Measurement-based Power Profiling of Data Center Equipment

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I. Introduction

Power-aware and thermal-aware techniques such as power-throttling and workload manipulation have been developed to counter the increasing power density in the current data centers. The basis for any such power-aware and/or thermal-aware technique, however, depends heavily on the equipment's power consumption model assumed. The goal of this paper is to perform power-profiling of different systems—namely, the Dell PowerEdge 1855 and 1955—based on actual power measurements. Gamut (Generic Application eMUlaTor) benchmark [1], double-precision matrix multiplication, and convolution of two vectors are used for varying the CPU utilization and Disk I/O.

II. Motivation & Objectives

As the servers in a data center are normally powered through the chassis, the power measurement is performed by employing the power meter between the data center power supply and the chassis power inlet. The principal factor in the power consumption of the chassis is the amount of computation performed in these devices. There are two parts to computational power consumption: i) *base power consumption*, which is a fixed power required to run the chassis and all the servers in the idle state; and ii) *task power consumption*, which is a variable power required to execute the tasks assigned to the servers in the chassis. Depending on the utilization of computing resources by the tasks, the power consumption varies according to the hardware of the server.

Merkel and Bellosa [2] used task power profile history to develop workload manipulation technique in multi-processor systems. Resource utilization has been used as a proxy for power consumption in [3]. The ensemble/chassis power control has been performed based on the resource utilization at the servers. Linear correlation between component utilization and power consumption has been assumed in [4], where thermal predictions are performed based on component power. Linearity is further assumed in chassis power consumption in [5], where thermal evaluation of the data center is performed based on power estimation at each chassis.

In this work, we perform profiling of the chassis power-consumption for different tasks based on experimental measurements. Our results validate the linearity with CPU utilization for Dell PowerEdge 1855 and 1955 systems. Variation in other component utilization such as disk I/O rate in these systems does not vary the power consumption.

III. Methodology & Preliminary Results

The measurement was performed in three steps: i) *empty chassis power measurement* to observe power requirements to run the chassis unit, ii) *power measurement of chassis with single server* to observe power requirements of a single server, and iii) *power measurement of full chassis* to observe the aggregate power requirements of the chassis fully loaded.

1) Empty Chassis Power Consumption: We observe that the empty chassis power consumption for the PowerEdge 1855 is 820W, whereas for the PowerEdge 1955 it is 490W.

2) Single Server in a Chassis: Figure 1 shows the variation in power consumption for the PowerEdge 1855 and 1955 systems. The main contributing factor between the difference in power consumption for these two systems is the base chassis power consumption. As a result, PowerEdge 1955 leads to 25-40% lower power consumption than the PowerEdge 1855 systems. This is in spite of the high computing capacity of the PowerEdge 1955 systems, i.e. 8 cores vs 2 cores (Table 1).

3) Full Chassis Power Consumption: Both Dell PowerEdge 1855 and 1955 chassis have 10 server slots. We performed the full chassis power measurements for Dell PowerEdge 1955 servers. Figure 2 summarizes the results for the total power consumption of the full chassis.

The CPU utilization increases the power consumption linearly, whereas the disk I/O variation does not have any effect. Figures 3 and 4 further show the power consumption of the chassis for the two applications—matrix multiplication and vector convolution. From the data, we see that the power consumption is highest for small input data, i.e. when the data fits the cache. Thrashing leads to less power consumption. This further concludes that disk I/O variation does not affect the power consumption in these systems. It can be verified that

TABLE I
EQUIPMENT USED FOR THE EXPERIMENTS

Model	Chassis	Processor	Disk	Memory	O/S
Dell PowerEdge 1955	7U Modular Chassis BMX v.1.4.2	2 Intel Xeon(R) quad-core @ 2.33 GHz	Fujitsu Serial ATA (SATA) 40GB @ 5.4K RPM	16GB SDRAM	Linux 2.6
Dell PowerEdge 1855	7U Modular Chassis BMX v.1.3	2 Intel Xeon(R) uni-core @ 2.33GHz	Maxtor Ultra 320 SCSI 146GB @ 10K RPM	4GB Fully Buffered DIMM Memory	Linux 2.4

