The Microsoft Windows Server 2008 R2 OS incorporates enhanced power management tools that can complement 11th-generation Dell PowerEdge server capabilities such as the Dell Active Power Controller feature to help control power consumption and increase energy efficiency in enterprise data centers.

Key Power Management Enhancements

Although processors generally consume a smaller proportion of overall server power than they did a few years ago, they still require a significant amount of energy. Administrators can control the power consumption of Intel Xeon processors through two primary mechanisms:

- **P-states**: P-states manage processor power consumption by modulating processor power and frequency.
- **C-states**: C-states are processor sleep states, which for Intel Xeon processors run from C0 (a fully operational state) to C6 (currently the lowest possible state for these processors).

The Intel Xeon processor 5500 series and DAPC in 11th-generation Dell PowerEdge servers offer increased control over processor power consumption. The Intel Xeon processor 5500 series and supported chipsets are designed to provide enhanced C-state capabilities compared with previous-generation processors. DAPC provides a firmware-based mechanism for controlling P-states that can complement Windows Server 2008 R2 OS power management capabilities.1

The core parking feature in Windows Server 2008 R2 provides a processor scheduling policy designed to minimize the number of cores in use, enabling unused cores to enter a lower C-state when they are not needed. Because of the increasing prevalence

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of multi-core processors, effective management of core usage can potentially reduce power consumption on a wide variety of systems. Figure 1 shows the Windows Server 2008 R2 Resource Monitor for a PowerEdge R610 server with two quad-core Intel Xeon processors, clearly displaying which cores have been parked.

Windows Server 2008 R2 also includes enhanced control over P-states, which helps control server power consumption—although this is one area where DAPC can provide advantages over OS power management under certain circumstances. Administrators can monitor and manage both P-states and C-states using Windows Management Instrumentation (WMI) and Group Policy when OS power management is enabled. Because DAPC manages P-states at the firmware level, P-state control and monitoring are not available to the OS when DAPC is enabled. However, organizations can still benefit from other Windows Server 2008 R2 power management features such as core parking even when DAPC is on.

Other power management enhancements in Windows Server 2008 R2 include the following:

- **Intelligent Timer Tick Distribution (ITTD):** ITTD extends processor sleep states by not waking the processor unnecessarily.
- **One-to-many power management:** This feature is primarily a management tool, but can be useful if IT staff routinely push out power management changes. As part of this overall infrastructure, Windows Server 2008 R2 also introduces an enhanced Power Metering and Budgeting interface to instrument and manage servers.2
- **Individual setting control:** Administrators can now individually control and manage each power management setting, providing a much finer level of control compared with managing settings as a group.3

**DAPC AND OS POWER MANAGEMENT EFFICIENCY**

Both Dell and Microsoft have focused significant engineering efforts on enhancing server energy efficiency. But for IT administrators, where are the inflection points? When does it make sense to choose DAPC over OS power management and vice versa?

First of all, DAPC and Windows Server 2008 R2 OS power management approaches can complement each other in several ways. Because DAPC affects only P-states, not C-states, many environments can benefit from using DAPC along with the additional C-state control offered by the OS. In addition, the 11th-generation Dell PowerEdge server BIOS implements Advanced Configuration and Power Interface (ACPI) 4.0 Power Metering objects that allow monitoring through the Windows Server 2008 R2 Power Meter Interface (PMI), enabling OS events to be triggered when administrator-defined thresholds are reached. This integration provides an additional standardized mechanism for monitoring power consumption in the data center.

However, DAPC and OS power management can also offer specific advantages under different circumstances. DAPC is designed to provide power savings over OS power management at utilization levels of roughly 40–90 percent; at low and very high utilizations, DAPC and OS power management tend to converge. The WMI capabilities introduced in Windows Server 2008 R2 can offer different ways to control power management settings, but if administrators want to take a “set it and forget it” approach, and if testing in the specific environment demonstrates that DAPC can provide higher efficiency than OS power management, then DAPC would generally be recommended.

To demonstrate the relative efficiency of DAPC and OS power management under different conditions, in June 2009 Dell engineers used industry-standard benchmarks to evaluate power consumption in two PowerEdge server models across a range of utilization levels from idle to the maximum throughput achievable on each model. The first was an 11th-generation PowerEdge R710 configured with two quad-core Intel Xeon X5570 processors at 2.93 GHz; 8 GB of RAM; a

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2 For more information on this interface, visit msdn.microsoft.com/en-us/library/dd573949.aspx.
3 For more information on Microsoft Windows® OS power management features, visit www.microsoft.com/whdc/system/pnppwr.
250 GB, 7,200 rpm Serial ATA (SATA) hard drive; a Dell Serial Attached SCSI (SAS) 6/iR storage controller; one 570 W power supply unit (PSU); and a default installation of Windows Server 2008 R2.

The second server was a 10th-generation PowerEdge 2950 configured with two quad-core Intel Xeon E5345 processors at 2.33 GHz; 8 GB of RAM; a 250 GB, 7,200 rpm SATA hard drive; a Dell SAS 6/iR storage controller; one 750 W PSU; and a default installation of Windows Server 2003 R2 with Service Pack 2 (SP2).

In the first set of tests, the Dell team compared DAPC against Windows Server 2008 R2 OS power management in the 11th-generation PowerEdge R710 server. Figure 2 shows the resulting data set across the full tested throughput range, while Figures 3 and 4 show the same data specifically for the 0–50 percent and 50–100 percent throughput ranges, respectively. As these results show, OS power management has a slight edge when throughput is below 40 percent of a system’s peak capabilities, while DAPC has a significant advantage when throughput is above 40 percent.

In the second set of tests, the Dell team compared the 11th-generation PowerEdge R710 running Windows Server 2008 R2 against the 10th-generation PowerEdge 2950 running Windows Server 2003 R2 with SP2. Figure 5 shows the results. In these tests, the PowerEdge 2950 drew 251 W at its peak throughput. The PowerEdge R710, in contrast, drew 218 W at its peak—consuming 13 percent less power than the PowerEdge 2950 while providing 66 percent higher maximum throughput.

These tests illustrate the dramatic difference that latest-generation hardware and software can have on overall system power consumption and throughput. For organizations that are considering an upgrade but are concerned about the initial capital outlay, the results may provide some idea of the long-term possibilities and efficiencies that latest-generation systems can offer.
Administrators should keep in mind that results may vary depending on configuration and workload; to identify the appropriate power management approach in their own environments, they should test their specific systems and workloads.

**BEST PRACTICES FOR DATA CENTER ENERGY EFFICIENCY**

How efficiently a data center runs depends primarily on three factors: hardware capability, firmware capability, and software capability. To achieve maximum efficiency, these three elements must work together. By running Microsoft Windows Server 2008 R2 on 11th-generation Dell PowerEdge servers, organizations can help ensure effective power management at all three levels, with latest-generation Dell hardware and firmware capabilities such as DAPC providing a complement to the enhanced OS power monitoring and management features in Windows Server 2008 R2.

As always, testing with actual workloads in an organization’s specific IT environment is crucial to determining the appropriate power management approach for that environment. Upgrading to latest-generation servers and software and investing in the up-front effort to evaluate the systems in the context of production workloads can help administrators significantly reduce costs for systems, power, cooling, and space.

**Thomas Cantwell** is a member of the team responsible for developing and deploying Microsoft server products at Dell.

**Greg Darnell** is a member of the Server Architecture team at Dell.

**Peter Tsai** is a member of the Server Operating Systems Engineering team at Dell.