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Power Saving System in Green Data Center

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***Abstract*—**Power consumption is rapidly increased in data centers because the number of data center is increased and more the scale of data center become larger. Therefore, it is one of key research items to reduce power consumption in data center. The peak power of a typical server is around 250 watts. When a server is idle, it continues to use around 60% of the power consumed when in use, though vendors are putting effort into reducing this "idle" power load. Servers tend to work at only around a 5% to 20% utilization rate, partly because of response time concerns. An average of 10% of servers in their data centers was unused. In those reason, we propose dynamic power management system to reduce power consumption in green data center. Experiment result shows that about 55% power consumption is reduced at idle time.

***Keywords*—**Data Center, Green IT, Management Server, Power Saving.

I. Introduction

POWER consumption is rapidly becoming a key design problem for servers deployed in large data centers and web hosting facilities [1]. A server should be able to deliver peak performance when requested. Nevertheless, peak performance is required only during some time intervals. Similarly, system components are not always required to be in the active state. The ability to enable and disable components, as well as of tuning their performance to the workload, is a key in achieving energy-efficient server [2]. Dynamic power management is a design methodology that dynamically reconfigures an server system to provide the requested services and performance levels with a minimum number of active components or a minimum load on such components [3], [4]. Dynamic voltage scaling adjusts the operating voltage and frequency of the CPU to match the intensity of the workload. Voltage scaling reduces energy consumption by virtue of the fact that the energy consumed by a processor is typically directly proportional to V2, where V is the operating voltage. To ensure reliable operation, processor frequency must also be reduced proportionally with voltage [1]. Voltage scaling works particularly well in Web servers sing typically, their configured capacity is significantly larger than the average encountered workload [5].

The peak power of a typical server is around 250 watts. When a server is idle, it continues to use around 60% of the power consumed when in use, though vendors are putting effort into reducing this "idle" power load. Servers tend to work at only around a 5% to 20% utilization rate, partly because of response time concerns. An average of 10% of servers in their data centers were unused [6]. In those reason, we proposed dynamic power management system (DPMS) for green data center.

The rest of the paper is organized as follows. In section II, we show DPMS requirements. In section III, we propose DPMS design for green data center. Section IV provides the implementation, and some concluding remarks are finally given in section V.

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II. DPMS Requirements

There are some requirements for dynamic power management system. That is, power consumption monitoring, power management policy, power management controlling, and power consumption result reporting.

A. Power Consumption Monitoring

DPMS should monitor the power consumption of energy resources in green data center. The power consumption is monitored for a long time and the maximum power consumption data are saved. The power consumption data for a long time are used to analyze the power consumption pattern. The maximum power consumption data are used to decide a power capping value. The real-time power consumption is monitored at point in time and average over an interval. It can monitor the power consumption single server level, rack level, and data center level. The difference between real power consumption value and monitored power consumption value should be low enough because the power consumption value can be calculated by the monitored data. The emergency condition can be handled using the power threshold alerting function, which monitors platform power against targeted power budget. Whenever the target power budget cannot be maintained, it sends alert message to the user.

B. Power Management Policy

DPMS can collect power consumption data daily, weekly, and monthly to analyze the power consumption data. The power consumption forecasting is possible using the historical data. Knowledge of historical power consumption records can be used to put together accurate power forecasts into the future that will allow negotiations with utility suppliers for power contracts. Advance knowledge of power consumption allows utilities to schedule generation accordingly and deliver power at lower prices. DPMS can make and change the power management policy dynamically. A single node can choose the policy dynamically, and the policy also can select any nodes in green data center dynamically. The policy may be classified by workload such as CPU-intensive workload, I/O-intensive workload, and memory-intensive workload. The power capping policy can be scheduled by data center environment dynamically. Load balancing policy and time based policy can be used to save power consumption in green data center. The one of the most important policy is a SLA (Service Level Agreement) driven power allocation to workload.

