SAVE POWER AND SPACE BY CONSOLIDATING MULTIPLE OLDER OPENSTACK SERVERS ONTO THE NEC DX1000 MICROSERVER CHASSIS

Do more database work in less space using less power
with the NEC DX1000 MicroServer Chassis powered by Intel®

Handle more orders
33X the total OPM
in a database scenario

Save data center space
Replace up to 33
2U servers with one
high-density 2U chassis

Use less energy
86% less power for
the same amount of work

compared to a legacy HP ProLiant DL380 G7 server

Many companies' data centers hold racks of older servers running cloud-based workloads, such as databases, web servers, and scale-out applications. In addition to monopolizing a great deal of space, these older servers can also require significant resources to power and cool. What if you could take a rack and a half of these legacy servers, and replace them with a single 2U solution?

In the Principled Technologies data center, we found that the ultra-dense new NEC DX1000 MicroServer Chassis could perform 33 times the database work of a single HP ProLiant DL380 G7 server, meaning it could replace 33 of these legacy servers. It did so while using 97 percent less space and 86 percent less power than 33 HP servers would use. If you have racks of older servers in your data center, replacing them with the NEC DX1000 MicroServer Chassis is a great way to free up space and dramatically reduce your power and cooling costs.

ABOUT MICROSERVERS

A microserver solution, such as the NEC DX1000 MicroServer, comprises a chassis that contains many standalone compute nodes and some shared infrastructure components, including networking, power supplies, and management interfaces. While this concept is similar to that of traditional blade server environments, a microserver solution may have lower power and cooling requirements, greater densities, and a lower cost per unit.

Organizations typically use microservers in applications requiring large numbers of server nodes, such as private cloud environments, Web server farms, HPC environments for parallel processing, and compute nodes for Hadoop and big data. Their use in cloud computing is growing.

HOW MANY OLDER SERVERS CAN THE NEC DX1000 REPLACE?

We knew that because of its tremendous density and small form factor, the NEC DX1000 had great potential for consolidating large numbers of older servers. We designed our testing to quantify this potential: Knowing how many older servers it could replace can help you understand the return on investment you'd get with this solution.

We began by setting up a server representative of many older servers active in data centers today: an HP ProLiant DL380 G7. We configured an OpenStack environment to encapsulate the private cloud that your organization may be running, then set up the DL380 G7 as an OpenStack compute node and created a virtual machine (VM) instance with the following specifications:

- Ubuntu OpenStack private cloud
- PostgreSQL 9.3
- 1 vCPU
- 4 GB of memory
- 10 GB of disk space

We then spawned a number of virtual machines, all containing the database software, and we ran a database workload on the VMs, measuring CPU utilization on the DL380 G7 server. We used DVD Store, an online transaction processing (OLTP) benchmark that simulates an online business, to measure the number of orders per minute (OPM) that the VMs on the older server could handle. We then added identical VMs until we reached 65 to 70 percent total CPU utilization, with the goal of showing how many VMs, and therefore orders per minute, we could achieve on this particular host server running at 65 percent utilization. We found that the HP ProLiant DL380 G7 supported 18 VMs at that level, and that it required two threads and .04 think time from our benchmark tools.

Next, we set up the NEC DX1000 to run the same OpenStack private cloud software. We began by running the same number of VMs (18) that the older server supported using the same test parameters. On the NEC DX1000, this required just four of the NEC DX1000's 46 available nodes—three fully utilized and one partially utilized. Put differently, in just a fraction of the physical space, the NEC DX1000 MicroServer handled the same workload as the legacy HP ProLiant DL380 G7. In fact, on the four MicroServer nodes, we achieved 47.8 percent more OPM than on the HP VMs, and CPU utilization was only 35 to 40 percent on those four nodes, leaving much of the box remaining in terms of compute power.

The NEC DX1000 MicroServer still had additional compute power to give, so we increased the number of VMs to "fill the box." We increased the VM count to 200, used 40 nodes for compute, and repeated our tests, again using the same parameters of two threads and .04 seconds think time.

Finally, the ultimate test was to see the true output of running the 2U NEC DX1000 MicroServer at the same 65 percent overall CPU utilization watermark we targeted on the legacy server. To do so, we increased the execution threads and decreased the think time on the 200 VMs until CPU utilization across all 40 nodes reached 65 to 70 percent. Throughout all of our testing, we measured the amount of power that the solutions used. Note: For more details about our testing, see Appendix D.

