Virtualizing Your Process Control Computers

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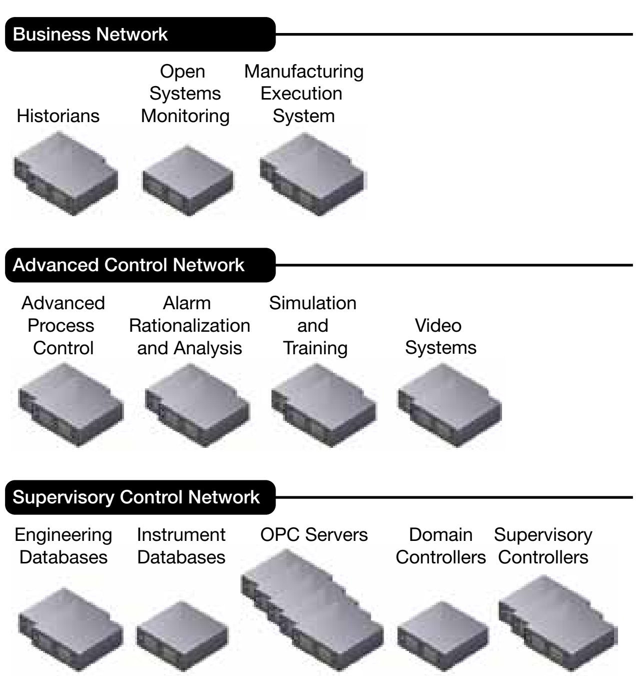
By employing the latest virtualization solutions for process control systems, chemical plants can reduce PC hardware requirements, simplify system management, and lower the total cost of ownership, as well as improve site availability, reliability, and disaster recovery.

In today's demanding economy, chemical process industries (CPI) firms strive to reduce operating costs while maintaining or increasing production levels and bringing new projects online faster and at a lower cost. Process control systems, which employ numerous computers, represent opportunities for cost savings and efficiency improvements at production facilities.



▲ **Figure 1.** Plant control systems typically have many physical machines, each performing a different job.

Maintaining a large computer fleet poses many challenges, including:

• *hardware proliferation*. Plant management seeks to reduce computer hardware in the facility, while ensuring acceptable safety, reliability, and production levels.

• *technology churn*. Process control engineers want to minimize the problems caused by frequent operating system (OS) and hardware changes, or technology churn, which is expensive and complicates day-to-day system management functions.

• *patching disruptions*. Operating system and application patching — *i.e.,* the installation of a piece of software code designed to fix a specific problem in a computer program or its data — is time-consuming and disruptive to plant operations. Process control groups want to be able to reduce or automate patching while ensuring OS and application reliability and security.

• *IT skills shortage.* Information technology (IT) skills are essential for maintaining modern control systems. Although most companies have been increasing IT expertise within process control groups, such skills remain in short supply.

Virtualization does more with less

The distributed control system (DCS) infrastructures running a typical chemical facility reside on multiple physical servers. In the past, each server hosted a separate application (Figure 1) that required a high percentage of the server's resources. As technology evolved, servers became faster and faster. Application performance needs, however, did not increase at the same pace as hardware performance, leading to lower utilization rates. Today a server typically

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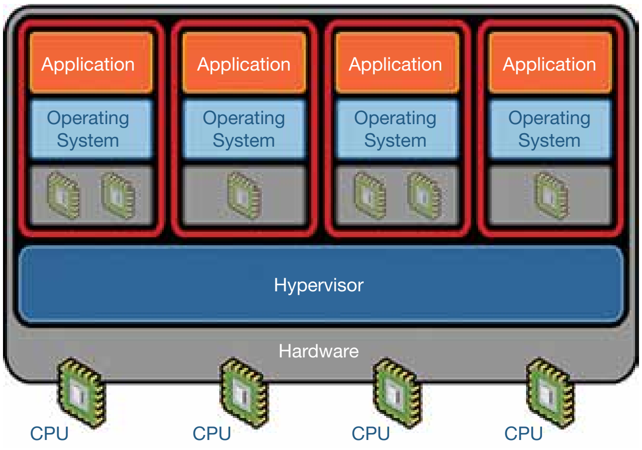
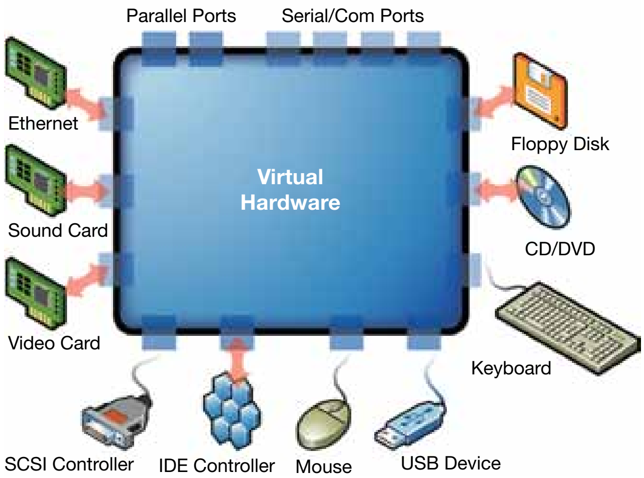


