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

Fname Lname[1], Fname Lname[2] Fname Lname, Fname Lname, Fname Lname, Fname M. Lname, and Fname Lname

[1] Institute Name, City State Zip, Country,
Name@email.adr,
WWW home page: http://web/page.html
[2] Another Institute, nstitute Department, address1, address2, Country

Abstract. Some of the largest supercomputer centers in the United States are developing new relationships with their electricity service providers. These relationships, similar to other commercial and industrial facilities, are driven by mutual interest to save energy costs and improve electricity grid reliability. Supercomputer centers are concerned about electricity price, quality, environmental impact and availability. Electricity service providers are concerned about supercomputer center's impact on the electrical grid reliability; for energy consumption, peak power and fluctuations in power. Supercomputer center power demand can be greater than 20 megawatts (MW) or more - the theoretical peak power requirements are greater than 45MW - and re-occurring intra-hour variability can exceed 8MW. As a consequence, there are some supercomputer centers whose electricity service providers are asking for hourly forecasts of power demand, a day in advance. This paper explores today's relationships, potential partnerships and possible integration between supercomputer centers and their electricity service providers, and its value. It evinces the challenges for this possible HPC-Grid integration, and then cites opportunities to overcome the barriers using feedback from a questionnaire of Top 100 List sized supercomputer centers in the United States.

1 Introduction

Supercomputing centers(SCs) with petascale[3] systems for high-performance computing(HPC) are realizing the large impact they will be putting on their electricity service providers(ESPs) with peak power demands of 20megawatts(MW) and instantaneous power fluctuations of 8MW. Today, with the impetus for moving towards Exascale[4], the need to address challenges arising from even larger

[3] Petascale computing refers to computing systems capable of atleast 10^{15} floating point instructions per second(FLOPS).
[4] Exascale computing refers to computing systems capable of atleast 10^{18}FLOPS.

peak power demands and instantaneous power fluctuations will be imperative in aiding electric-grid reliability.

The electric-grid reliability is an extremely important aspect to optimally manage and link electric supply with demand. Changes in electric usage by end-users from normal consumption patterns can affect the electric-supply infrastructure. It is important to understand the effects induced on reliable power-supply by the end-users like SCs, with high power demand and instantaneous fluctuations, to help moderate their effects. Consequently, ESPs are now seeking hourly forecasts of power demand from SCs, a day in advance.

Like every coin has two faces, the large power demand of SCs also make them pivotal in aiding ESPs to maintain reliable supply to other end-users. When the triple digit temperature hits the valley the power consumption in the domestic household surges. As friendly neighbors, Lawrence Livermore National Laboratory(LLNL), helps its ESP by decreasing the load on the grid by lowering its power usage. The above is one among the many other instances where SCs have shown to be resourceful in aiding their ESPs.

In the past, it was large smelters and manufacturing industries who extended great influence on the electric-grid. But today, supercomputing centers with their increasing power demands happen to be key players influencing electric-grid integrity. Supecomputing centers want energy efficiency to lower costs, but it is important to understand if this need finds a key interest in ESP. Likewise, it is important to understand the significance of electric-grid reliability - a priority for ESP - from the perspective of SC. Only a mutual understanding of concerns between the SC and ESP could lead to evolution of a symbiotic relation and fathom beyond the current producer-consumer paradigm, paving the way for possible integration of HPC with the Electric-Grid.

The Energy Efficient HPC Working Group (EE HPC WG) has been investigating opportunities for large supercomputing sites to more closely integrate with their electricity service providers. The objectives of this investigation are to understand the willingness of SC to co-operate with their ESP, their expectations from ESP, and the feasible measures that the SC could employ to help ESP. To achieve our objectives a questionnaire was deployed whose respondents were Top100 List class supercomputer centers in the United States, the results of which are documented in subsequent sections.

There has been tremendous research advances in the field of Demand-Response(cite DR). Leveraging prior work on data center and grid integration opportunities done by Lawrence Berkeley National Laboratory's (LBNL) Demand Response Research Center(cite LBNL DR datacenter integration paper), we attempt to understand the existing software infrastructure from the ESP that is available for DR. Perhaps one of the most straightforward ways that supercomputing centers can begin the process of participating in demand-response is by using this existing software infrastructure to manage their electricity requirements in a tightly coupled manner, facilitating energy efficiency.

The second section of this paper brings forth the goals and challenges of the supercomputing community. The third section gives the electric service

providers' view of the world. The fourth section of this paper presents the results of the questionnaire. The fifth section of the paper describes opportunities, solutions and barriers. A sixth section concludes and suggests future work. Finally, the last section recognizes additional authors.