NEC DX1000 MicroServer Chassis delivered 33 times the performance

We found that, at our maximized benchmark configuration, the total database performance output of a single NEC DX1000 containing 46 server nodes, running 40 nodes specifically for our workload, was 33 times that of an HP ProLiant DL380 G7 server (see Figure 1).
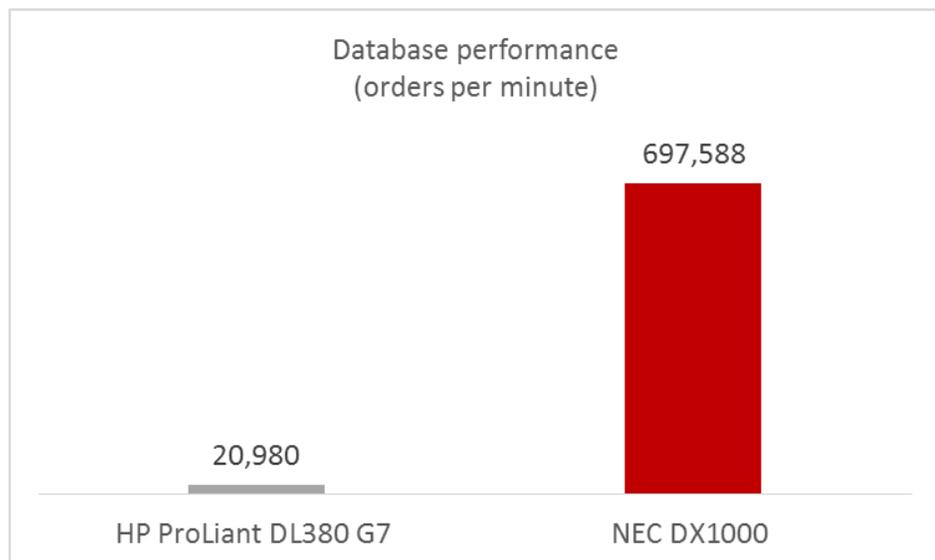
Figure 1: The total database performance of a single NEC DX1000 enclosure was 33 times that of an older HP ProLiant DL380 G7 server.

Database performance
(orders per minute)

697,588

20,980

HP ProLiant DL380 G7   NEC DX1000

NEC DX1000 MicroServer Chassis uses a fraction of the rack space

Data center space is precious, and you want to get the most from every cubic foot of space you have. Thanks to an extremely dense architecture packed into a slim 2U form factor, the NEC DX1000 can dramatically reduce the amount of space you need to achieve your performance goals.

As Figure 2 shows, by doing 33 times the work of an HP ProLiant DL380 G7 server, and thereby able to replace 33 servers, the NEC DX1000 could reduce the data center space needed by 64U, or a whopping 97 percent. This means that a NEC DX1000 enclosure could replace more than one and a half racks' worth of older servers – and that doesn't even account for extra network switches the legacy servers require. Those components are unnecessary with the NEC DX1000, which contains its own redundant high-bandwidth switches.

Figure 2: Rack space requirements for the two solutions that produce the same amount of performance. Less rack space usage, which saves a company money, is better.

Amount of rack space required for equivalent output from the two solutions (less is better)

66

2

33 HP ProLiant DL380 G7 servers

A single NEC DX1000
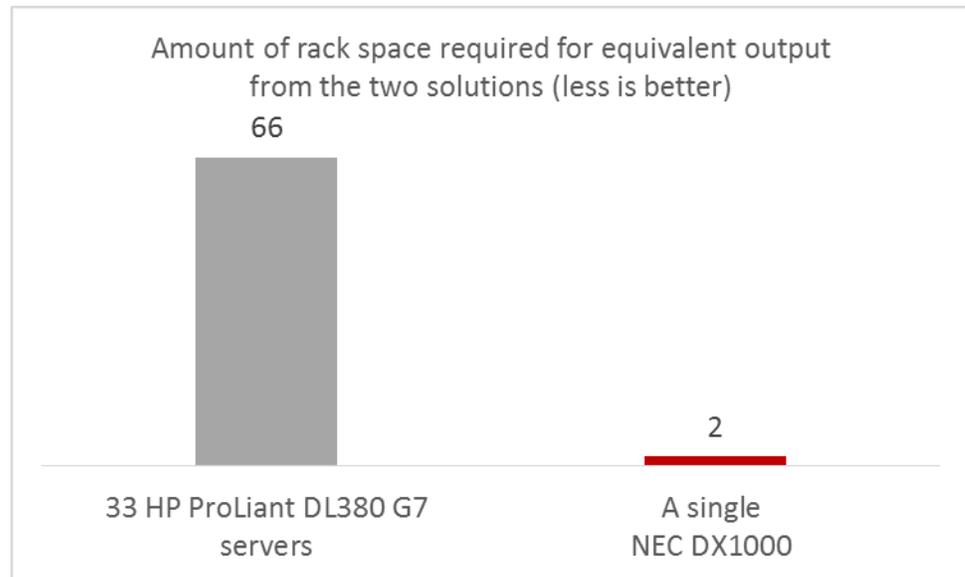
NEC DX1000 MicroServer Chassis can reduce power usage by 86.4 percent over 33 HP servers

Because power usage accounts for a significant portion of any data center budget, companies are always looking for greater power efficiency. Throughout all of our testing, we measured the amount of power that each solution used.

