

Qualcomm: Standardizing on Virtualization



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Section 1: Introduction / Customer Summary

For Qualcomm, the well-known wireless telecommunications research and development company, virtualization started as an experiment. The experiment in consolidating physical server computers proved successful, and the Qualcomm IT department aggressively pursued virtualization starting in 2003. VMware® Infrastructure offered extraordinarily good return on investment almost immediately.

The Qualcomm IT department offers its internal customers virtual machines in a pre-determined lowest-common-denominator configuration for free. This no-cost approach, along with rapid provisioning, won many early converts. Others endorsed virtualization after intensive training and IT staffers' constant efforts to meet and educate anyone posing concerns or challenges. Regularly scheduled meetings address virtualization status, strategy and capacity planning.

In the past four years, instances of Windows operating systems at Qualcomm have grown dramatically (more than tripling in that time), while the number of physical Windows machines has actually dropped. Furthermore, the number of administrators required to run those machines has increased only marginally. Thus, Qualcomm has been able to use virtualization to cut its administrative burden, particularly through faster provisioning of servers and a reduced workload in balancing servers.

Qualcomm has implemented virtual infrastructure as core part of their IT architecture, focusing on automating manual IT processes and further reducing IT operating costs. For example, decommissioning unused virtual machines has further reduced infrastructure cost and led to the reclaiming of more than \$1 million worth of capacity. Other efforts have automated many tasks, such as provisioning and decommissioning virtual machines. In addition to automation and cost reduction, performance is becoming a priority for Qualcomm. A new initiative seeks to roll out a set of high-performance virtual machines that can handle heavier workloads. The performance requirements mean that such machines may not achieve many of the consolidation benefits that first excited Qualcomm executives. But virtualization has yielded so many other benefits—such as mobility and agility to recover from hardware failures—that Qualcomm plans to continue expanding its implementation of VMware virtualization products.

Section 2: Challenge / Business Requirements

Qualcomm develops innovative digital wireless communications products and services. Its patent portfolio includes approximately 6,200 United States patents and patent applications for Code Division Multiple Access (CDMA) and related wireless technologies, which are licensed to more than 140 companies worldwide. Headquartered in San Diego, California, Qualcomm is included in the S&P 500 Index and is a 2007 Fortune 500 company. It has garnered awards including listings in *Fortune's* "Most Admired Companies" and "100 Best Companies to Work for in America," as well as *CIO Magazine's* top 100 list for operational and strategic excellence.

In March 2003, Qualcomm began embarking on a virtualization journey. "We were testing, just playing around with the software," recalls David Hewett, senior IT manager at Qualcomm. At the time, much of the Qualcomm IT budget was spent on physical server computers at the San Diego headquarters and dozens of global sites. Demand for IT resources was high.

The company had 450 physical servers, a number that was growing at the rate of 40 percent annually. Hewett and IT Lead Engineer Paul Poppleton started investigating whether VMware Infrastructure could help consolidate servers.

"Almost before we knew it, we had mushroomed into a production environment," says Hewett. "I don't think we really realized that virtualization was going to take off quite as quickly and extensively as it did." In addition to the benefits of server consolidation, Qualcomm's efforts brought growing insight into how to use virtualization to optimize IT management processes and increase the reliability and availability of the environment.

Section 3: Solution Evaluations

In 2003, the Qualcomm IT team also considered blade servers as a way to lower costs. “Blade servers were interesting,” says Poppleton, “but we needed a greater reduction in power and space requirements than blade servers could provide at the time.”

So Qualcomm started evaluating a single instance of VMware ESX Server. Poppleton and Hewett found that several internal administrative tools worked in the virtual machines just as they had natively on a server. Migrating a couple of production servers went well, and soon additional requests filled that first ESX Server host to capacity. From the beginning of that evaluation, the Qualcomm team was impressed with the robustness and reliability of ESX Server, which prompted the decision to move quickly into production. “We had very few problems,” recalls Poppleton. “Our IT team and test users were so impressed with this initial test that we felt comfortable aggressively moving forward with the consolidation of aging production servers.”

1. Overcoming the “server hugger” mentality

Not everyone at Qualcomm rushed to embrace the new technology, however. Hewett recalls hearing hallway conversations along the lines of: “That virtualization stuff won’t work.” Even some entire departments made formal objections: “We’re not going to use virtualization because we need the horsepower, so we have to have physical machines.”