▲ **Figure 2.** Virtualization works by inserting a thin layer of software, called the hypervisor, directly on the computer hardware.



▲ **Figure 3.** The hypervisor layer presents a set of "virtual hardware" that has the same components as physical hardware.

runs at only 5–10% of its rated capacity.

Virtualization enables servers to be used more effectively by splitting one physical server into many virtual servers. This is done by inserting a thin software layer, known as a hypervisor, directly on the computer hardware (Figure 2). The hypervisor layer makes a set of virtual hardware accessible to each operating system. To the OS and the application, the hypervisor is indistinguishable from a regular machine. The virtual hardware has all of the same components as physical hardware (Figure 3), and it remains consistent and stable regardless of the underlying physical hardware used to host the virtual machines.

The virtual hardware, along with the virtual disk, operating system, and application, can be encapsulated in a single set of files, known as the virtual machine. In allowing multiple virtual machines to run on one computer, the hypervisor also isolates the virtual machines from one another and from the underlying physical hardware. This ensures that a problem on one virtual machine cannot propogate to another. It also allows a virtual machine to be easily moved from one physical machine to another because it is not coupled to the underlying hardware.

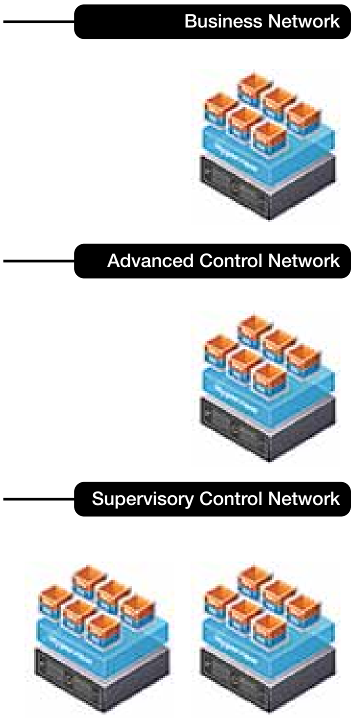
Virtualization and the CPI plant

Virtualization offers many benefits for a chemical manufacturing or processing facility:

Reduced PC hardware requirements. With virtualization, a typical chemical plant's operations can be consolidated on fewer servers (Figure 4). As a result, the facility can reduce the number of physical computers and lower associated operating and maintenance costs. Virtualization also enables the plant to expand without adding new hardware, because many virtual machines can be run on one server. Additional virtual machines can be added as long as sufficient resources are available on the server to meet their operational needs.

Example: increasing UPS capacity without the need for an upgrade. A control room was running out of uninterruptible power supply (UPS) capacity. Rather than upgrading the UPS and all of the electrical feeds, plant management chose to virtualize the control room. This allowed the facility to reduce the quantity of control room hardware and defer the need to add more UPS and electrical feeds.

Example: minimizing hardware requirements for a satellite facility. A plant was adding a new satellite facility, and was directed by management to reduce the quantity of hardware at the new site due to power and space constraints. Virtualization achieved an 80% reduction over traditional deployment methods in required hardware, and proportional reductions in space and power. This was accomplished by pooling computer resources rather than pairing applications and servers in a traditional one-to-one relationship.