Because the NEC DX1000 is a single, integrated chassis containing many server nodes, it uses far less power than 33 of the HP ProLiant DL380 G7 servers that you would need to deliver the same performance. As Figure 3 shows, this consolidation would reduce your power usage by 86.4 percent – which translates directly to savings.

Amount of power in watts that each solution used
(less is better)

8,415

1,137

33 HP ProLiant DL380 G7
servers

A single
NEC DX1000

Figure 3: Power usage for the
two solutions to produce similar
performance. Less power used is
better. We tested a single HP
DL380 G7 and extrapolated to 33
servers to match the
performance level of the NEC
DX1000.
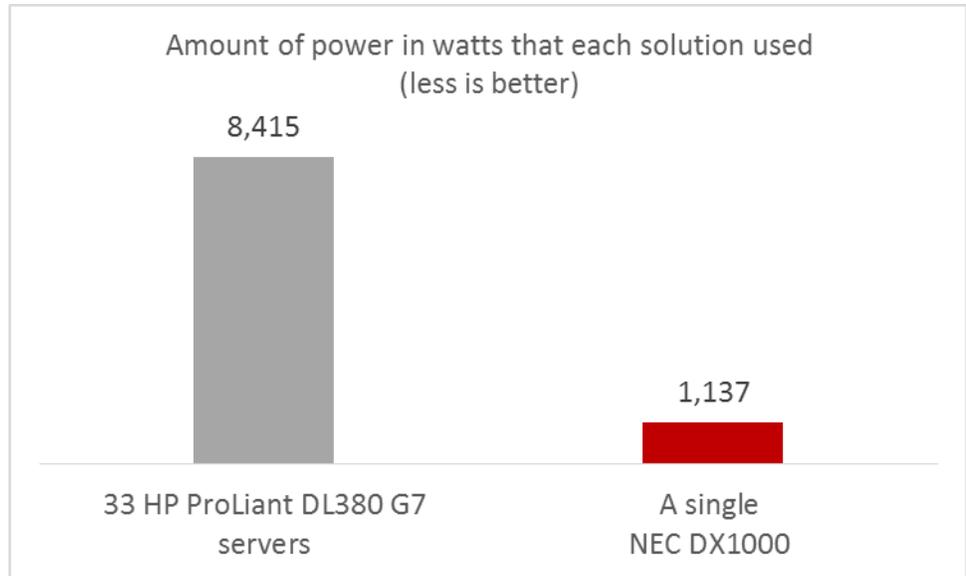
Another useful way to view the benefits of consolidating to the NEC DX1000 is by looking at performance per watt. We calculated this by taking the number of orders per minute that each solution delivered and dividing it by the number of watts the solution used. As Figure 4 shows, compared to the 33 HP ProLiant DL380 G7 servers, the NEC DX1000 yielded more than 7 times as many OPM per minute for each watt of power.

Orders per minute per watt that each solution delivered
(more is better)

613.3

82.3

33 HP ProLiant DL380 G7
servers

A single
NEC DX1000

Figure 4: Performance per watt
for the two solutions that
produce the same amount of
performance. More OPM per
watt is better.
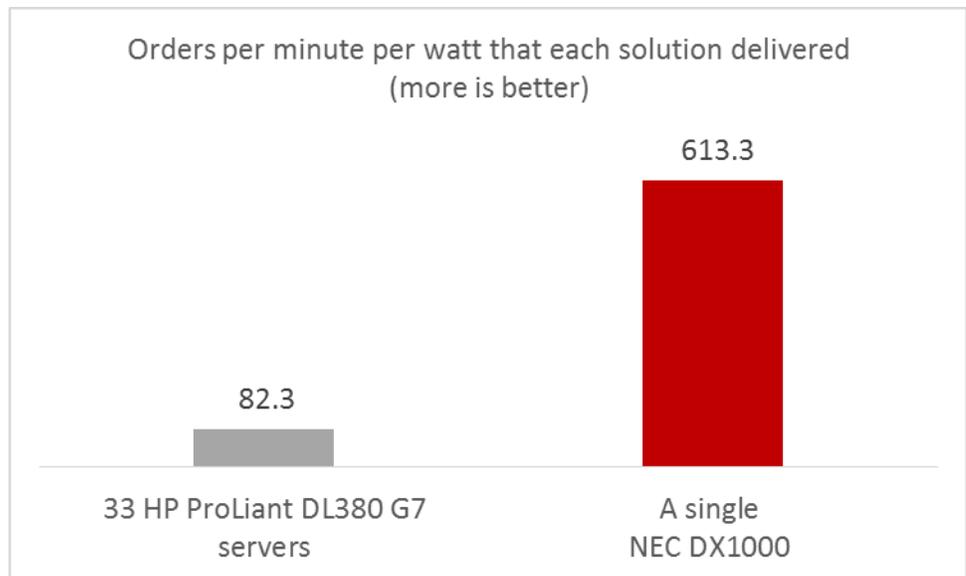
CONCLUSION

The NEC DX1000 platform is an extremely dense, powerful solution that uses less power and takes up significantly less space than the 33 legacy servers required to achieve the same level of performance. With integrated high-bandwidth switches and dedicated SSD storage on every node, this solution can easily outperform a traditional server environment with just a fraction of the data center resources. If your organization is considering refreshing your older legacy environment, or if you are looking for a platform that can provide strong performance and scale-out capabilities in a dense, efficient form-factor, the NEC DX1000 could be exactly what you are seeking.