Hewett, Poppleton, and their team worked hard to address every such challenge. “We’d take our show on the road,” Poppleton says. “We’d crash department meetings, giving presentations on why it was a good technology and why we were so confident in it.”

Hewett agrees: “We had endless formal and informal presentations of the technology. Some of them were pretty stressful—out-and-out attacks on the technology that we would have to defend. And I think we were successful every time.”

From the beginning of that evaluation, the Qualcomm team was impressed with the robustness and reliability of ESX Server, which prompted the decision to move quickly into production.

“People weren’t really aware of how the technology worked,” Poppleton says, “or how we were using it here, or the options they had. We needed to change some people’s perception of the technology through education.”

The higher levels of management, however, were more impressed by the ROI and TCO statistics. “It’s a very fast return on investment,” Hewett says. “You get a return on the second virtual machine you provision on a piece of hardware—because you’ve gone from a 1:1 to a 2:1 ratio. A physical device costs more than an ESX Server license, so at a very simple level, any virtual machine after the second one is pure ROI!”

Poppleton uses a simplified cost example to demonstrate: a new physical server can cost approximately \$7,000 for the equipment and labor to install it. The consolidated approach costs \$1,250 per server, representing a savings of \$5,750. “The bottom line is that we saved a lot of money, on the order of thousands of dollars per server,” Poppleton concludes.

Hewett agrees. “Showing those results to senior management makes for a pretty easy sell.”

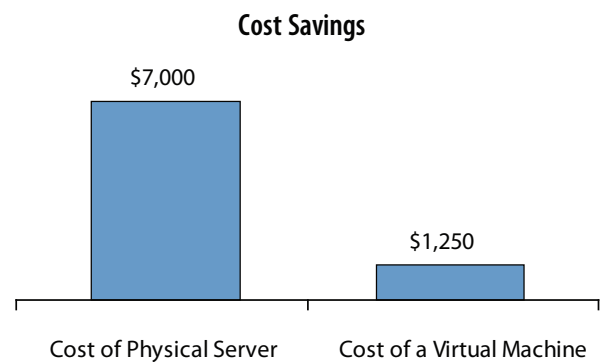


Figure 1

A new physical server can cost approximately \$7,000 for the equipment and labor to install it. The consolidated approach costs \$1,250 per server, representing a savings of \$5,750. “The bottom line is that we saved a lot of money, on the order of thousands of dollars per server,” Poppleton concludes.

Section 4: Deployment

Deployment grew steadily over the years. Qualcomm developed a rollout plan that started with the oldest and least critical servers, then marched through more critical servers, including Web servers, database servers and other application servers. As of August 2007, as Figure 2 shows, in the three major data centers Qualcomm has satisfied the net growth of Windows application servers through the use of virtualization. Worldwide, 43 sites such as regional sales centers as well as the major data centers shown in figure 2, the company has 271 ESX Server instances, with over 2,000 active virtual machines.

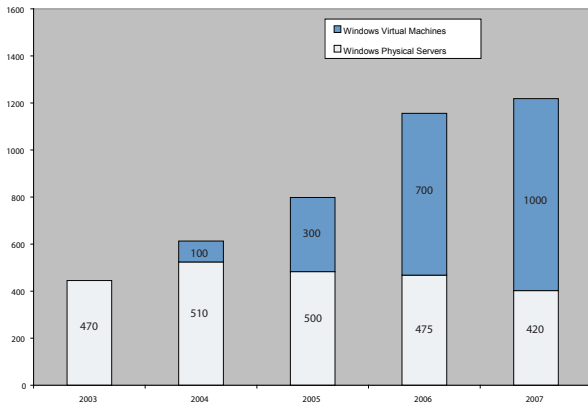
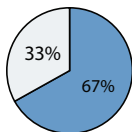


Figure 2

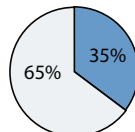
Virtual machines have replaced physical servers to the point where now 67 percent of Microsoft Windows workloads (the focus of this case paper) run on VMware Infrastructure. Guest operating systems include Microsoft Windows 2000, Windows 2003, Windows XP, Red Hat Enterprise Linux, and SuSE Linux 9. Applications running in virtual machines include Microsoft Active Directory, Citrix, SMS, file and print servers, web servers, disaster recovery, and others.