▶ **Figure 4.** Virtualization reduces hardware requirements (Figure 1) by enabling a set of nodes to be consolidated into fewer servers running virtual machines.

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Reduced frequency and impact of OS or hardware changes. Plant managers typically see no incremental benefit to operations from upgrading the OS or hardware. They upgrade to maintain reliability as hardware is replaced, and to continue to receive support and security patches. These upgrades do not increases a plant's output, but are done to avoid unplanned downtime.

Virtualization can help to reduce the cost of system upgrades. It allows hardware to be maintained for as long as it continues to provide the minimum performance level an application requires of a virtual machine. It also allows applications to stay on the same OS longer, because the ability to run on the physical hardware no longer depends on the hardware itself, but rather on what the virtualization environment supports.

When hardware changes are required, virtualization eliminates the need to reinstall an OS and allows operations to continue without interruption during the hardware replacement, thereby minimizing disruption to plant operations.

Example: replacing faulty hardware without reinstallation or downtime. A server running virtual machines developed a fault and needed to be replaced. The system administrator transferred the virtual machines from the failing server onto a different server. After all of the virtual machines had been moved, the faulty node was shut down, repaired, and placed back into operation. Virtualization allowed this to be done quickly and while the virtual machines were running, without impacting their applications.

Example: extending support for legacy software. The plant had a legacy application running on an OS that was not supported by current-generation servers. The hardware on which this software package was installed had failed. The application was virtualized and run in a virtual machine, which was possible because the hypervisor supports the OS rather than the underlying hardware.

Easier overall system management. Virtualization enables the hardware configuration, OS, and application to be contained in a single capsule. This capsule can be turned into a template that can be used to create new versions of the virtual machine. Creating virtual machines in this manner reduces configuration errors and installation time, and ensures more reliable and repeatable results. With virtualization, plants can expand or upgrade without adding new control system nodes or installing new copies of the operating system or application.

Virtualization improves diagnostic capabilities, allowing operators to monitor system performance and access the desktop of any node. Health and status information can be viewed from an integrated user interface. Remote management is also simplified because, unlike physical machines, a virtual system does not require a dedicated remote desktop and management functions.

Example: deploying new nodes based on existing templates. A project required an additional application control environment node and engineers sought a fast method of deploying the node using an existing template. Executing this task with virtualization involved entering basic installation parameters (*e.g.,* machine name and OS license key) into the node, which was then added to a virtualization resource pool. The work was completed in about an hour. In comparison, physical execution might have taken several weeks. The plant would have had to purchase a new machine and await its delivery, install the hardware, and set up the OS. Then engineers would have had to apply template-specific settings to the machine, load and patch the software, and add the node to the control system.

Example: deploying new nodes based on supplier-provided virtual appliances. A chemical plant needed to deploy a new application quickly. The application, which was available as a virtual appliance, was downloaded and placed into the resource pool in less than an hour. Physical execution would have required engineers to locate the necessary hardware, find space to mount the equipment in the rack room, and then load the base OS. They would have had to wait for software delivery, study the accompanying documentation, and complete the application installation. It is likely this process would have taken many weeks.

Improved availability, reliability, and disaster recovery. The virtualization environment monitors the status

An Old Concept Re-emerges

Virtualization was first used more than 30 years ago by IBM to logically partition mainframe computers into separate virtual machines. Partitioning allowed mainframes to multitask by running multiple applications and processes simultaneously. Since mainframes were expensive resources at the time, they were designed for partitioning to leverage the investment fully.

Microsoft Windows broke away from the centralized model during the 1980s and 1990s. Rather than sharing resources centrally, as in the mainframe model, organizations used the low cost of distributed systems to build islands of computing capacity. The broad adoption of Windows and the emergence of Linux as server operating systems in the 1990s established x86 servers – those based on Intel's CPU architecture — as the industry standard.

Today, the increasing underutilization of x86 machines is driving resurgence in virtualization:

- Some form of virtualization is used by all of the Fortune 1000 companies.
- 51% of *newly deployed* x86 server workloads were virtualized in 2010, and this is expected to rise to 69% by 2013.
- 13% of *all* x86 server workloads were virtualized in 2010; this is expected to increase to 22% by 2013.