APPENDIX A – ABOUT THE COMPONENTS OF THE NEC DX1000 MICROSERVER SOLUTION

The NEC DX1000 MicroServer Chassis

NEC designed the DX1000 MicroServer platform to support open solution platforms while satisfying business requirements for cloud services and big data analytics. Companies can use this platform to lower their energy and operational costs and increase space efficiencies.

Powered by the Intel® Atom™ C2000 processor and Intel's high port count, low-latency FM5224 Ethernet Switch, the NEC DX1000 MicroServer is one of the world's denser servers, optimized for innovative applications for hyper-scale data centers and hosted by NEC cloud services.

The NEC DX1000 MicroServer chassis is a super-high-density server system with a maximum of 46 one-way servers in a 2U enclosure. The chassis contains two integrated switches, each with 40Gbps uplinks, providing ample bandwidth for every node in the chassis. Each node contains an 8-core Intel Atom processor, 32 GB of high speed RAM, a 128 GB SSD for low-latency, high-speed storage, and 2.5GbE high-speed network connections. A single standard server rack can house up to 16 chassis for a maximum of 736 servers per rack.

Figure 5: The NEC DX1000 Microserver Chassis.

The Intel Atom processor C2000 product family

The Intel Atom processor C2000 family incorporates five models ranging from a two-core, 1.7 GHz CPU to an eight-core, 2.4 GHz CPU. The C2000 family is made of 64-bit system-on-chip (SoC) processors for lightweight scale-out workloads such as Web servers or cold data analytics. The Intel Atom C2000 family is designed for extreme density and energy efficiency for these workloads. These systems include built-in GbE/2.5GbE, SATA, and USB ports and have server-class features such as Error Correcting Code (ECC) memory and Intel Virtualization Technology®.

To learn more about the Intel Atom processor C2000 product family and the C2750 we used in our testing, visit www.intel.com/content/www/us/en/intelligent-systems/rangeley/atom-c2000-product-family-based-platforms-overview.html

Ubuntu OpenStack

Ubuntu OpenStack overview

Ubuntu OpenStack is a modular Infrastructure-as-a-Service (IaaS) cloud software built on Ubuntu Linux operating system. It is the most commonly deployed major OpenStack distribution in production cloud environments.[1]

Ubuntu OpenStack provides a variety of tools that makes rapid deployment, configuration, and management of your underlying cloud resources straightforward. The LTS versions of Ubuntu provide long-term support and stability for the base operating systems powering these tools.

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[1] www.ubuntu.com/cloud/openstack

APPENDIX B–DETAILED SERVER CONFIGURATION

Figure 6 provides detailed information about the server configuration.

System	NEC DX10a Server Cartridge (46 nodes)	HP ProLiant DL380 G7
Power supplies		
Total number	2 in-chassis	2
Vendor and model number	Delta Electronics DPS-1600FB A	HP DPS-750RB A
Wattage of each (W)	1600	750
General		
Number of processor packages	1	2
Number of cores per processor	8	4
Number of hardware threads per core	8	2
System power management policy	Balanced	Balanced Power and Performance
CPU		
Vendor	Intel	Intel
Name	Atom	Xeon
Model number	C2750	E5520
Stepping	B0	D0
Socket type	BGA1283	LGA1366
Core frequency (GHz)	2.40	2.27
Bus frequency	8.0	5.8
L1 cache	.43MB	128 KB
L2 cache	4MB	1024 KB
L3 cache	N/A	8192 KB
Platform		
Vendor and model number	DX10a	HP ProLiant DL380 G7
Motherboard model number	GC-MDC10-NJ	ProLiant DL380 G7
BIOS name and version	AMI 5.6.0007	HP P67 (07/02/2013)
BIOS settings	Default	Default
Memory module(s)		
Total RAM in system (GB)	32	96
Vendor and model number	Samsung® M474B1G73QH0-YK0	Samsung M393B1K70BH1-CF8Q4
Type	PC3-12800	PC3-8500R
Speed (MHz)	1600	1,333
Speed running in the system (MHz)	1600	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	11-11-11-35	7-7-7-24
Size (GB)	8	8
Number of RAM module(s)	4	12
Chip organization	1Gx72	1Gx72
Rank	Dual	Dual