Percentage Virtualized

Microsoft Applications on VMware Infrastructure 3



Linux Applications on VMware Infrastructure 3



■ Virtualized □ Not Virtualized

Figure 3

We came to recognize that virtual infrastructure gave us the power to introduce automation in many IT processes that we previously performed manually.

In 2003, Qualcomm had started with deployment of VMware ESX Server 1.2. Starting in February 2004, the company implemented VMware VirtualCenter to control its data center computing resources from a centralized point. At the same time, the company deployed VMware VMotion™ which provides live, zero-downtime migration of live virtual machines from one physical server to another. “We’ve utilized VMotion extremely heavily,” says Brian Weck, virtual infrastructure operations lead. “It offers so many benefits: being able to deal with downtimes, being able to do maintenance on the hardware supporting ESX Server hosts, and being able to balance resources. VMotion is a must-have capability for anyone seriously thinking of deploying virtual infrastructure.”

On 50 percent of its machines, Qualcomm has now upgraded to VMware Infrastructure 3. In these implementations, the company uses VMware Distributed Resource Scheduler (DRS) to dynamically allocate resources among virtual machines.

At first, the virtualization software ran on HP ProLiant DL760 eight-way servers; then, Qualcomm moved to DL580s, then BL25p blades; and now the company uses BL460cs. For almost two years now, Qualcomm has been using dual-core blade servers, and has recently started moving into quad-core blades. Hewett says, “We’ve gone from eight-way to four-way to two-way, and the cost of the virtual machine actually halved.” The cost savings has resulted from decreasing hardware costs, the agility of the smaller, multi-core servers, and improved licensing efficiency.

During phase II of their server consolidation effort, Qualcomm used the VMware Capacity Planner to help assess 176 physical servers and plan their migration to virtual machines. The tool worked successfully enough that Qualcomm is planning to use it again soon in a different data center.

Despite their planning efforts, however, the Qualcomm team found that they had considerably underestimated the demand for virtual machines. “We kept getting to a point where we were almost running out of capacity,” Hewett says. “We wanted to stay ahead of that demand.” To help accomplish that end, they set up a biweekly capacity planning meeting—one of three regular meetings that proved valuable for Qualcomm as it moved forward in its virtualization effort.

With Tier 1 machines handling some of the larger workloads, Qualcomm expects to increase from the current level—67 percent of enterprise Windows Servers virtualized—up to 80 percent within three years.

Section 5: Virtual Infrastructure Operations

VMware Infrastructure at Qualcomm is now supported by a dedicated Virtual Infrastructure team that was originally integrated with the Windows server group. The company has established a methodology where system administrators at local and remote sites can manage day-to-day virtual infrastructure operations while adhering to company-wide standards to ensure quality of service. Current practices include an Operating Level Agreement (OLA) between the central Virtual Infrastructure group and the different sites to establish access control privileges and standard configurations. Qualcomm encourages the administrators at remote sites to take responsibility for their operations by signing the OLA.

In order to ensure smooth virtual infrastructure operations, Qualcomm has established three types of regular meetings:

- Virtual infrastructure capacity planning meetings are biweekly, and focused solely on capacity.
- Status meetings are biweekly, with a tactical orientation and a large audience that includes anyone who helps with virtual machines.
- Strategy meetings are monthly, with a smaller core group of attendees. These meetings address strategic questions such as whether to switch to blade servers or how to handle future ESX Server releases.

Virtualization Operations Planning Meeting	Audience	Frequency
Capacity Planning Meetings	Capacity Planners	bi-weekly
Status Meetings	All VM Users, providers	bi-weekly
Strategy Meetings	Core Technology Group	monthly

Figure 4

I. Training staff

Qualcomm has recognized staff training as an important success criterion. “We did heavy training early on in our implementation,” says Hewett. Qualcomm retrained some of the Windows server team, in part to demonstrate its commitment to VMware as a key component of the IT infrastructure.

However, Qualcomm went one step further in training. Hewett says, “For a lot of the system administrators who might provision servers for applications but don’t necessarily administer the virtualization infrastructure—we put them through VMware training anyway. We knew they would embrace the technology more after they had taken the training. They might go in skeptics, but they would leave evangelists.” Qualcomm now has 15 VCPs (VMware certified professionals); the company has had four onsite classes with one more planned, for a cumulative enrollment of 60 to 70 people.

