Using virtualization to differentiate industrial products

Dell PowerEdge VRTX and Intel® Virtualization Technology extend the benefits of virtualization into industrial automation and process management solutions.

Introduction

While virtualization has long been used to consolidate resources and realize cost-savings in enterprise data centers, it is relatively new in industrial settings. When virtualization was still nascent, many organizations had concerns about latency and failures in critical manufacturing and processing operations. Industrial operations are also slow to adopt new technology because production availability is paramount and often processes can’t be easily or economically stopped.

For example, unplanned downtime in a plant can cost millions of dollars per day in lost production. In many industrial processes, where raw materials are added under precise conditions to achieve a desired blend, interrupting the process can result in failure to achieve the end product. In addition, plants may need to maintain a continuous process to maximize equipment utilization and stay competitive.

Reflecting these realities, industrial organizations traditionally favor solutions that require few, if any, changes. Capital equipment, including industrial automation and other computerized systems, must have a long operational life to minimize acquisition and maintenance costs. Companies may prefer to wait until they are buying new hardware to update the software, so they can minimize planned downtime. Finally, many industrial companies are very concerned about adding system complexity and do not want to rely on IT experts to maintain their control system — so any virtualization solution must be as simple as possible.

Entering new industrial territory

Today, Dell and Intel are helping overcome the barriers to adopting virtualization for industrial applications. Manufacturing and process management solution providers have seen the proven cost-savings that can be gained through consolidation of equipment and applications.
Virtualization empowers OEMs to reduce system size, cost and power consumption.

Executive summary
Virtualization is entering new territory: Dell OEM Group and Intel are helping industrial automation and process management solution providers deliver virtualization benefits with an easy-to-use, integrated system that can help providers differentiate their offerings. Developing the right platform requires overcoming significant barriers to virtualization within industrial settings.

This paper focuses on the key elements — including the Dell PowerEdge VRTX shared infrastructure platform, Intel® Virtualization Technology (Intel® VT) and other optimizations — that make it possible to overcome these barriers.

Industrial system consolidation allows manufacturing and processing companies to reduce costs by eliminating unnecessarily redundant hardware and combining control system workloads. And by breaking the connection between hardware and software, virtualization enables organizations to update their industrial software to the latest version without replacing the hardware, or replace aging computer hardware while continuing to run legacy software.

With multiple operating systems able to run simultaneously on a single platform, virtualization empowers developers and original equipment manufacturers (OEMs) to:

- Reduce system size, cost and power consumption
- Bring innovation to market faster while preserving legacy code
- Enhance security, safety and availability through application isolation and software redundancy

Dell and Intel technologies combine to enable adoption of virtualization in industrial settings in several ways. First, the Dell PowerEdge VRTX shared infrastructure platform is helping simplify the introduction of virtualization in industrial locations. Another enabler is Intel VT, which helps overcome processing overhead and latency problems inherent in virtualization hypervisors. In addition, long-term system availability and multiyear support for Dell and Intel products helps extend the product lifecycle and reduce maintenance costs for industrial companies.

Simplifying virtualization with Dell PowerEdge VRTX
Dell PowerEdge VRTX offers an end-to-end solution for implementing virtualization in industrial automation environments. It enables manufacturing and processing facilities to quickly and economically deploy virtualized infrastructure and begin benefitting from the consolidation and cost-saving capabilities of virtualization.
VRTX integrates servers, storage, networking and management, providing the functions of a complete data center with virtualization capacity in a single chassis the size of a 5U rack.

The PowerEdge VRTX platform provides high server density of up to four dual Intel® Xeon® processor server nodes to easily support virtualization projects. PowerEdge VRTX can communicate with thin clients used for control systems, and through virtualization of PowerEdge VRTX servers, virtual machines (VM) can communicate with multiple thin clients, including some in remote areas of a manufacturing or processing facility (see figure).

The latest Intel Xeon processor E5 family dramatically increases performance per server node for running multiple applications that need low latency. All four server nodes have access to low-latency internal shared storage that is ideal for virtualization, with up to 48 TB of data and drives that support dynamic movement of workloads among virtual machines.

Several PowerEdge VRTX features help organizations reduce costs. The in-chassis storage is highly economical and less time-consuming to manage than traditional storage area networks (SANs). An embedded Gigabit Ethernet (GbE) switch eliminates the need to purchase a separate networking device and PCI Express (PCIe) resources that are shared across the compute nodes within the chassis. And Intel Xeon processors are used for both servers and storage, making it easier and more cost-effective to develop shared platform or converged infrastructure solutions.

To help ensure the continuous uptime required in industrial settings, PowerEdge VRTX also employs the latest high-availability features, including RAID and redundant power supplies and fans. Full-functioned unified system management with Chassis Management Controller (CMC) takes much of the time and effort out of system administration and control, and PowerEdge VRTX systems management is integrated with major third-party management tools to protect installed investments.