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Specialty Chemicals Plant Goes Virtual

Honeywell Specialty Materials recently applied virtualization at its Geismar, LA, production plant. Located on the Mississippi River, approximately 60 miles west of New Orleans, this facility manufactures high-performance specialty chemicals and related materials.

Virtual computer systems were initially used at the Geismar site for offline testing and development. Then the plant's operator training system (OTS) was virtualized, using a platform virtualization hypervisor. Virtual images of each physical computer were created, transferred onto a virtual server, and started up in a virtual environment. Network security was achieved with a virtual firewall appliance, and security equivalent to that of the plant's process control network (PCN) was replicated inside the virtual environment.

Next, Geismar personnel upgraded the OTS to a newer software version. This effort involved creating or cloning the virtual machines needed for updated applications. Databases were then transferred over and the new system started up and debugged. Once the OTS was ready to go online, the training department was given access and the older virtual machines were shut down.

Within the virtualized OTS environment, the virtual server functions like a physical server — even the control strategies running in the virtual machines are identical to those on the plant floor. The virtual server mimics the inputs and outputs of the real system and allows the physical servers to interface with the simulation system as if they are communicating with the real plant (Figure 5).

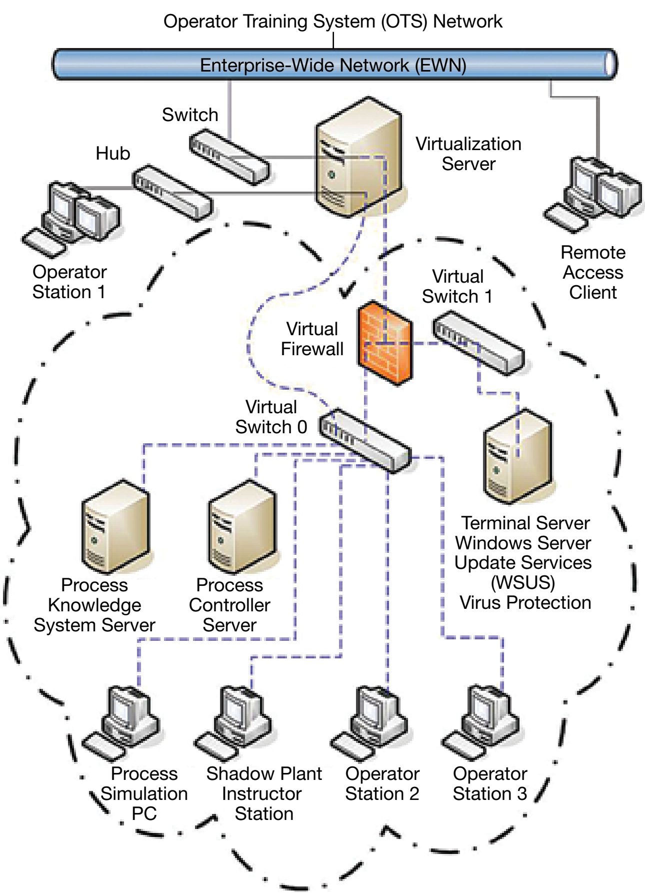
Based on the success of the OTS project, Honeywell Specialty Materials decided to use advanced process control (APC) applications to virtualize the online production systems. Engineers first downloaded a pre-built application server virtual appliance, which was then cloned to produce the required nodes. IP addresses were then renamed and changed, and added to the process control domain. APC software was installed. Downloading operator station software as a virtual appliance, creating a utility server virtual machine running the upgraded operating system and applications, and installing the asset management applications on this server completed the virtualization process. The virtual APC applications have been performing online control at the Geismar facility for more than a year with few problems.

of virtual machines and, if necessary, will restart a virtual machine on another host. It can also detect the failure of an entire host and restart its virtual machines on other hosts. Other technologies allow a virtual machine to be mirrored on two hosts, enabling a virtual machine to withstand a host upset without any impact on operations.

Some virtualization solutions enable facilities to simplify and automate the key elements of disaster recovery, including: setting up and testing disaster recovery plans; executing failover when a control center disaster occurs or as the event requires; and reverting to the primary control room. This makes it possible to provide faster, more reliable, and more affordable disaster recovery protection than previously possible.