C. Power Management Controlling

DPMS can control the energy resources. The power capping is a guard rail preventing server power consumption from straying beyond preset limits. It prevents a sudden surge in power demand. So, If the severs in a rack is set the power capping value, more servers can be put in the rack. Therefore, the entire power consumption in data center can be reduced. The power capping value should be set more than the maximum value to not affect on performance. It should control the energy resources to solve the disaster environment. In some disaster conditions, it can set the power capping value lower even if performance is affected. The node level power consumption control means the power consumption control of a stand-alone server. The rack level power consumption control means the power consumption control of one rack. The data center level power consumption control means the power consumption control of a data center.

D. Power Consumption Result Reporting

The power consumption result reporting shows the power consumption at node level, rack level, and data center level. This can be used for detailed analysis of power consumption behavior of a particular workload or at a particular time interval. Reports can be generated with a wide variety of grouping and aggregation options. Power consumption data should be aggregated at daily, weekly, monthly levels, and more. And power consumption data can be grouped by a combination of location or service.

III. Dynamic Power Management System

A. DPMS Platform

As you seen in Fig. 1, server power management platform is consisted of server basic platform, power management interface, energy resource manager, DPM platform, and user interface. The server basic platform is consisted of hardware and operating system. As you know, the baseboard management controller (BMC) provides the intelligence behind intelligent platform management. The BMC manages the interface between system management software and the platform management hardware, provides autonomous monitoring, event logging, and recovery control, and serves as the gateway between system management software and the intelligent platform management bus (IPMB) and intelligent chassis management bus (ICMB). The power management interface connects with the server basic platform to monitor and control the power consumption by using intelligent platform management interface (IPMI), advanced configuration and power interface (ACPI), and dynamic voltage and frequency scaling (DVFS). The IPMI is a standardized computer system interface used by system administrators to manage a computer system and monitor its operation. The ACPI establishes industry-standard interfaces enabling OS-directed configuration, power management, and thermal management of mobile, desktop, and server platforms. DVFS may refer to dynamic voltage scaling and dynamic frequency scaling. Dynamic voltage scaling changes the voltage value used in a component depending upon circumstances. Dynamic frequency scaling changes the frequency of a microprocessor either to conserve power or to reduce the amount of heat generated by the chip. Voltage and frequency scaling are often used together to save power. The energy resource manager (ERM) manages energy resources such as CPU and node. It can monitor energy resources and saves the energy related data continuously. The DPM basic platform has policy manager, monitoring manager, control manager, and reporting manager. The policy manager analyzes the power consumption data and can decide a policy for power saving. The monitoring manager continually monitors the power consumption. The control manager can control the energy resource via the power management interface. The reporting manager reports the power consumption data and power saving result to user. User can monitor, control the power consumption via user interface. All of the manual control operation should be certified and confirmed.

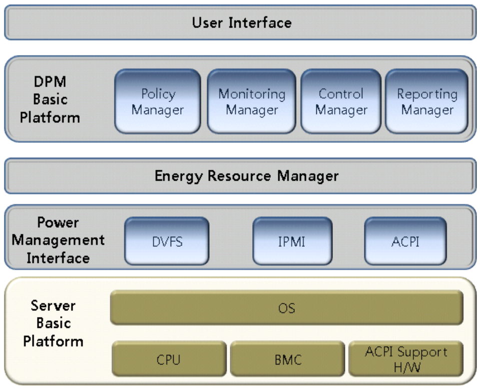

Fig. 1 DPMS platform

B. DPMS Structure

We design DPMS for green data center as seen Fig. 2. The one of the most important goals is dynamically optimize server performance and power consumption. One dynamic power management server cannot monitor and control all nodes in data center because there are lots of nodes in data center. Therefore, DPMS has a 3-layer hierarchy structure, that is, it has a dynamic power management (DPM) master server and a DPM group server and nodes. One DPM group server can monitor and control 255 nodes. The DPM master server can monitor and control nodes through the DPM group server and manages several DPM group servers. The DPM master server provides power consumption management for nodes, racks, and group of nodes in green data center. The DPM master server manages the power consumption of nodes in green data center using IPMI, ACPI, and DVFS.

