SOLUTION BRIEF

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Optimizing Operations with Virtualized Industrial PCs

Factories can save time and money, boost equipment utilization and reliability, and reduce their clean-room footprint by upgrading and virtualizing industrial PCs

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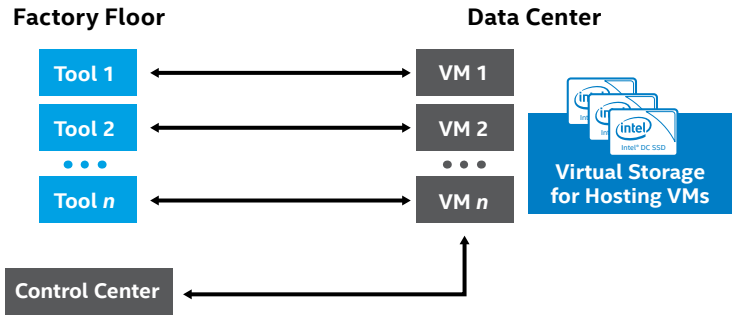
Introduction

Intel IT sought a factory solution to optimize operations and reduce costs in support of Intel's growth strategy. Over the past few years, we upgraded all the industrial PCs (IPCs) – clients located in front of every production tool in the clean room – to Intel® Core™ i7 processor-based machines. We also migrated to Microsoft Windows* 10, which enabled us to consolidate an increased workload at the edge. During the construction of a new factory, we developed and implemented a virtualized station controller[1] solution that added a new level of efficiency and enabled faster deployment. The solution combines servers equipped with Intel® CPUs, enterprise-level Intel® Solid State Drives (Intel® SSDs), virtualized storage, and virtualized servers that host all the IPCs we previously had next to each tool on the factory floor. These are now hosted from the factory data center.

Our solution enabled us to avoid the capital expenditure (CapEx) of purchasing many new PCs since each tool now has a dedicated virtual PC. We have also cut operating expenses (OpEx) by eliminating the labor cost of installing the physical PCs that in many cases is more expensive than the PCs themselves. We also freed up clean-room floor space by relocating PCs from the factory to an on-premises data center. Virtualization also consolidates operations and maintenance into one console for fast and easy fixes, helps reduce operating costs, and improves operational efficiencies. Employing a stretched cluster across multiple data centers enhances business continuity and reliability.

Relocating IPCs From The Factory Floor To An On-Premises Data Center



Acronyms

MTTR	mean time to repair
SAN	storage area network
VM	virtual machine
IPC	industrial PC

Business Challenge

The typical clean room in an Intel® factory features many production tools, with an industrial PC (IPC) placed near each tool for all industrial tasks. The IPCs typically communicate with the manufacturing equipment, the manufacturing execution system (MES), and other central systems. These dedicated (non-shared) IPCs run Windows* 10, powered by an Intel® Core™ i7 processor, and are equipped with a single direct-attached consumer-grade 256 GB Intel® Solid State Drive (Intel® SSD). This setup is relatively inexpensive and provides acceptable latency (generally less than 5 ms for 50 percent read/50 percent write I/O)[2]. However, IPC utilization is only 25 to 50 percent on average. The setup also lacks the specified capacity to accommodate spikes in demand, creating a possibility for failure that negatively impacts production tools.

While it may be typical, this setup is not ideal for the following reasons:

- Clean-room space is limited and PCs take up precious space and require millions of feet of Ethernet-to-PC cables.
- The labor, wiring, stainless steel holders, and other factors involved in physically installing PCs are expensive, costing more than the PCs and taking months to deploy to thousands of tools.
- If a PC malfunctions, a technician must perform a lengthy sanitization routine before gaining access to perform PC maintenance, driving up mean time to repair (MTTR).
- Business continuity/disaster recovery infrastructure is less than optimal.

Intel needed to increase operational efficiencies; free up clean-room floor space; more easily and quickly address PC maintenance issues to minimize downtime and impact on production; and protect our data while keeping information readily available. Virtualization using a traditional, centralized storage area network (SAN) was possible, but it tends to be very expensive and represents a single point of failure that could bring an entire factory to a halt.

