

**CRAY**



## **HPM2016:**

**HPC Power Management: Knowledge Discovery**

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# KAUST Power Capping Summary

- **Shaheen2: 36 cabinet Cray XC40, #10 top500 June2016**
- **Constrained by site power/cooling availability**
  - During acceptance: 2.9 MW limit
  - After acceptance: 2.3 MW limit
- **Two power capping approaches:**
  - Two static queues
  - Dynamic capping with Slurm
- **System and application power profiling used heavily to:**
  - Tune Slurm dynamic power capping
  - Tune application and identify performance problems early in runs
  - Monitor cabinet and system level power usage



# KAUST: Shaheen2, 36 Cabinet Cray XC40

- **6174 dual socket Haswell nodes, 32 cores/node**
  - Cray XC40, Xeon E5-2698v3 16C 2.3GHz, Aries interconnect
- **Theoretical peak performance: 7.2 PF**
- **Shaheen2 on Top 500: [www.top500.org/system/178515](http://www.top500.org/system/178515)**

List	Rank	Cores	Rmax	Rpeak	Power (KW)
06/2016	10	196,608	5,537.0	7,235.2	2,834.0
11/2015	9	196,608	5,537.0	7,235.2	2,834.0
06/2015	7	196,608	5,537.0	7,235.2	2,834.0

COMPUTE

STORE

ANALYZE

# KAUST: Constraints



	During Acceptance	After Acceptance	Peak
Power Cooling	Allocated 2.9 MW <ul style="list-style-type: none"><li>When others systems off/idle</li></ul>	Allocated 2.3 MW	2.94 MW running <ul style="list-style-type: none"><li>LINPACK + 2 apps across full machine</li></ul>
Capping	Two Static Queues <ul style="list-style-type: none"><li>1805: Nodes Uncapped</li><li>4367: Nodes capped @ 270W</li></ul>	Slurm Dynamic	Disabled
Notes:	Data center capacity: <ul style="list-style-type: none"><li>Cooling 2.9 MW</li><li>Power ~ 3.2 MW</li></ul>	Systems: <ul style="list-style-type: none"><li>Shaheen2</li><li>BG/P 16 racks (~ 500 KW)<ul style="list-style-type: none"><li>Decommissioned end of 2015</li></ul></li><li>Several other small clusters</li></ul>	

# KAUST: Two Power Capping Approaches

	Two static queues:	Dynamic capping with Slurm
Pros	<ul style="list-style-type: none"><li>Performance reproducibility</li></ul>	<ul style="list-style-type: none"><li>Better utilization and distribution of power across nodes</li><li>Reduced time for production runs</li></ul>
Cons	<ul style="list-style-type: none"><li>Large scale code cannot run</li><li>Lower overall utilization</li></ul>	<ul style="list-style-type: none"><li>High variability of performance<ul style="list-style-type: none"><li>Up to 2x for compute bound applications when machine is used more than 50%</li></ul></li></ul>
Notes	<ul style="list-style-type: none"><li>1805: Uncapped nodes</li><li>4367: Nodes capped at 270W</li><li>Capped queue up to 2X slower</li><li>Users prefer uncapped nodes</li></ul>	<ul style="list-style-type: none"><li>Monitoring used to tune Slurm</li><li>Ability to dynamically disable power capping</li></ul>



Thanks to Bilel Hadri  
[bilel.hadri@kaust.edu.sa](mailto:bilel.hadri@kaust.edu.sa) for help pulling  
together information needed for this  
presentation.

# Backup Slides



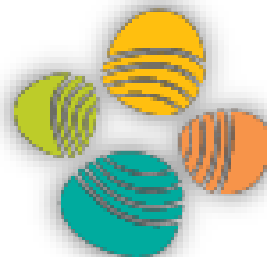
# How the site used power monitoring data?

- **Real-time system power data available**
  - Used by sys-admin, computational scientist, and data centers admins
- **Power profiling of applications, especially the full scale ones**
  - Used when strategizing/optimizing full scale Gordon Bell runs on Shaheen2
- **Detecting issues on applications performance**
  - Known compute intensive code drawing less than 200W per node
    - Found issue in the communication pattern
  - During acceptance runs
    - No need to wait for 40 minutes for a first performance number when the power per cabinet was less than 55KW, while it should operate in the 80s KW

# KAUST: Power and Cooling Constraints

- **Data center capacity:**

- Cooling 2.9 MW
- Power ~ 3.2 MW



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- **Systems:**

- Shaheen2
- BG/P 16 racks (~ 500 KW)
  - Decommissioned end of 2015
- Several other small clusters

# KAUST: Shaheen2 Constraints

- **Shaheen2 during acceptance:**
  - Allocated 2.9 MW
- **Shaheen2 after acceptance:**
  - Operating with 2.3MW power/cooling limit
- **Shaheen2 reached a peak of 2.94MW**
  - LINPACK + 2 other applications
  - Running at full scale across the machine





# Static Queues

- **Two static queues: (using CAPMC)**
  - 1805: Uncapped nodes (allowed to run at full potential)
  - 4367: Nodes capped at 270W
- **Pros:**
  - Performance reproducibility
    - Capped queue is up to 2X slower for some applications
- **Cons:**
  - Large scale code cannot run
  - Lower overall utilization since waiting is longer
    - Users tend to prefer uncapped nodes

# Dynamic capping with SLURM

- **Pros:**

- Better utilization and distribution of power across the nodes
- Reduced time for production runs vs static capping at 270 watts

- **Cons:**

- High variability of performance
  - Up to 2x for compute bound applications when system load > 50%

- **Notes:**

- Used Cray monitoring to tune SLURM parameters
  - Improve utilization and distribution of allocated power
- Ability to dynamic disable power capping on the fly
  - Dedicate the machine up to 75%, Idle the rest
  - Ability to change power limits in case of maintenance or issue with cooling