A **MICRON** CASE STUDY

All-Flash Virtualization for Global Manufacturing IT

Data is massive and complex. With Micron® memory and storage solutions, your IT infrastructure doesn't have to be.

Enterprise IT has enthusiastically adopted virtualized computing to create flexible and available compute, memory, network and storage resources. According to IDC's virtual machine forecast[1], "Virtualization is the foundation of the data center, with over 80% of workloads being virtualized today."

Micron Technology uses virtualization in IT to manage our semiconductor memory manufacturing systems. We also design, build and support core elements of the virtualization/hyperconverged infrastructure (HCI) ecosystem. Our fast flash storage and flexible memory solutions accelerate time to results for the leading hypervisor solutions.

This case study offers an insider view of virtualization, with perspectives from our flash product development teams and Micron's global IT group for manufacturing.

Micron's Flash vSAN Leadership

We helped create the future! Micron was the first company to accelerate VMware vSAN™ with an all-flash hardware configuration (demonstrated at VMworld® 2014).

Why Enterprises Choose Virtualized Computing

IT is constantly challenged to do more with less, and do it all faster. The ever-increasing avalanche of demand for data over-stresses traditional IT infrastructure whose complexity and siloed design does not scale well. Data center architects and IT managers realize:

- Business of all sizes, in all markets, can benefit from virtualization.
- Virtualization can benefit both desktop and server deployments.
- There are multiple ways to virtualize infrastructures.
- Traditional desktop infrastructures (one physical system per user) and server deployments (one application per server) are expensive to buy, deploy and support.
- Virtualized deployments scale more easily and can help match budgets to needs and deployment to demand.

1. https://www.redhat.com/cms/managed-files/ca-red-hat-virtualization-datacenters-hybrid-cloud-containers-idc-analyst-paper-f8188-201707-en.pdf

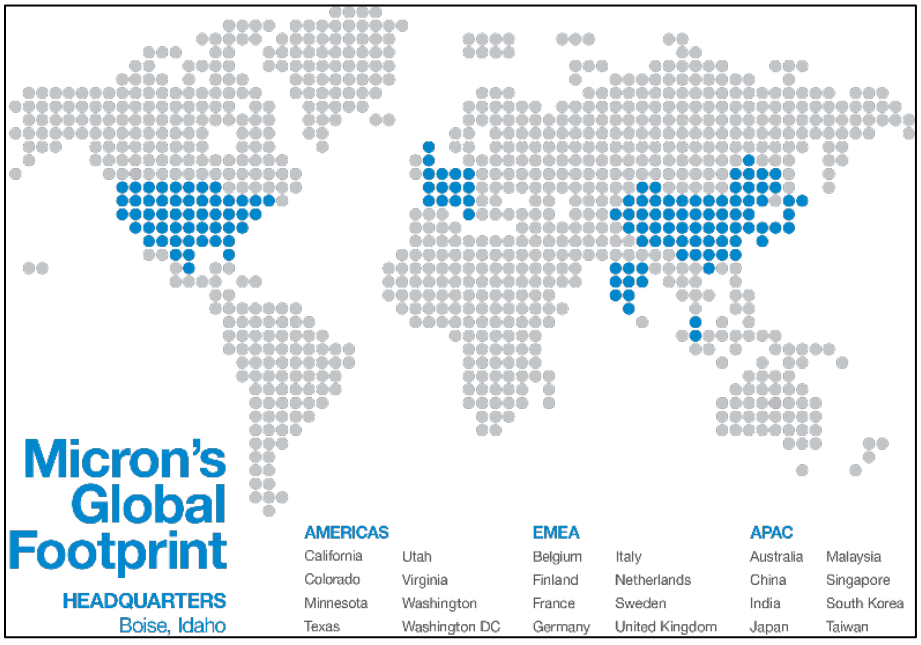
Managing Global Fabrication Facilities with Powerful IT Tools

Micron has 40+ years of experience in designing, manufacturing and supporting memory and semiconductor products. We are the third largest memory company in the world, and the only one based in the United States. We have facilities in more than 17 countries. And, as a sign of our continued innovation, we are in the top 10 list of worldwide patent holders, with more than 26,000 lifetime patents. Our products range from 3D NAND SSDs, to GDDR5X memory for graphics cards and other DRAM innovations, to persistent memory solutions like NVDIMM and 3D XPoint™, to multichip packages, advanced computing solutions and more.