II. Setting a \$0 chargeback model

From day one, the Qualcomm IT Department has had a \$0 charge-back model for the VMs they provision. “Looking back, we think that certainly was a critical decision,” Hewett says. “It’s like giving out free candy. We would tell people, ‘We can get you a physical server provision, and it’ll be ready for you in six to eight weeks and cost you, say, \$10,000—or we can give you a free virtual machine tomorrow.’ No cost and rapid provisioning made it an easy choice for users.” This strategy was one of the key factors that led to such widespread acceptance of virtualization at Qualcomm.

III. Eliminating over-provisioning with standard “bare-bones” configurations

One of the most exciting capabilities of virtual infrastructure is the ability to dynamically adjust resources to demand, in a way that’s simply not possible in the physical world. Since the capacity of a physical server is fixed, business owners tended to request extremely powerful machines to handle temporary spikes in demand. As a result, physical servers typically ran tremendously underutilized most of the time.

Qualcomm eliminated such wasteful over-provisioning by providing virtual machines in a standardized, bare-bones configuration. Hewett says, “We decided we would give out virtual machines with a standardized, lowest-common-denominator resource configuration and then increase the resources if we had to.” He would not succumb to a request for, say, 2GB of RAM because that’s what had been on a physical machine.

VMotion is a must-have capability for anyone seriously thinking of deploying virtual infrastructure.

"Obviously, if you give someone 2GB of RAM, it's very difficult to later say, 'Look, you're not using it, we want it back.' It's much easier to find out if they do need more and give it to them. But what we have actually found, though, is that it's pretty rare that we have to increase resources. The lowest common denominator works pretty well. In fact, if anything, we've reduced the lowest-common-denominator configuration, rather than increasing it."

IV. Decommissioning virtual machines

In the middle of 2004, Qualcomm realized that the success of virtual infrastructure threatened to substitute physical server sprawl with virtual machine sprawl. So Hewett and colleagues set out to decommission virtual machines. "We started asking administrators whether or not they were still using their virtual machines," Hewett says. "If they were, fine. But if they weren't, they needed to let us know so we could decommission those machines."

It took a major shift in people's thinking. In most environments, once your department finally gets a physical server, you hold onto it tightly. But virtualization allows Qualcomm to turn that traditional view on its head. "We can give people as many virtual machines as they like forever—as long as they give us back virtual machines that they're not using," says Weck. "They need to give up on the idea that a machine is theirs and, instead, realize that all machines are simply applications running on resources. If you don't need a resource any more, give it back to us so we can re-purpose it for somebody else. The more that you do that, the more we can deploy."

The model "is working fantastically well," says Hewett. The results are dramatically apparent in Figure 5, where the line showing the number of decommissioned virtual machines, starting at zero in early 2004, now climbs at the same rate as the line showing virtual machines deployed. "In our major data centers, we've now decommissioned more machines than we have running," says Hewett. "That represents a huge cost savings in capacity. If we had not had a good way of governing when a virtual machine was no longer being used, we probably would

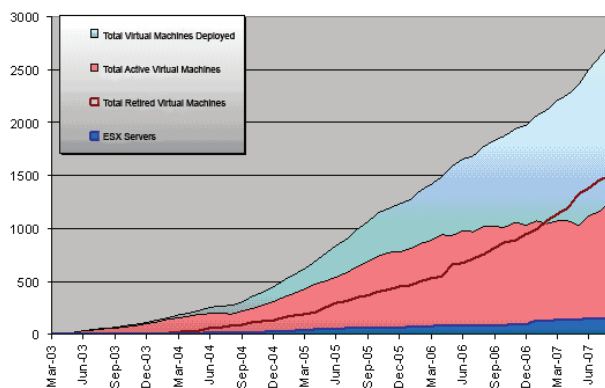


Figure 5

now have more than 1,000 extra virtual machines running. That's more than \$1 million worth of virtual machine capacity just sitting there, used up for no good reason."

V. Improving IT management efficiency with automation

"We came to recognize that virtual infrastructure gave us the power to introduce automation in many IT processes that we previously performed manually," says Hewett. Apart from the compelling cost savings, the ability to optimize IT processes is the single biggest driver of the continued expansion of virtual infrastructure. For example, the company's Web-based resource request function now interfaces with a provisioning tool that automatically provisions virtual machines on the same day they are requested. The rapid, automated response contrasts sharply with the provisioning time for physical servers, which had been as long as eight weeks.