**Boosting system performance with Intel VT**

Designed to improve the performance and stability of a virtualized environment, Intel VT provides unique hardware accelerators that help reduce the latency in hypervisor processes, such as executing instructions to access critical hardware resources. Intel Xeon processors with built-in Intel VT acceleration are available in Dell PowerEdge servers and other hardware, and Intel® Core™ vPro™ processors offer Intel VT acceleration for embedded solutions.

The Dell PowerEdge VRTX platform provides high server density to support virtualization projects.
Intel® VT for Intel® Architecture (Intel® VT-x) introduces hardware accelerators into the processor that execute sensitive instructions, relieving the hypervisor of these duties and greatly reducing the overhead of virtualization. To improve I/O, Intel® VT for Directed I/O (Intel® VT-d) adds hardware accelerators to the chipset that enable the hypervisor to securely assign I/O devices to specific guest operating systems. Intel® VT for Connectivity (Intel® VT-c) improves the network performance of virtualized devices by integrating hardware assists into network adapters.

Reducing latency with APIC virtualization

A unique latency challenge of virtualization stems from interrupts, the requests sent to the processor to provide resources for various devices and computing tasks. These requests are managed by advanced programmable interrupt controllers (APICs) and generate a degree of latency. But with virtualization, additional latency is introduced as different virtual machines enter and exit APIC registers to be assigned resource access. The virtualization hypervisor software must allocate time for each VM to access critical processor resources based on the application running in that VM. A significant portion of VM exits are due to these interrupts — in some cases, a VM exit must occur before any reads or writes to APIC registers can take place.

To reduce the latency created by these VM exits, Intel® APIC virtualization technology offloads interrupt management from the hypervisor to new APIC registers created in the Intel processor. There, many of the VM exits are optimized or eliminated, greatly reducing latency (see figure). APIC virtualization is available in Intel Xeon processors from the 32nm Intel Xeon processor E5 series forward.

Existing treatment

- **020H** APIC ID (RW)
- **030H** APIC Version (RO)
- **080H** TPR (writes exit if below threshold) (RW)
- **090H – 0A0H** APR, PPR (RO)
- **0B0H** EOI (RW)
- **0D0H – 0F0H** LDR, DFR, SIVR (RW)
- **100H – 270H** ISR, TMR, IRR (RO)
- **280H** ESR (RW)
- **300H** ICR_LO (RW)
- **310H** ICR_HI (RW)
- **320H – 380H** LVTs, Timer Initial Count (RW)
- **390H** Timer Current Count (RO)
- **3E0H** Timer Divide Configuration (RW)

Access with APIC-Register virtualization

- **020H** APIC ID (RW)
- **030H** APIC Version (RO)
- **080H** TPR (writes exit if below threshold) (RW)
- **090H – 0A0H** APR, PPR (RO)
- **0B0H** EOI (RW)
- **0D0H – 0F0H** LDR, DFR, SIVR (RW)
- **100H – 270H** ISR, TMR, IRR (RO)
- **280H** ESR (RW)
- **300H** ICR_LO (RW)
- **310H** ICR_HI (writes never exit) (RW)
- **320H – 380H** LVTs, Timer Initial Count (RW)
- **390H** Timer Current Count (RO)
- **3E0H** Timer Divide Configuration (RW)

VM exits before any read or write
No VM exits on reads; VM exits after some writes based on data

With normal treatment, most operations (in red) require VM exits before any read or write. With Intel APIC virtualization, VM exits are reduced in all but two of those operations (in red).
Case in point: Emerson Process Management

Companies around the world turn to Emerson Process Management not only for industrial automation technologies and services, but also for expertise and solutions to help solve problems and build an advantage for the future. For example, the Emerson DeltaV™ Digital Automation System helps plants improve operations by harnessing predictive technologies in an interoperable way to connect processes and production.

Working with the Dell OEM Group

Emerson began to work with Dell 10 years ago to integrate Dell PowerEdge servers, Dell Precision workstations and Dell OptiPlex thin clients into Emerson products. This integration provides the cost-benefits and open standards of commercial off-the-shelf technologies with added functionality designed specifically for demanding process control applications.

The Dell OEM Group helped create a standard configuration for the hardware in the U.S. and ensures that global manufacturing plants copy those configurations exactly to ensure product consistency. Dell also performs system integration, installing Emerson DeltaV software into products and then shipping those products directly to Emerson customers around the world.

The relationship with Dell OEM has helped Emerson avoid the costs of procuring components, configuring hardware, ensuring regulatory compliance, shipping products and keeping spare systems and parts in inventory. It has also helped Emerson reduce the time to deploy new products by eliminating the time for in-house component testing and configuration.