Though Micron does not disclose production amounts or cleanroom space, Micron fabs are constantly busy, and the company is building more. For example, in 2018, Micron broke ground on a new fab in Singapore to be dedicated to manufacturing 3D NAND flash memory. This will be in addition to the two 300-mm 3D NAND facilities already in Singapore. While this is just one example, Micron's global footprint extends to 12 fabs worldwide.

Micron's Semiconductor Fabrication Facility, Boise, Idaho

This virtualized IT environment is how Micron accommodates the rigor, flexibility and extensibility for of our complex manufacturing processes. Running almost 19,000 virtual machines (VMs) on just 950 or so physical hosts places enormous demand on those platforms, so we load them with our own high-performance Micron SSDs and DRAM. In addition to "drinking our own champagne," we gain the benefits of reduced size and power needs compared to similar VM deployments that use HDDs.



- **12 manufacturing sites**
- **951 physical hosts**
- **1893 processors**
- **18,624 cores**
- **275+ TB memory**
- **~18,500 machines**

Micron IT has also moved beyond legacy storage area networks (SANs) which, according to Jason Bair, enterprise architect for Micron Compute and Storage, required "hundreds of legacy disk drives to get the throughput our applications demanded," along with large storage arrays and specialized SAN skills to manage the networks to which they are attached. Moving from complex, high-maintenance block-level storage to server-internal SSDs helped us build our software-defined data center (SDDC) approach. This gives Micron IT the flexibility to support virtually all types of workloads, freeing data administrators' time from configuration and maintenance work to spend on revenue-generating projects.

About 70 percent of Micron IT global applications are virtualized. Our hyper-converged infrastructure frees IT from having to create and support data centers in every Micron office. "The use of virtualization and specifically HCI combined with our SSDs allows Micron to bring the necessary resources into our smaller offices without bringing in the complexity of the various components of a data center to an office that may or may not have the resources or skillset to manage those components," says Bair. "Flash with HCI allows us to bring together compute and storage in a simple, high-performing operational model that can be easily managed and scaled when necessary. We see HCI as a critical piece to our further enablement of the hybrid cloud model and flash as a key enabler."

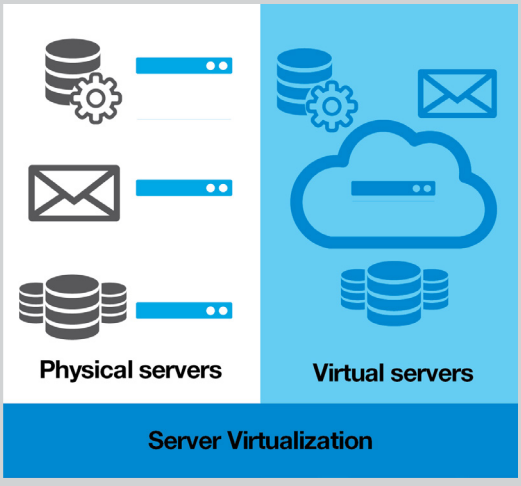
How Micron IT Builds and Consumes the Layers of Virtualization

1	Infrastructure as a Service (IaaS)	Cisco Unified Computing System™ data center platform, also HPE blade servers and HPE OneView infrastructure management
2	Deployment	Micron-developed portal plus scripts and elements of Microsoft® Operations Manager (MOM)
3	Operation	VMware vSphere® Storage vMotion® with VMware vSphere® High Availability enabled; deploy templates and cloning for more efficient operation
4	Monitoring & Reporting	Portfolio of VMware vCenter® applications, plus third-party tools for some monitoring (Veeam® ONE™, Splunk®)
5	Lifecycle & Remediation	Evaluating VMware vRealize® Automation™ for lifecycle management
6	Disaster Recovery	Backup policies and snapshots that leverage our virtualized infrastructure
7	Management Packs	Evaluating vRealize Operations Service Discovery Management Pack which builds a relationship or dependencies between services from different VMs, and other management tools

What is Virtualization?

Virtualization, or sharing physical hardware among multiple compute instances, brings several benefits to growing businesses: easy deployment and scale, matching budget to needs, simple configuration management, efficient use of rack space, and long-term value. At its core, virtualization is a transition from physical computers (desktops or servers) to software-based versions of physical computers (called virtual machines, or VMs). VMs are like their physical counterparts in many ways: VMs run operating systems and applications; they have processing power and memory specifications; they can connect to other computers (virtual or physical) using virtual networks and network adapters.