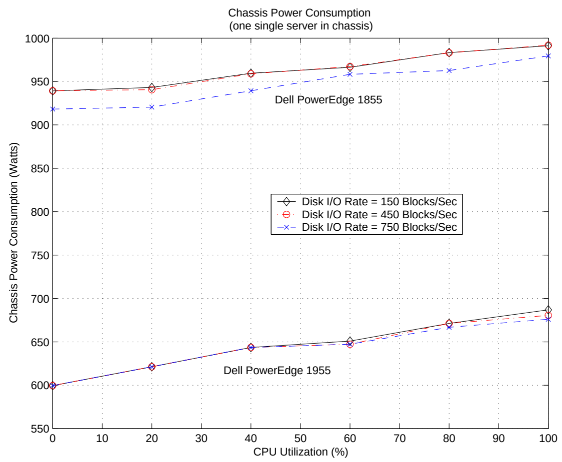

Fig. 1. Chassis Power Consumption for Single Server in Chassis.

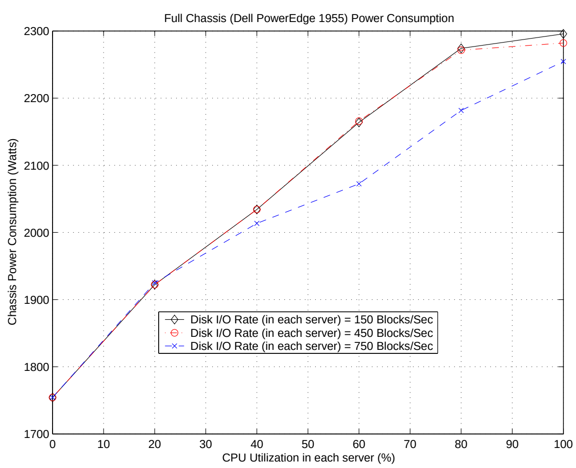

Fig. 2. Dell PowerEdge 1955 Full Chassis Power Consumption.

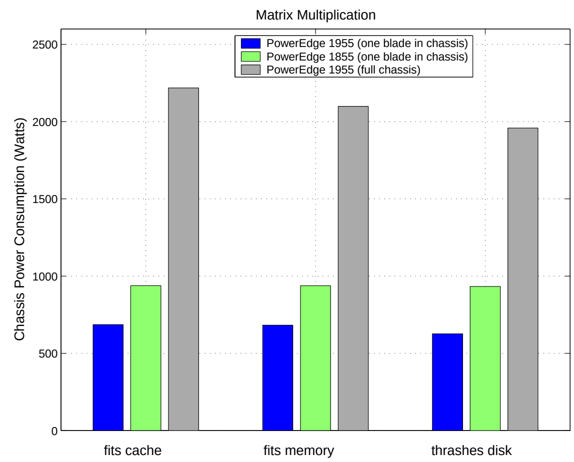

Fig. 3. Double-precision matrix multiplication.

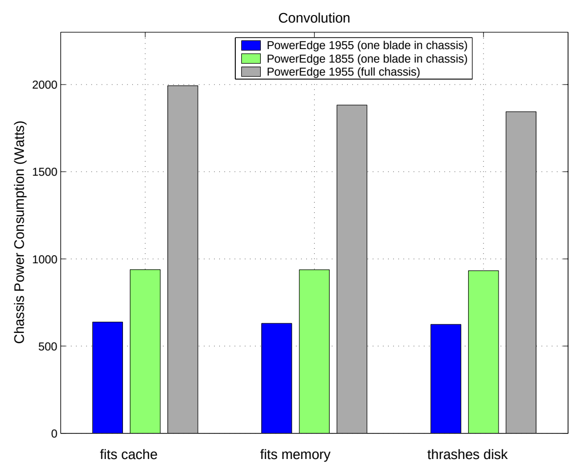

Fig. 4. Convolution of two vectors.

the power consumption linearity with CPU utilization holds for single and multiple servers in the chassis.

Similar power profiling for Dell PowerEdge 1955 systems has been performed in [6]. We found certain discrepancies in the results. For a single server at idle state in the chassis, the measurements in this work are 100W higher than [6]. Work is in progress to investigate the reasons behind the discrepancies.

IV. ACKNOWLEDGMENTS

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