Solution

During construction of a new factory data center, we solved all these challenges by virtualizing the IPCs on a stretched server cluster in an on-premises data center. We developed a virtualized station controller solution that enabled us to move the IPCs from the clean room to a centralized location, reducing the capital expenditure (CapEx). The solution uses virtual machines (VMs) hosted on servers powered by Intel® Xeon® processor E5-2600 family and enterprise-level Intel SSDs. The server clusters use a software-defined, virtualized storage solution.

Instead of distributing thousands of workstations (IPCs) across the factory's clean rooms, we now use a server cluster in the data center, where each server hosts multiple clients (see Figure 1). Each hardware component is fully redundant with at least one fault tolerance. Duplicate virtualization host servers are part of each single cluster but reside in different geographical locations. This model is invaluable for business continuity and disaster recovery in the event of service interruptions. Data is mirrored across two data centers, assuring minimal impact on a station controller in the case of a data center failure.

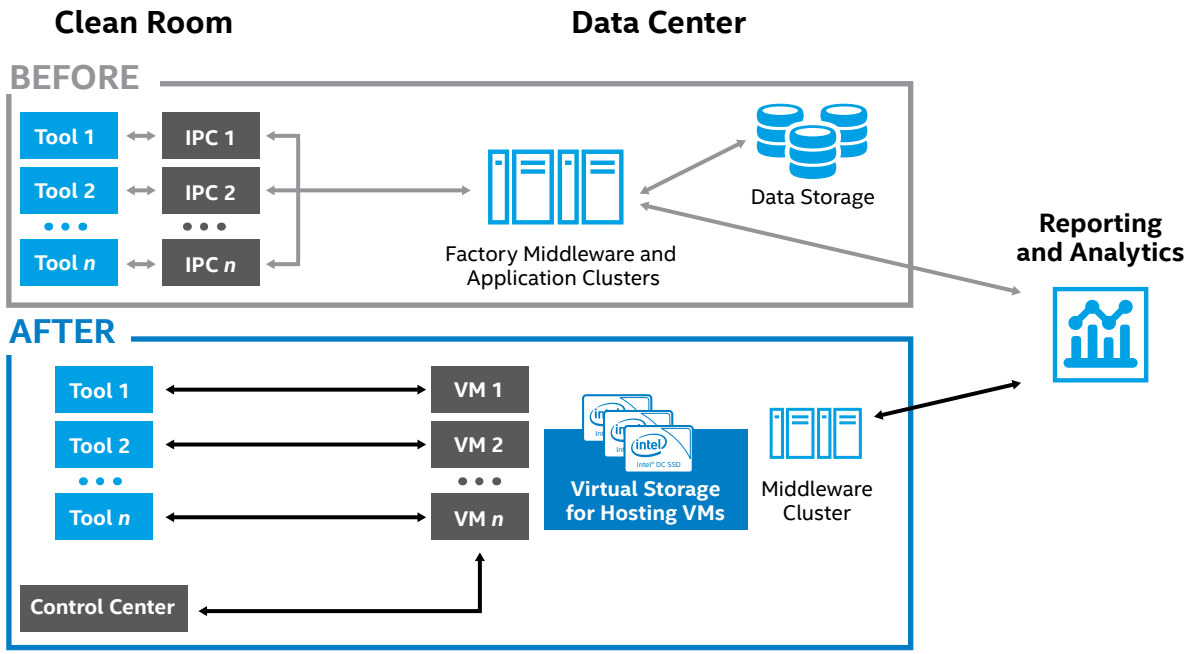


Figure 1. Relocating industrial PCs (IPCs) from the factory floor to an on-premises data center and using software-defined virtualized storage technology boosts efficiencies, increases reliability, and saves clean-room space.

Solution Components

- Virtualized IPCs in an on-premises data center on clusters powered by Intel® Xeon® E5-2600 processors and enterprise-level Intel® SSD DC S4600 Series[3]
- 10 GbE Ethernet
- Virtualized, software-defined storage solution
- Stretched cluster for business continuity

Our virtualized, software-defined solution offers several significant benefits:

- Our distributed, shared-nothing infrastructure helps eliminate a single point of failure; it also offers configurable redundancy and resiliency that increase failure tolerance at the disk, host, network, rack, server room, and site levels.
- We can define per-VM storage policies that are administrated by the virtual infrastructure administrator instead of requiring a separate SAN administrator.
- We can achieve nearly linear scale-up and scale-out as needs change.
- Our solution outperforms Tier-1 SAN for both I/O per second (IOPS) and I/O latency, and provides similar performance to direct-attached SATA SSDs.