Another feature, called snapshotting, captures the current state of a virtual machine like a photograph. All aspects of its operation — including disk, memory, and CPU state — are captured and can be recalled later. Snapshotting is often performed just before patches are about to be installed, so if there is an installation problem, the snapshot can be used to roll back the virtual machine to its earlier state.

Example: cloning virtual machines for process development. After virtualizing the control system infrastructure, a plant's staff was easily able to clone virtual machines for use in off-process development. Had physical execution been employed, the plant would have needed to acquire hardware identical to that used in operations, perform online backup, and transfer the new system to the off-process nodes — a procedure that would have taken many days. In addition, much more hardware would have been



▲ **Figure 5.** This operator training system allows operators to gain experience as if they were running actual operations.

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required to achieve the same result.

Example: using baseline snapshots when nodes are corrupted. When an operator corrupted a control room station node, production processes were instantly rolled back based on a snapshot of the baseline conditions. This problem, which could have taken hours to rectify with a physical approach, only required a system administrator to take a backup disk to the control room and restore the node.

Example: protecting an application lacking redundancy. A critical application did not have built-in redundancy. The virtualization supplier provided a solution for application failure detection, which allows the application to be restarted automatically on the same or different physical hardware. This provided a basic level of redundancy for the application.

Choosing a virtualization partner

Virtualization is a complex technology, and its implementation requires guidance from the solution provider. When you are ready to select a virtualization partner, asking these questions can help you choose wisely:

• Does the supplier have a dedicated, strategic approach to virtualization, including a roadmap for future products?

• Does the supplier have the ability to deliver a complete, ready-to-run virtualization solution consisting of all required components?

• Does the supplier provide installation/configuration and performance guidelines for supported nodes?

• Does the supplier have the ability to design, deliver, and maintain its virtualization solutions over the long term?

• Does the supplier have proven expertise in virtualizing process control systems?

You should also consider these important factors:

Turnkey infrastructure. A solution provider should be able to supply and support all components of a tested, turnkey virtual infrastructure and provide best practices and configuration guidance. The selected supplier should offer a full range of products for process, advanced control, and business domains — not just a compliance checklist. This way, you will have only one telephone number to call for solution support and can avoid disagreements between multiple suppliers.

Applications support. Evaluate a supplier's ability to support virtualization-ready applications across its portfolio. Supplying the virtual infrastructure for a chemical facility is pointless if there are no applications to run on it.

Virtualization capabilities. Virtualization can improve a chemical facility's IT performance and reliability by offering enhanced capabilities, such as hardware replacement without downtime, or new availability for previously nonredundant applications, as well as new solutions such as improved control-room disaster recovery. However, you can only take advantage of these capabilities if your chosen virtualization partner supports them.

Support services. Choose a technology supplier who is able to help you assess, design, implement, and manage a virtual infrastructure. A qualified supplier should provide comprehensive support for technical assistance, training, execution, and after-market services.

Getting started with virtualization

Virtualization is suitable for many companies, and is particularly well suited to a medium to large operation with many workstations and servers that can be consolidated. Smaller companies with fewer workstation and servers may not find the virtualization value proposition compelling.

A virtualized system can be implemented gradually. A facility can start small, gain confidence in virtualization technology and processes, and then expand. Common initial virtualization applications include:

Off-process development. Because these systems are, by their nature, noncritical, this is a good place to start applying virtualization while providing new levels of flexibility and resource utilization. Virtualization enables rapid setup and teardown of off-process tests, and easy configuration of multiple off-process labs on a single set of hardware. Users can perform upgrade testing while doing simultaneous engineering checkout.

Noncritical ancillary nodes. If this is supported by the vendor, industrial sites can begin to virtualize noncritical ancillary nodes, such as web access portals, active directory servers, and open process control (OPC) servers.

Business domain interface software. Virtualization is being widely adopted in the IT domain. Therefore, industrial control applications that interface with data centers are more exposed to this technology because the systems they connect to are already virtualized.

Final thoughts

Chemical processing facilities face significant challenges in maintaining IT infrastructure. By applying virtualization technology to open control systems, plants can improve server utilization rates, reduce disruptive operating system and hardware changes, simplify overall system management, and ensure the availability and reliability of critical assets. CEP

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