System	NEC DX10a Server Cartridge (46 nodes)	HP ProLiant DL380 G7
RAID controller		
Vendor and model number	N/A	HP Smart Array P410i
Firmware version	N/A	5.70
Cache size	N/A	512 MB
Hard Drive		
Vendor and model number	Toshiba® THNSNH12	HP EH0146FARWD
Number of disks in system	1	8
Size (GB)	128	146
Buffer size (MB)	N/A	16
RPM	N/A	15k
Type	SSD	SAS
Ethernet adapters		
Vendor and model number	Intel I354	HP NC382i Gigabit Ethernet
Type	2 x 2.5GbE Backplane	4 x 1GbE PCI-E
Driver	IGB-5.0.5-k	
Operating system		
Version	Ubuntu 14.04.2 LTS	Ubuntu 14.04.2 LTS

Figure 6: Server configuration details.

APPENDIX C – DETAILED TEST METHODOLOGY

Configuring the server and VM

We configured the HP ProLiant DL380 G7 server with eight 15K SAS drives in a RAID5 array. We accepted the default parameters for the NEC DX10a server nodes.

Deploying OpenStack

In building the OpenStack platform, we referenced "Deploying an OpenStack Private Cloud on NEC DX1000 MicroServer Chassis," available at www.principledtechnologies.com/NEC/DX1000_OpenStack_deployment_0415.pdf.

Creating custom OpenStack Flavor

1. Log onto the OpenStack Dashboard.
2. Select Admin tab → System Panel → Flavors.
3. Select Create Flavor.
   a. Enter Flavor Name.
   b. For vCPUs, enter 1.
   c. For RAM MB, enter 4096.
   d. For Ephemeral Disk GB, enter 20 GB.
   e. For Swap Disk MB, enter 0.
4. Click Create Flavor.

Creating OpenStack Instance

1. Select Project → Compute → Instances.
2. Select +Launch Instance.
   a. Select Availability Zone.
   b. Enter Instance Name.
   c. Enter an instance count of one.
   d. Select instance boot source → Boot from Image.
   e. Select Ubuntu boot image.
   f. Select Access & Security tab.
   g. Select appropriate key pair.
   h. Select Networking tab
   i. Select Private Network
   j. Select the launch button.
3. Assign floating IP to newly created VM.
4. Select the More tab for newly created VM.
5. Select Associate Floating IP.
6. If no floating IP addresses are available in IP Address, pull down select + button.
7. Select Allocate IP.
8. Select Associate.

Installing PostgreSQL on the Ubuntu OpenStack VM

We used the PostgreSQL database server, version 9.3, as the database software on the VMs. Log onto the VM.

1. Install the PostgreSQL database server and client:

```
# sudo apt-get install postgresql
```

2. Initialize the PostgreSQL database cluster for the first time:

```
        service postgresql start
```
3. Tune the database engine. Modify the following lines of the
   `/etc/postgresql/9.3/main/postgresql.conf` file:
```
        checkpoint_segments = 16
        shared_buffers = 128MB
```
4. Add two lines to the PostgreSQL configuration file `pg_hba.conf` to permit SQL queries from the client
   network:
```
        host ds2    ds2   0.0.0.0/0         trust
        host ds2    ds2   0.0.0.0/0         trust
```
5. Modify the listen_addresses line in the PostgreSQL configuration file `postgresql.conf`:
```
        listen_addresses = '*'
```
6. Run `service postgresql restart` to restart PostgreSQL with the new settings.
7. Download the latest DVD Store distribution for PostgreSQL from linux.dell.com/dvdstore/ and upload the file to
   the VM.
8. Unpack the DS2 distribution into `/ds2`.
9. Change directory to `/ds2/pgsqlds2`.
10. Follow the DVD Store instructions for generating the text file data.
11. Log on as postgres user:
```
        # su postgres
```
12. Run the shell script `/ds2/pgsqlds2/pgsqlds2_create_all.sh`

Cloning PostgreSQL VM in OpenStack
1. Log onto the OpenStack Dashboard.
2. Select Project tab → Compute → Instances.
3. Select the VM where Postgres and DVD Store have been installed.
4. Select Create Snapshot.
5. Enter Snapshot name → Select Create Snapshot.

Deploying PostgreSQL image in OpenStack
- Create two host aggregates.
- Select Admin → System Panel → Host Aggregates.
- Select Create Host Aggregate tab.
- Enter name for Host Aggregate.
- Enter name of Availability Zone.
- Select Host within aggregate tab.
- Place hosts into proper zone for testing.
- Select Project → Compute → Instances.
- Select +Launch Instance.
- Select Availability Zone.
- Enter Instance Name.
- Enter an instance count.
- Select instance boot source → Boot from Image.
- Select newly created snapshot image.