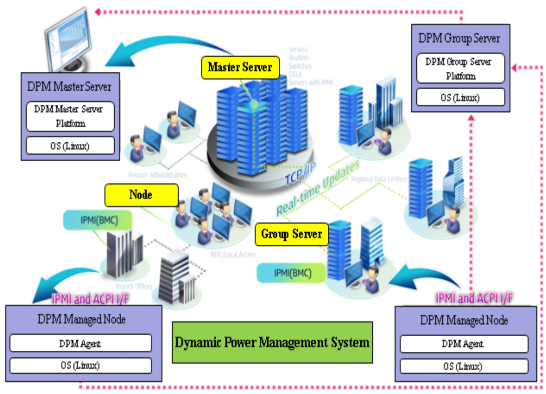

Fig. 2 3-layer DPMS structure in green data center

The DPMS block diagram is shown in Fig. 3. Each DPM node has a baseboard management controller (BMC) board and uses Open IPMI library to collect power consumption information. DPM group master requests DPM nodes information periodically and manages DPM nodes information. DPM group server sends nodes information whenever DPM master server requests it. DPM master server monitors and collects DPM nodes information at data base (DB). The DPM master server platform with PBM (Policy based management) and DPM analyzes the monitored data and controls nodes in green data center via IPMI, ACPI, and DVFS. The PBM manages policies and rules that save power consumption. It can make a policy by using historical data automatically. System manager (User) can make a policy in person via user-friendly user interface. DPM manages energy resources to save power consumption dynamically. That is, it monitors energy resources in real time and controls those dynamically. The user monitor and control the green data center using web based user interface (UI) program. The all commands except a system on/off command use TCP/IP packet. The system on/off command uses a BMC interface.

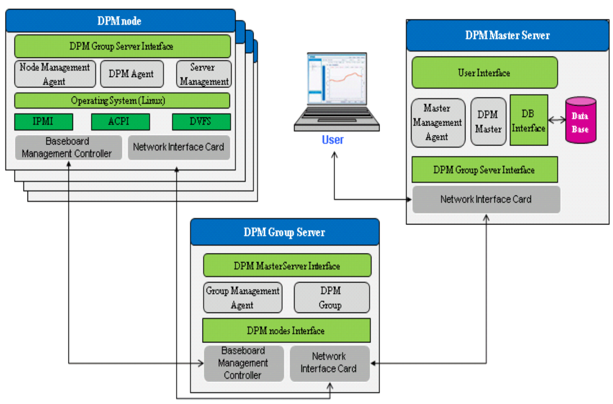

Fig. 3 DPMS block diagram

The DPMS flow chart is shown in Fig. 4. Each DPM agent gets node information using BMC and other sensors in each node. DPM group server initiates nodes and then creates TCP server to connect with the DPM agents. The DPM group master requests node information periodically and receives it and then manages it at local DB. The DPM group master creates TCP server to connect with a DPM master server. The DPM group server sends nodes and DPM group server information whenever the DPM master server requests it. The DPM master server manages node and DPM group server and manages power consumption policy. The DPM master server sends control command to the DPM group server when some nodes are needed to change power consumption configuration. The DPM group server analyzes the command and then sends power control command to each node. The node changes power configuration using IPMI, ACPI, and DVFS. If emergency is occurred at a node, the node send alarm message to the DPM group server and the DPM master server.