To help with virtual infrastructure monitoring, automation and provisioning, Qualcomm uses VMware Service Orchestrator (VSO). They intend to use the tool to automate as many processes as possible. For example the team has started to automate the process of decommissioning virtual machines. "It will be a flow," says Hewett, "evoked based on a predetermined expected lifespan of the machine, which asks, 'Are you still using this virtual machine? If no, 'click here' to start an automatic process for decommissioning (with a few 'Are you sure?'s built in). That will make this process much more efficient than the current manual one and add to our vision of 'self-serve servers'."

Automation continues to be a high priority. "What we want to be doing," says Hewett, "is not only auto-provisioning virtual machines, but actually giving out pre-approved batches of virtual machines to application owners. Then they can provision their own virtual machines up to that pre-approved limit and continually commission and decommission. That would give them ultimate control over turnaround time and allow us to focus on just-in-time provisioning of hardware ahead of that demand."

VI. Increasing reliability and availability

Another key benefit of virtual infrastructure is the increased stability of virtual machines compared to purely a physical environment. "When we moved some Windows NT 4.0 machines from a physical machine to a virtual machine, they actually became more stable," says Hewett. "We had some crash-dump analyses showing that the failures were almost exclusively caused by hardware and driver issues, and the virtual machines had fewer failures. So we were able to show people that by moving to a virtual machine they would enjoy not only better performance but more stability as well."

"It was actually something of a double-edged sword," adds Poppleton. "It was nice because the systems weren't crashing anymore, but that made it harder for us to get rid of those old boxes once they were stabilized and running." But in general the analyses—as well as some investigations into specific issues—helped counteract the potential finger-pointing that frequently accompanies new technology. In any environment, cynics traditionally enjoyed immediately blaming any problem on "the network"—now "the virtual machine" is becoming cynics' default scapegoat. "But honestly," Hewett says, "when we helped them inspect what's going on, it was rarely the virtual machine. Sometimes it was, and we helped tune it to an acceptable level, but that was rare." Now, four years into virtualization, such claims have largely ceased.

VII. Standardizing on Virtualization

Qualcomm has evolved into a "virtual-machine-first" company—virtualization is the default policy for new Windows application servers. Hewett says, "In my position I'm responsible for approving both physical Windows Servers and virtual Windows Servers, so from my perspective I always wanted to see an attempt to use virtual machines first." Again, massive early training helped. Hewett altered the Qualcomm resource request function so that users could no longer request a certain type of physical machine (such as an HP ProLiant DL380), but instead a set of resources (such as CPU, RAM, and disk space). The request function can then determine whether a virtual machine can meet those needs.

Section 6: Impact of Virtualization

By far the biggest impact during the years of virtualization at Qualcomm has been the huge cost savings. "This is a very fast ROI solution," says Hewett. "In fact, when we first started showing our CIO and other senior IT management how much we were saving through virtualization, the ROI was so good on hardware alone that we didn't need to show additional savings. At some point we were asked to show data center operating cost savings as well, so we asked the data center guys, 'If we hadn't virtualized these 1,000 servers, what would that have cost you?' And they pretty much told us they would have had to build a new data center." Hewett now figures the data center savings represent 150 percent of the hardware savings (in other words, for every \$100 of hardware savings, there's an additional \$150 of data center savings, resulting in total savings of \$250).

The savings were so dramatic that the team used to joke that if they put a bunch of fake servers in a machine room and hire people to sit behind them with flashing lights. "It would still be cheaper than it would to provision the hardware," Hewett chuckles.

In addition to the hardware and data center savings, Figure 2 on page 5 presents another dramatic category: IT management efficiency. Hewett explains the graph as follows: "Over the last four years, while instances of Windows operating systems have gone up in a straight line—very steep upward growth—the physical Windows machines not only have stayed flat, they've actually gone down over time, to where we now have fewer than we did in 2003. So in the aggregate, that growth has entirely been satisfied by virtualization.

"But here's the most important statistic of all," he continues, discussing Figure 6. "In March 2003, we had six people supporting those 445 Windows machines—fairly close to the industry standard of 75 servers to one admin. In August 2007, we have 7 heads—a server-to-admin ratio of about 240:1. All the growth in workloads has been supported by roughly the same number of administrators we had four years ago." Virtual infrastructure has given Qualcomm the power to increase IT management efficiency at a pace equal with—and continuing to rise with—the threefold growth in workloads.

