g. power awareness job scheduling according to real power demand as well as available power capacity in rack (or cluster)</td>
<td>Energy Efficiency and Service Reliability</td>
</tr>
<tr>
<td>Dynamic Cluster Performance management</td>
<td>Dynamically adjust platform performance states according to rack power demands and actual resource utilization.</td>
<td>Performance Per Watt Efficiency</td>
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</table>
DRPP - Dynamic Rack Power Provision

- Power Budget
  - Assurance Buffer for uncertainties

- Actual Peak/Spike in Power Consumption

- Average Power Consumption

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1. Normally lower utilized area

2. Redundant power rarely used (e.g., battery backup unit, 2nd power source etc.)

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>15%\(^{(1)}\) of provision power, the utilization ratio less than 1%.

>20%\(^{(2)}\) of power capability (BBU), locked as back-up and rarely used.

Total >30% of power capacity is under-utilization!

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Proposed Solution Goal:
1. Decrease power over-provisioning margin
2. Dynamically increase peak capacity
3. Increase utilization of back-up power

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Intel Dynamic Rack Power Provision Technology to balance power utilization and improve rack density

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\(^{(1)}\) - 15% is concluded from analysis of typical online rack system, and subject to change with environment change.

\(^{(2)}\) - The general design of backup power unit capacity is same as rack power capacity, and 20%–30% of backup power capacity is rarely used even under power failure condition.
Turbo Rack - Innovative, Non-Disruptive Solution

Software - Power Awareness Intelligence
- Real-time Power Insights
- Group Power Capping and Dynamic Peak Capacity Provision
- Intelligent Job Scheduling/Migration

Application Interface - RESTful
- Contributed as Redfish API
- Easy Application Integration

Hardware - Distributed Energy System
- Open Interfaces for 3rd party battery system integration
- Unified architecture support, including OCP and conventional rack

Firmware - Algorithm Optimization
- Adaptive Power Re-balance Algorithm
- Configurable Power Limiting

Enabled by Dynamic Rack Power Provision Technology with improvement on power utilization and rack density by 15%~25%[^1]

[^1]: 15%~25% is per evaluation analysis from specific workloads (WLS), and subject to change for different environments.
[^2]: Refer to https://datacenterfrontier.com/ocp-compute-rack-makers/
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<th>Descriptions</th>
<th>Telemetry and Analytic</th>
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<tr>
<td>Power Awareness Scheduling</td>
<td>Schedule/Migrate workload according to power intelligence, e.g. energy efficiency, power budget, dynamic power capacity</td>
<td>System/rack power, power analysis.</td>
</tr>
<tr>
<td>Uniform airflow/Thermal Condition scheduling</td>
<td>Dynamic adjust workload placement to get one uniform thermal condition to avoid hot-spot in datacenter (with better PUE as well as)</td>
<td>Inlet/outlet temperature, Return Temperature Index(RTI), Rack Cooling Index(RCI)</td>
</tr>
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<td>Failure Event Triggered Migration</td>
<td>Migrate workload to other cluster or rack in case some critical failure events (e.g. power, or thermal) is identified</td>
<td>Failure events</td>
</tr>
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![Graphs showing power usage and temperature data](https://via.placeholder.com/150)
Turbo Rack Video (Intel)

2 minutes 30 seconds