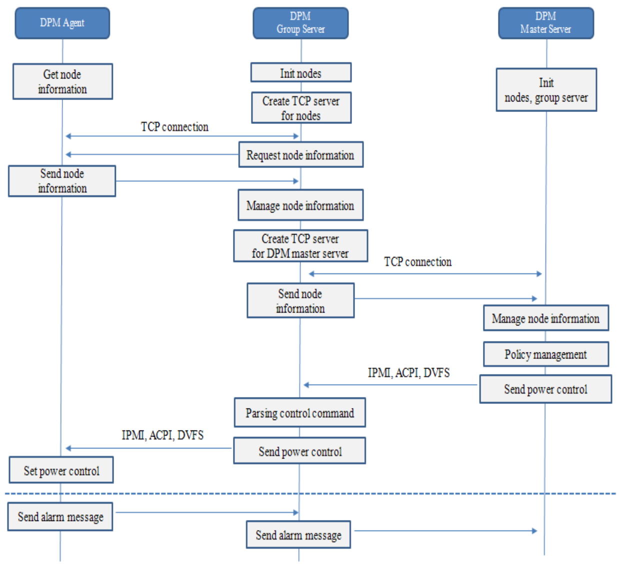

Fig. 4 DPMS flow chart

IV. Implementation

We implemented the power saving system in green data center. First, the DPM master server can monitor nodes in green data center as shown Fig. 5. The node information such as CPU is described in detail and CPU, memory, network usages are shown using a graph. The temperature information is also shown in this. Second, the nodes in green data center can be controlled to save power consumption, as shown Fig. 6. The nodes are listed and each node can be controlled by IPMI, ACPI, and DVFS. If user changes the ACPI value or DVFS value of the node, the node changes the values immediately. If user wants to turn off a node, the node can be turned off using IPMI command. And the node turned off can be turned on using IPMI over LAN command.

Fig. 5 Node information monitoring

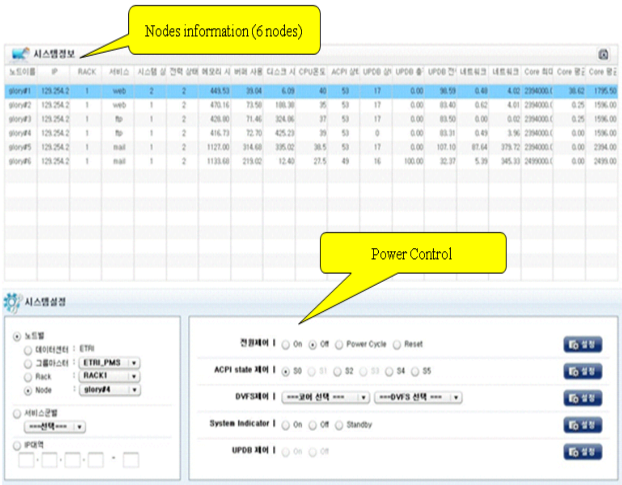

Fig. 6 Nodes power control

The power saving is shown in Fig. 7. The power consumption value is about 400 watt at 6 nodes (output power in Fig. 7). The power consumption is about 180 watt after setting power control using ACPI, DVFS, and IPMI. The power consumption is reduced about 55%

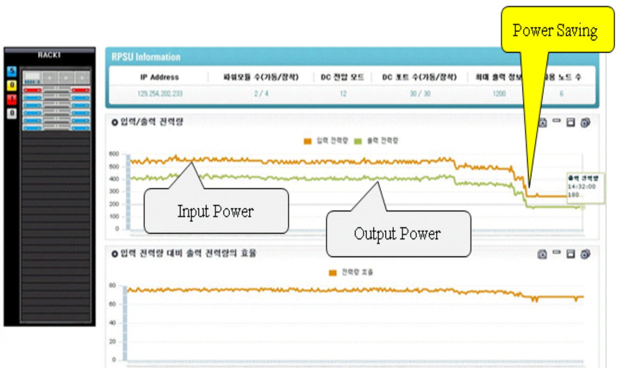

Fig. 7 Power saving monitoring

V. Conclusion

For saving power consumption in data center, we consider the DPMS requirements for green data center and then we propose the DPMS platform, structure, and block diagram for green data center. We implement this system to monitor and control power consumption using IPMI, ACPI, and DVFS. We show about 55% power saving at idle time through experimental result.

For further work, we plan to develop DPMS without performance degradation. The performance is essential factor in data center. So, performance degradation should not be occurred due to power consumption saving.

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