Review of *Using Batteries to Reduce the Power Costs of Internet-scale Distributed Networks*

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Summary

In this paper, the authors show that a CDN can utilize batteries to significantly reduce both the total supplied power and the total power costs, thereby establishing batteries as a key element in future distributed network architecture. The paper is divided into five main parts, including persuasive figures.

In the first part, the author introduces the layout of hardware of the CDN system consisting of the CDN architecture, power and batteries. The load balancing system of a CDN is optimized for maximizing availability, performance and bandwidth costs. Power price varies from one location to another, which influences the cost saving to some extents. The authors model three different values for power proportional factor to simulate a reduction of idle power so that the goal of reducing power consumption can be realized. As for battery, motivated by the fact that a colocation facility may find it cost-effective to procure even more energy storage capacity than offered by typically provisioned UPS units, the authors explore cost saving opportunities for CDNs which need to provide its clusters with access to batteries that they can control/operate according to their needs. The opportunities are influenced by five factors and they are battery capacity, maximum discharge and charge rates, energy loss factor, battery lifetime and battery deployment model.

The second part is about power supply optimization. The authors explain it in three aspects: power supply minimization, power cost minimization and role in CDN power provisioning. As for power supply minimization they take into accounts the battery capacity, loss rate and maximum charge rate. In terms of power cost minimization, the authors consider the unit cost of power, the amortized unit cost of the battery capacity and the expected lifetime of the battery. When it comes to CDN power provisioning, the authors’ work can provide techniques for the CDN operator to analyze potential savings for different deployment scenarios, server energy usage trends, future power cost regimes and different battery technologies.

In the fourth part, power savings analysis is described in detail. Specifically, the authors compare the minimum total power supply achievable with and without batteries. They ascertain the power savings achievable by a CDN as a function of the battery capacity, battery cycle rate, discharge/charge ratio, power proportional factor and battery deployment model. As for battery capacity, the fact is observed that even small battery capacities of 1-5 minutes can offer appreciable power savings of about 4-7% and that the higher power savings of up to 14% are yielded by a battery capacity of 40 minutes. In terms of battery lifetime, discharge/charge ratio, power proportionality and heterogeneous battery provisioning, the authors use figures showing the relation between power savings and battery cycle rate, the relation between power savings and power proportionality factor and power savings provided by heterogeneous batteries compared to homogeneous ones, respectively.

Cost savings analysis is presented in the fifth part. Cost savings depend on battery characteristics, power proportionality and power supply prices. From the three figures, we can know that cost savings can be different because of different battery sizes, that the cost savings improve as servers become more power proportional and that power cost savings increase with power price.

The Strengths and Contributions

The authors state and solve two key optimization problems in power supply and battery provisioning for a CDN: minimizing the total power supply and minimizing the total cost. To realize the minimization of the total power supply and power cost, the authors use a linear programming approach which is capable of solving more complex variants of this kind of problems.

They characterize the benefits that batteries provide and how these benefits vary with power demand, battery characteristics, power prices, battery prices, battery lifetimes and server power proportionality. Especially, the authors provide the illustration of the power demand sequence and threshold policies for servers with low and high power proportionality factor.

They use their formulation and algorithms on extensive realistic load traces from Akamai’s CDN and model the power contracts prevalent in the CDN industry to make an assessment of the power and cost reduction achievable by using batteries. For their empirical evaluation, they use two types of traces collected every five minutes during the measurement period. The first type has cluster load information that consists of each cluster reporting its average server load every five minutes and the geographic location of each cluster. The second type is user load information that includes the number requests made and the total bytes download by the users in the user IP block from that cluster in the each 5-minute time window. Combining the two traces enables them to derive how much user load originated at each block of IPs and which cluster served them for each 5-minute time window.

Weakness

In the paper, the authors have made several constricted conditions or prerequisites, i.e. the optimization is a little ideal. For example, when calculating the total power supply to be minimized, the authors assume that the maximum discharge rate equals to the peak power. Another example is in the part of CDN architecture. The CDN’s servers are homogeneous and the local load balancing system distributes the incoming load into a cluster evenly among servers so that each server receives the average cluster load. From the paper, however, we have no idea about the layout of heterogeneous CDN’s servers.

New Research Opportunity

The paper and the authors’ work are viewed as the first step in exploring the feasibility of batteries in a CDN by providing a high-level analysis of what might be possible. What they have done provides motivation for a more detailed exploration that considers the hardware design, placement, spatial requirements and any additional operational costs associated with deploying batteries.