

# **The Electrical Grid and Supercomputer Centers: An Investigative Analysis of Emerging Opportunities and Challenges**

## **Summary**

### **Abstract:**

- Explores today's relationships, potential partnerships and possible integration between SC and their electricity providers and its value.
- Develops a model for possible integration between supercomputer centers and the electrical grid.
- Explores utility of this model based on feedback from a questionnaire of Top 100 in US.

### **1. Introduction and Background**

- Takes as a starting point LBNL's model for integrating data centers and electrical grid
- \* Describes programs that are used by the electricity service providers to integrate with their customers(demand response) and methods used to balance the grid supply and demand of electricity.
- \* Describes strategies that data centers might employ for managing their electricity and power requirements.
- Virtualization and geographic load shifting were eliminated as potential SC strategies though included in datacenters(DC).
- 1. Describe model for integration
- 2. Prior Work
- 3. Questionnaire Results
- 4. Opportunities, solutions and barriers.
- 5. Conclusions and Future Work.

### **2. Supercomputing centers and electrical grid integration**

- The integration model describes programs that are used by the electricity service providers to encourage particular behaviors by their customers and methods used to balance the grid supply and demand of electricity.
- Describes strategies that data centers might employ for utility programs to manage their electricity and power requirements and lower costs.

#### **2.1 Electricity Demand and Supply Side Mgmt**

- Electricity providers use demand-side mgmt for both energy efficiency and to balance the electricity supply. This includes programs for energy conservation, energy efficiency and peak load mgmt, and responses to changing supply conditions.
- *The focus for this paper is on programs that are targeted at load mgmt.*
- Supply side mgmt methods are used to ensure the efficient generation, transmission and distribution of electricity.
- *As the electric grid evolves to a more dynamic and distributed system, its integration with and responses from HPC centers can be used to support supply-side programs.*

#### **2.2 Supercomputer Center Response Strategies**

- One dimension of the response model, to participate in supply-side programs is through a list of demand-side management strategies. These strategies can be used by a supercomputer site to manage power in response to a request from their electric service provider.
- The above could also be used for improving energy efficiency. But former is of interest here.

### **3. Prior Work**

- Addresses strategies that HPC centers can take to manage power.
- There is not a lot of work that is specifically focused on power mgmt in response to a request from an electrical service provider.

#### 4. Questionnaire

- To understand the current experiences of supercomputer center's interaction with their electricity service providers (SPs).
- Analysis restricted to US since the results of the survey and practices of demand response is highly correlated and driven by energy policies in the country.
- 19 of the Top100 approached, 11 responded.
- Total power load as well as the intra-hour fluctuation of the sampled sites varied significantly.
  - \*  $4 > 10\text{MW}$ ,  $2 = 5\text{MW}$ ,  $5 < 2\text{MW}$ .
  - \* 3MW intra-hour variability as the bottom of scale assumed.
  - \* For  $> 10\text{MW}$ , intra-hour fluctuation varied from  $< 3\text{MW} - 8\text{MW}$ .
  - \* 1 5MW site experienced 4MW variability.
  - \* The rest sites less than 3MW variability.
- Most of the intra-hour variability was due to preventative maintenance.
- Most discussion between SC facility and electric service providers about programs and methods used to balance the grid supply and demand of electricity has been limited to demand side.
- More than half of the respondents are not interested in shedding or shifting load during peak demand.
- Responding to pricing incentive programs is not considered owing to either pricing being fixed or done by another organization outside immediate control.
- 80% have not had discussion about congestion, regulation and frequency response.
- 36% have discussed use of renewables and more than half are interested in future.
- 75% had not requested information from providers or vice-versa.
- Given the low levels of current engagement between the electricity service providers and the supercomputer centers, it is not surprising that none of the SC centers are using any power mgmt strategies to respond to grid requests by their electrical service providers.
- The evaluation of power mgmt strategies will be considered relevant and effective for grid revealed:
  - \* Power Capping, Shutdown and Job scheduling - High interest and impact.
  - \* Load migration, back-up scheduling, fine grained power mgmt, thermal mgmt - Medium
  - \* Lighting control and back-up resources - Low.

#### 5. Opportunities/Solutions and Barriers

- The biggest opportunity in the integration of the electrical grid and supercomputer centers is to start a process of negotiation/interaction between utility providers and HPC centers, which seems to be in a small way happening from SPs.
- There isn't a clear business case on the part of SC center for pursuing integration and needs to be further understood and developed.
- According to survey data and literature review, the greatest opportunities for HPC centers to develop integration capabilities are related to system software.
- Sites are developing experience with energy efficiency that can transfer to power mgmt for utility integration.
- Job scheduling is seen with the greatest interest and impact as coarse-grain power mgmt is dependent upon job scheduling. Job scheduling will also require to keep high utilization at the SC center.
- Load migration though with its problems of security, software tuning etc can be employed using advance reservation capabilities in schedulers.
- Grid computing protocols, interfaces and standards can facilitate execution of DR strategies.
- The integration process will require improved capabilities from the SPs, but this improvement will also help to cater non-HPC clients.
- Survey data and literary review suggest load shifting as better, use of renewables lucrative, dynamic pricing is promising.
- Lack of knowledge about congestion, regulation and frequency.
- There is a need for accounting system at SC centers that could be used to forecast and model future energy of an HPC center, for its integration with the electricity grid. However, the way this would be integrated is still an open question but nonetheless it would need to adhere to some standards.