Functionally, VMs are like physical computers. Physically, they are very different. VMs don't have physical processors for their exclusive use; they share the processors of the platform on which they are running (their host, usually a physical server in the data center) and they share the host's memory. Their virtual network adapters also share the host's physical network adapters. These functions are managed by the software platform's hypervisor. Common hypervisors in the marketplace include VMware®, Microsoft Hyper-V® and Red Hat™ Kernel-based Virtual Machine (KVM).



Virtualization for Enterprises

Migrating from a physical infrastructure (1 physical computer per user/1 physical server per application) brings tremendous benefits to a growing enterprise. When IT needs to support new users or new application servers, virtualization brings real value. Micron IT, like many enterprise IT groups, could run the risk of creating and managing excessive platform configurations. For example, offering different physical configurations to match system capability to each staff member's primary duties can lead to excessive management overhead. Precise matches between desktop computer configurations and the daily needs of staff can be difficult (plus, the stocked configurations may be too powerful to be economical, or not powerful enough to be fully productive).

VM Configuration and Management is a Breeze

Virtual **desktop** configurations, consisting of a processor, memory configurations, storage space, type and location, networking and a host of other configuration options, are set up in a software management console. Since the desktops are virtual, there are no configurations to manage, no specifications to align.

Virtual **server** configurations are very similar. Traditional server deployments run one application on one physical server. Virtual server deployments run one application on one virtual server. A group of virtual servers shares the hardware resources of a physical server. And all these VMs—desktops and servers—can be managed through a unified console or dashboard, often called a single pane of glass.

Easy VM Deployment Enables Fast Scaling

In addition to the ease of VM management, we can deploy VMs simply through the management interface in the hypervisor software. Physical systems (desktops or servers), in comparison, must be budgeted, ordered, delivered, unpacked, installed, loaded, configured and connected.

As the number of user (or application servers) grows, the advantages of sharing host hardware across multiple VMs multiplies. For example, as in the figure to the right, suppose we are hiring 120 new call center employees. If we used conventional desktops, we would need a physical desktop computer (budgeted, purchased, delivered, loaded and installed) for each new employee on their first day. If a supplier misses a shipment, if a system arrives defective or if we have other delays, we could have users on-hand and unproductive until the problem is remedied. But with a virtual desktop infrastructure (VDI), we would simply set up a new VM for each new user via our management console. A few clicks and we're done. Scaling up requires less time and overhead.

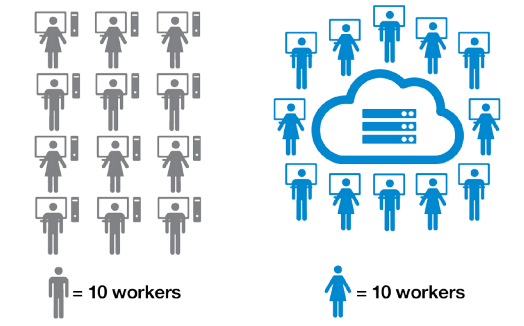
Avoiding Over- and Under-Budgeting

Virtualizing IT infrastructure enables server consolidation, which reduces the costs of project set-up. A TCO analysis white paper by VMware shows an average 70% savings on hardware and software with virtualization. When budgeting to support the set up and build out of an entirely new business unit or project, data architects often run a risk of over-budgeting (buying and deploying more resources than we need) or under-budgeting (the opposite). If we over-budget, we risk wasting capital; if we under-budget, we risk having our resources misaligned with our actual hiring.

Packing More in Less Space to Improve Resource Use

Because application server VMs share physical hardware, we can pack more application servers in less data center rack space. When we need to run 10 server applications (such as a clustered database, a clustered e-mail application, analytics and others), we can run each as a VM on shared hardware instead of running each on its own hardware. This improves resource use and helps drive better results from less hardware. A conventional deployment might require 10 physical servers. If we virtualize, it would require fewer.

The benefits are expanded by choosing fast, flash storage. Micron's IT groups use our own products for storage and memory, giving us the improved total cost of ownership (TCO) of SSDs over HDDs: smaller footprint, less power usage, less cooling required.



Example Desktop Virtualization

Virtualization and HCI on All-Flash Platforms

If your IT team is challenged by new deployments and new growth, and they must handle these with fewer resources (doing more with less), all-flash virtualization can help manage the ever-increasing data avalanche. Growth demands can over-stress traditional IT infrastructure and staff, and as with Micron, growth is ever escalating.