Assessing the advantages of virtualization

Dell OEM began talking with Emerson about the benefits of virtualization. For example, with a virtualized environment, Emerson customers could begin benefitting from the consolidation, cost-savings and high availability that are possible with virtualization. Emerson could reduce the number of physical servers or workstations required by the control system in an effort to lower hardware, installation and maintenance costs. Virtualization also presented new opportunities for high availability and disaster recovery, which was not practical on traditional physical systems.

An additional benefit of virtualization was the potential energy savings resulting from reduced power and cooling requirements. Fewer servers or workstations also meant a smaller footprint, which is very important to industrial customers with limited control-room space such as on offshore oil rigs or floating processing plants.

The relationship with Dell OEM Group has helped Emerson reduce the time to deploy new products.
Developing and testing a solution
With support from Dell OEM, Emerson developed an integrated DeltaV Virtualization solution specific to industrial process control. The solution consisted of:

- The Dell PowerEdge VRTX with automated configuration for ease of hardware implementation
- An integrated virtualization management application called DeltaV Virtual Studio for easy configuration of virtual networks and creation of DeltaV virtual machines

Dell performed testing with Emerson in a custom engineering lab that duplicated the Emerson network environment on-site at Dell. Tests evaluated ways to reduce latency introduced by virtualization hypervisors. Using Intel VT and optimized interrupt/APIC virtualization, engineers ensured that latency was minimal and did not interfere with control systems performance. The test results confirmed that display call-up time for operators to obtain real-time information from process sensors was as fast as with traditional physical hardware — and often faster. Tests also confirmed that engineering applications involving significant network loading performed equivalent to physical systems.

Intel and Dell team up for Emerson Process Management

**Challenge:**
Emerson needed to deliver virtualization benefits to an industry adverse to complexity and concerned with system reliability.

**Solution:**
Emerson and Dell OEM integrate Dell PowerEdge VRTX with Intel Xeon processors with Emerson DeltaV virtualization solutions.

Dell configures, ships and supports solutions globally and is helping virtualize solutions to reduce customer costs and facilitate software implementation and maintenance.

Intel technology facilitates the system in key ways:

- Intel Virtualization Technology eliminates the latency barrier for process control systems
- Dense, high-performance processing supports virtualization
- Large-scale memory integrates data into a single, shared pool of virtualized storage

**Benefits:**
Emerson realized the following benefits with virtualization on Dell PowerEdge VRTX:

- Accelerated the time to market for new solutions with industry-standard hardware and lifecycle management support
- Retained a competitive edge by creating virtualized solutions that reduce system complexity and enhance system reliability
- Gained competitive advantage through an integrated virtualization solution tailored to process automation, which delivers high customer value at a competitive price

Call-up time for operators to obtain real-time information is as fast as with traditional hardware – often faster.
Emerson now offers the DeltaV Digital Automation System on Dell PowerEdge VRTX powered by Intel Xeon processors. The DeltaV control system consists of dedicated real-time controller hardware and workstation/server applications for human-to-machine interface (HMI), supervisory control, data history collection and other functions. Virtualization is used for the workstation/server applications. Emerson representatives are showing customers how they can use the system, and the company is experiencing a groundswell of customers eager to deploy it.

Customers are pleased that they can continue to run legacy operating systems on PowerEdge VRTX. They also appreciate the high availability and quick provisioning capabilities of virtualizing on PowerEdge VRTX. Based on feedback from Emerson’s industrial customers, Dell is adding a new PowerEdge VRTX feature: redundant controllers for the hard drives. Dell also works with Emerson’s local business partners to provide global support.

**Shared infrastructure delivers joint success in industrial settings**

As industrial manufacturers are forced to improve the performance and reliability of their process facilities, virtualization provides valuable benefits for optimizing computer resources while increasing system availability and reducing lifecycle costs. Dell and Intel are helping extend virtualization into industrial settings.

Dell PowerEdge VRTX with Intel Xeon processors and Intel Virtualization Technology provide a shared infrastructure platform that enables Emerson’s customers to realize the benefits of a virtualized environment. The solution provides a completely integrated infrastructure for customers to run the control system applications required to operate their plant. It also allows industrial system providers such as Emerson to offer a new and compelling solution that makes it easy to provide virtualization benefits to its customers.

**Dell and the Intel® Intelligent Systems Alliance**

Dell OEM is a Premier Member of the Intel® Intelligent Systems Alliance. From modular components to market-ready industrial systems, Intel and the 200+ global member companies of the Alliance provide the performance, connectivity, energy efficiency, manageability and security developers need to create smart, connected systems. Close collaboration with Intel and each other enables Alliance members to innovate with the latest technologies, helping developers deliver first-in-market factory automation solutions to improve manufacturing efficiency. Learn more at: intel.com/go/intelligentsystems-alliance.

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