- Select Access & Security tab.
- Select appropriate key pair.
- Select Networking tab
- Select Private Network
- Select the launch button.
- On VMs are being created, assign floating IP.
- Select the More tab for each VM.
- Select Associate Floating IP.
- If no floating IP addresses are available in IP Address, pull down, and select the + button.
- Select Allocate IP.
- Select Associate.

Running the test

About our DVD Store 2.1 workload

To create our real-world e-commerce workload, we used the DVD Store Version 2.1 benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute that the system could handle, to show what kind of performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your e-commerce environment.

We ran DS2 with various test scenarios or threads and think time. For the specific flags we used, see below. For more details about the DS2 tool, see www.delltechcenter.com/page/DVD+Store.

We created a series of batch files and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute metric, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Setting up the clients

Each DVD Store client contained the ds2pgsqldriver executable, and a script that could be run using PSEXEC to start the executable with the necessary parameters for each test scenario.

For the following three test scenarios, we used 2 threads and .04 seconds think time:

- 18 VMs on HP at 65% CPU utilization
- 18 VMs on 4 NEC DX10a nodes
- 200 VMs on 40 NEC DX10a nodes

For the test scenario of 200 VMs at 70% CPU utilization, we used six threads and .02 seconds think time.

Running the test

We configured our testing environment in the following manner across two hosts hosting 20 VMs (10 per host):

- Host 1
  - 10 Windows 2008 R2 Standard VMs with 24 GB of RAM and two vCPUs.
- Host 2
  - 10 Windows 2008 R2 Standard VMs with 24 GB of RAM and two vCPUs.

Using various automated scripts, we performed three runs for each test scenario to obtain the median DVD Store OPM for each.

In between each test, we executed the following steps to ensure we started from the same place in each test run:

1. When DVD Store scripts completes, stop dstat and ExTech data collection.
2. Gather all output files for DVD Store, dstat, and ExTech
3. Clean up prior outputs on DVD Store clients and hosts systems.
4. Reboot each OpenStack Hypervisor.
5. Restart all VMs.
6. Start Extech power collection.
7. Start dstat CPU performance collection script.
- Start DVD Store script.

Measuring power

To record power consumption during the test, we used an Extech Instruments (www.extech.com) 380803 Power Analyzer/Datalogger. We connected the power cords from the servers under test to the Power Analyzer's output-load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a power outlet.

We determined wattage measurements with the Power Analyzer's Data Acquisition Software. On a separate machine connected to the Power Analyzer via an RS-232 cable, we installed the software. We captured power consumption at 2-second intervals. Once rebooted, each server idled for 10 minutes prior to recording power measurements. For average power usage, we measured consumption throughout the 15-minute test run, collecting usage data in 2-second intervals.

APPENDIX D – THE SCRIPTS WE USED

Controller start DVD Store script

For these tests, the target IP addresses are the IP addresses of the virtual machines housing the databases.

HP DL380 G7 18 VMs
c:\ds2\ds2pgsqldriver --target=*<Target IPs >* --n_threads=2 --warmup_time=5 --think_time=.04 --run_time=10 --db_size=10GB --db_name=ds2 --csv_output=c:\ds2\server001_1801.csv
c:\ds2\ds2pgsqldriver --target= *<Target IPs >* --n_threads=2 --warmup_time=5 --think_time=.04 --run_time=10 --db_size=10GB --db_name=ds2 --csv_output=c:\ds2\server001_1802.csv

NEC DX1000 18 VMs
c:\ds2\ds2pgsqldriver --c:\ds2\ds2pgsqldriver --target= *<Target IPs >* --n_threads=2 --warmup_time=5 --think_time=.04 --run_time=10 --db_size=10GB --db_name=ds2 --csv_output=c:\ds2\server002_18nec.csv
c:\ds2\ds2pgsqldriver --target= *<Target IPs >* --n_threads=2 --warmup_time=5 --think_time=.04 --run_time=10 --db_size=10GB --db_name=ds2 --csv_output=c:\ds2\server001_18nec.csv

The above <Target IPs> refers to the list of the first nine targets in the 18-VM scenario. We split the client execution over two clients, targeting nine VMs each.

NEC DX1000 200 VMs
c:\pstools\psexec *<Target IPs >* cmd /c c:\ds2\server001.bat

NEC DX1000 200 VMs at 70 percent CPU utilization
c:\pstools\psexec *<Target IPs >* cmd /c c:\ds2\server005.bat
A total of 20 scripts targeting 10 DVD Store databases were created for test 200 VMs.

The above <Target IPs> refers to the list of 10 targets in the 200-VM scenario. We split the client execution over 20 clients, targeting 10 VMs each.

CPU performance-monitoring scripts

We created one script for each hypervisor and used command prompts to start each script. The locations used in the scripts are specific to our test environment and will be different when run in other test environments.