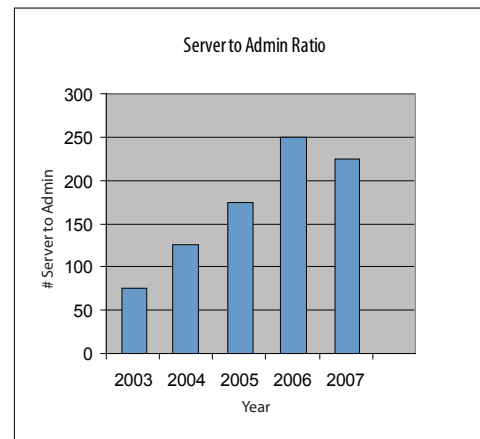


Figure 6

A major contributor to the administrative savings is faster provisioning of virtual machines. Qualcomm like many companies, had a fairly lengthy process for purchasing physical servers: getting a quote on the exact hardware, getting that number budgeted, going through a procurement process, receiving and unboxing the physical server, and then laying an image down on it and making the appropriate networking connections. Now, says Brendan McAuliffe, Windows Server group manager, "One of the huge advantages is that most of those steps are eliminated. All we do is copy one of the other servers and reissue it with a new name."

Additional timesavings has come from the resource adjustments automatically provided by VMware DRS. “We just have it set in automatic mode, right in the middle at three stars, and it takes care of everything for us,” Weck says. “It would have taken at least an hour of my time, every day, to go in and figure out how to do that tuning correctly.”

Departments have especially appreciated the shorter provisioning time and ease of creating new environments. The IT department frequently hands out virtual machines for testing, so users can see whether an operating system upgrade would affect existing applications, or how an application installs, or to test an application for a week before deciding to purchase. In the past many such requests had to be rejected because the lengthy process of provisioning a physical box wasn’t worthwhile for test servers.

But as users have enjoyed such benefits—and as skeptics’ fears have been allayed—pressure now, instead, has come from senior management. “We’ve consolidated pretty well,” says Hewett. “We’ve gotten the low-hanging fruit. But it’s been close to five years since we’ve started, and people have forgotten how much we used to spend on physical servers. Now the virtualization budget line gets more attention.”

Section 7: Looking to the Future

Qualcomm intends to continue rolling out VMware Infrastructure 3 throughout its environment. It has started a subscription to the new VMware Business Critical Support service, and is quite pleased with the early returns. Additionally, the company is about to bring out its first software development and testing infrastructure streamlined on VMware Lab Manager. And it is working on a “thin desktop” project, which will incorporate VMware Virtual Desktop Infrastructure (VDI).

Qualcomm has had VMware High Availability (HA) running for some time and plans to investigate using it to replace traditional operating system clustering. “We hope to be able to move some customers off of their existing clustering,” says Weck, “and just have them use the availability of the ESX Server hosts and the clusters.”

This will reduce costs and complexity of managing these traditional clusters. McAuliffe says, “If you’re doing one active-and one passive-node cluster, you’re doubling the cost of all the hardware.” Furthermore, he adds, it should actually increase uptime. “We’ve had examples of clustering solutions themselves causing some downtime,” he says. “Maybe you have to bring down the boxes for an upgrade, or the software doesn’t perform a failover correctly. It’s difficult to explain to someone that the HA part of their HA solution has caused an HA problem—and that’s the sort of issue we’d like to get away from. The current

clustering solutions we have are quite complex and require a significant level of expertise to operate; these are all hidden costs.”

Finally, Qualcomm is also working on hosting high-performance virtual machines. “There are so many benefits to virtualization beyond consolidation,” says Hewett. “As I mentioned earlier, we’ve captured the low-hanging fruit of consolidation. But we can also gain benefits from mobility and recovering from hardware failures. So we’re going to roll out a new tier of virtual machines with much lower ratios—say 4:1, four guests to one host. We’re calling these Tier 1 machines, and we’re going after larger servers, giving them more resources but taking advantage of those additional benefits of the virtualization layer.”

With Tier 1 machines handling some of the larger workloads, Qualcomm expects to increase from the current level—67 percent of enterprise Windows Servers virtualized—up to 80 percent within three years. The effort exemplifies Qualcomm’s second-generation journey to reap additional benefits from virtualization. “There have been so many positive surprises with virtualization,” says Poppleton, “that people here have come to expect them, and to request our new enhancements. So we’re enjoying the second phase, because everything has been so positive.”



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