Tightly Integrated, All-Flash Virtualization Multiplies Benefits

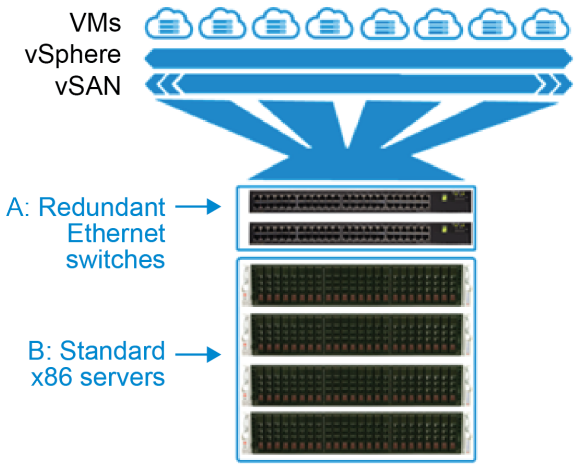
A traditional infrastructure can be complex. It is built on silos from different products, and product lines from different vendors, each of which may have their own warranties, support polices and maintenance contracts. Legacy hypervisor virtualization software runs on a siloed infrastructure built on standard servers (conventional, blade or both). The hypervisor runs on the servers and accesses long-term (capacity focused) rotational storage and all flash arrays (for acceleration), which are all connected using multiple network switches (Ethernet, Fibre Channel or possibly both) with backup/disaster recovery support (through an appliance, software or other means).

The hypervisor isn't integrated in these legacy designs. It's added on. Loose coupling can bring its own challenges, such as non-uniform management and limited cross-platform visibility. Also, long data paths may slow the performance of VMs.

All-Flash Hyper-Converged Infrastructure: Compact, Simple, Fast

VMware's vSAN with SSDs (an all-flash vSAN configuration denoted with an AF prefix as detailed in VMware's hardware guidance) is a good example of tight integration of fast storage, highly capable, standard servers and massive network bandwidth with a virtualization platform on which you can build. All-flash vSAN uses SSDs in the cache tier and capacity tier inside the servers on which VMs run. These are interconnected with high-bandwidth, low-latency fabrics.

The following figure shows an example all-flash, 4-node vSAN cluster.



Hyper-Converged All-Flash Infrastructure

This tightly coupled all-flash platform provides several advantages for virtualized computing:

- **Flash storage inside the servers**: There are no external flash arrays connected through their own network. SSDs inside the servers means vSAN provides ultra-short VM-to-data paths resulting in lightning-quick IO.
- **Uniform management**: A single pane of glass within the VMware vCenter console manages all vSAN's essential functions. Policy-based management makes this simple.
- **Cross-platform visibility**: Because vSAN is managed from within vCenter, you can have end-to-end visibility into storage including snapshots and replication. Plus, there's no VM-to-array mapping, also making it easier to see what is happening in your VMs from a single management console.
- **Short VM-to-data paths**: A single storage IO from a VM in an all-flash vSAN can execute on the VM host, or a host via high-bandwidth, low-latency fabrics.

One key benefit of a virtualized environment is that it makes converged IT possible—the amalgamation of compute, storage and networking into a single, software-defined infrastructure that is revolutionizing the industry.

"Take the time to evaluate which model (appliance versus ready-node versus roll-your-own) your organization will pursue and which makes the most sense for the capabilities of your organization," advises Bair. "As an architect, I will always be a vocal advocate, taking the time to understand the challenges and specific use-case, create the reference architecture and standards, and ensure they are agreed upon and published for all operational teams before implementation."

What's Next in Data Center Technology

We asked Jason Bair: **Data center technology is always evolving—new techniques, new media. What do you see coming down the pike, and why?**

"Two words come immediately to mind: simplicity and speed. There's a push in the data center to simplify the operational models of the past while still delivering more features and functionality. We see from the industry a focus on faster software development practices that have significantly decreased the release cadence of software versions. What was once a 12- to 18-month release cycle, has now become a quarterly one. The data center must be able to adapt to that speed. That means changing technologies and operational models to meet the speed the business requires.

I think we're seeing an incredible explosion of focus on artificial intelligence and machine learning. Having systems that can proactively monitor an environment and alert when that system operates outside its typical historical patterns—or can perform predictive maintenance to diagnose potential problems before they become catastrophic—is now a reality."

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Learn more at
www.micron.com/virtualization

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