- To execute DSTAT on the HP DL380 G7 and record the output into a CSV file, we used "dstat –crm --output dl380-dstat.csv"
- To execute DSTAT on the NEC DX1000 and record the output of each hypervisors , we executed:
    - o "dstat –crm –output nec18vm_node01.csv"
    - o "dstat –crm –output nec18vm_node02.csv"
    - o "dstat –crm –output nec18vm_node03.csv"

- o "dstat –crm –output nec18vm_node04.csv"
- To execute DSTAT on the NEC DX1000 and record the output of 40 hypervisors, we used "dstat –crm –output nec200vm_nodeXX.csv", where XX is the node number we targeted. We executed this command on each hypervisor.
- To execute DSTAT on the NEC DX1000 and record the output of 40 hypervisors, we used "dstat –crm –output nec200vm_70_nodeXX.csv", where XX is the node number we targeted. We executed this command on each hypervisor.

APPENDIX E – DETAILED TEST RESULTS

HP ProLiant DL380 G7 – 18 VMs

We began our testing by setting up a single HP ProLiant DL380 G7 and creating a virtual machine with the following specifications:

- Ubuntu OpenStack private cloud
- PostgreSQL 9.3
- 1 vCPU
- 4 GB of memory
- 10 GB of disk

We ran a database workload and measured the percentage CPU utilization. We then added identical VMs until we reached 65 percent CPU utilization. We found that the HP ProLiant DL380 G7 supported 18 VMs and handled a total of 20,980 orders per minute. Figures 7 and 8 show the CPU utilization and power usage during this run.

Figure 7: CPU utilization of the HP ProLiant DL380 G7.
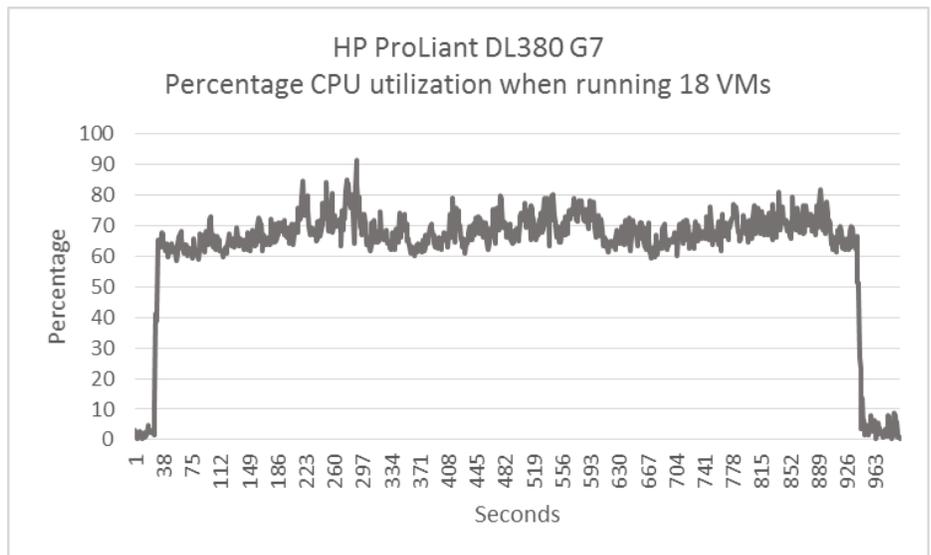
Figure 8: Power usage of the HP ProLiant DL380 G7.
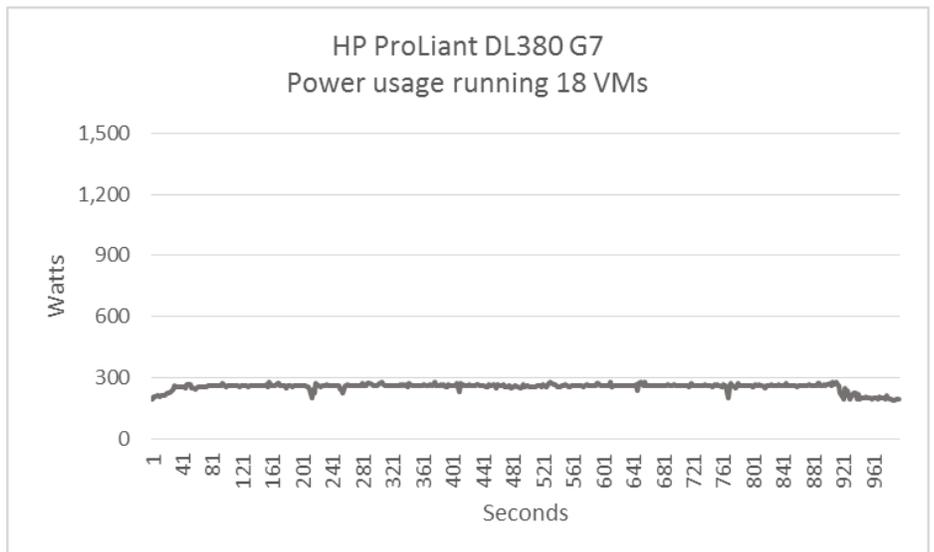
NEC DX1000 – 18 VMs

Next, we set up the NEC DX1000 to run the same OpenStack private cloud software and PostgreSQL database we used on the older server. First, we ran 18 VMs, the same number of VMs and the same parameters we ran on the HP ProLiant DL380 G7 server. The NEC DX1000 handled 31,002 OPM. Figures 9 and 10 show the CPU utilization and power usage during this run.