Results

Our virtualized station controller solution created dramatic time savings and efficiencies (see Table 1). For us, the implementation produced the following benefits:

- **Makes production tools more available.** In our experience, upgrading IPCs to Intel Core i7 processors equipped with Intel SSDs and Windows 10 increased production tool availability compared with our previous system.
- **Factory starts up fast, enables fast repairs.** Virtualizing the IPCs provides fast factory startup and minimizes operational MTTR. A startup build of 1,000 stations typically is a two-year project, but the virtualized solution can be set up with four clicks and takes only a few hours.
- **Simplifies and streamlines maintenance with remote management.** Prior to virtualization, if a station was not functioning properly or was unavailable, a technician had to enter the clean room, troubleshoot, and fix the problem—a process that took four hours. In contrast, we can now use snapshots to fix problems on the virtualized clients within minutes.
- **Adds resources quickly.** Previously, adding compute resources like disk space, CPU, or memory typically involved significant downtime; technicians now can add virtual resources in seconds with two clicks.
- **Makes the most of the clean room.** The virtualized solution also optimizes the use of clean-room space, saving more than 1,000 square meters on the manufacturing floor (assuming 2,000 PCs), since the clients are virtually hosted in a small cabinet in the data center.
- **Reduces CapEx and OpEx to help achieve positive ROI.** By virtualizing the IPC station controllers in a greenfield factory installation, we avoided the initial physical PC costs and saved clean-room space. We also cut MTTR and installation time, increasing equipment availability.

Windows* 10: Enabling Innovation

Upgrading hardware and OS simultaneously brings multiple benefits

Aging industrial PCs (IPCs) running Microsoft Windows* XP become unreliable, plus Windows XP has reached end-of-support. Lack of security updates and technical support, combined with legacy hardware put production equipment controlled by these IPCs at risk. In addition, the old OS was having trouble meeting the increasing compute demand at the edge, impacting productivity, decreasing efficiency, and proving expensive to run. We knew something had to change to improve the reliability of these critical IPCs.

Over the last few years, we upgraded IPCs across Intel's factories, migrating them to Windows 10 and giving them more powerful processors. Windows 10 enables a continually-updated OS model, minimizes the disruption and downtime of major OS upgrades, and allows for smooth deployment of new OS features. Intel® Core™ i7 processors and Intel® Solid State Drives (Intel® SSDs) can handle more compute with less latency than our previous Windows XP-equipped PCs. The new hardware and OS are more reliable than the legacy PCs, which equates to more uptime for manufacturing equipment and therefore better factory productivity.

Table 1. Virtualized Station Controller Benefits

Item	Physical Station Controller	Visual Station Controller
Startup Build of 1,000 Stations	Two-year project	Four clicks, overnight
Break/Fix – Rebuild	Four-hour SLA	One minute (24,000 percent improvement)
Station Unavailable	Requires troubleshooting in the clean room	Allows for remote central management
Hardware Maintenance	May require significant downtime	Low impact, no downtime
Add Compute Resources: Disk Space/CPU/Memory	Involves downtime, hardware swap, computer rebuild	Requires two clicks to add virtual resources

Change management was a critical component during our implementation of the virtualized solution. Technicians are accustomed to having an IPC next to each production tool and were reluctant to give up the equipment and control. To resolve this, we provided sufficient command centers for issue resolution, provided remote access to the virtual station controller, and ensured that this did not add more work for technicians.

Conclusion

We realized dramatic efficiencies by adding the virtualized station controller solution, which saved clean-room space, helped ensure business continuity, streamlined system maintenance, and created a more efficient factory environment that will help position the company for future growth. Other production facilities can likely reap similar benefits by implementing a virtualized station controller solution using IPCs in an on-premises data center on clusters powered by Intel Xeon E5-2600 processors and enterprise-level Intel SSD DC S4600 Series instead of PCs next to each tool on the factory floor.

For more information on Intel IT best practices, visit intel.com/IT.

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[1] A station controller is a computing system to interface, integrate, and automate manufacturing operations, manufacturing equipment, and manufacturing execution systems (MES).

[2] Based on internal testing by Intel IT.

[3] Note that we are considering an upgrade to Intel® Xeon® Scalable processors for the next extension and may upgrade the SSDs to Intel® Optane™ SSD DC P4800X for hot-write cache tiering.

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