Figure 9: CPU utilization of the NEC DX1000 running 18 VMs.
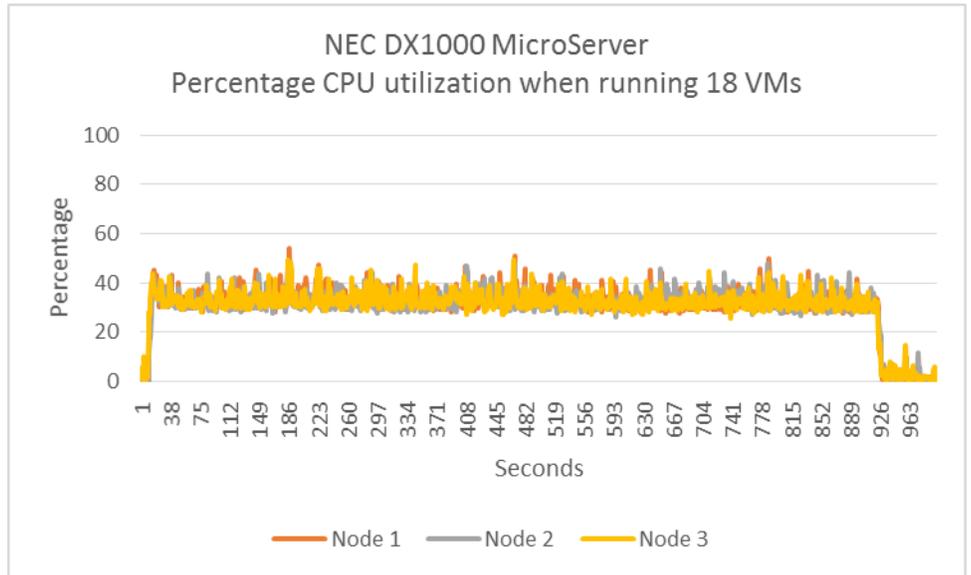
Figure 10: Power usage of the NEC DX1000 running 18 VMs.
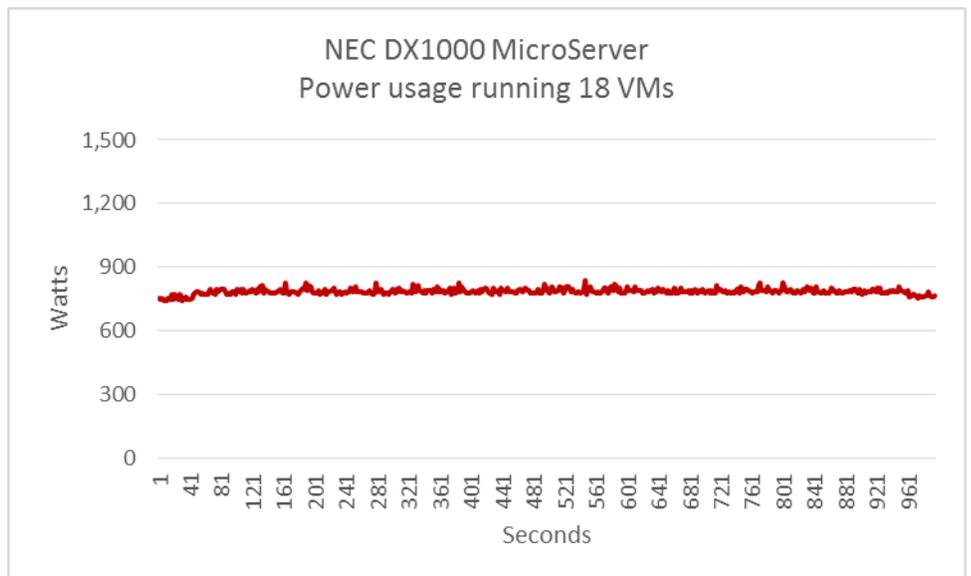
NEC DX1000 – 200 VMs at original test load

Next, we increased the number of VMs running on the NEC DX1000 to 200, utilizing 40 nodes at five VMs per node and the same parameters from our original testing. The NEC DX1000 handled 324,819 OPM. Figures 11 and 12 show the average CPU utilization over the 40 nodes, and the total power usage during this run.

Figure 11: CPU utilization of the NEC DX1000 running 200 VMs.

NEC DX1000 MicroServer
Percentage CPU utilization when running 200 VMs
(normal load)
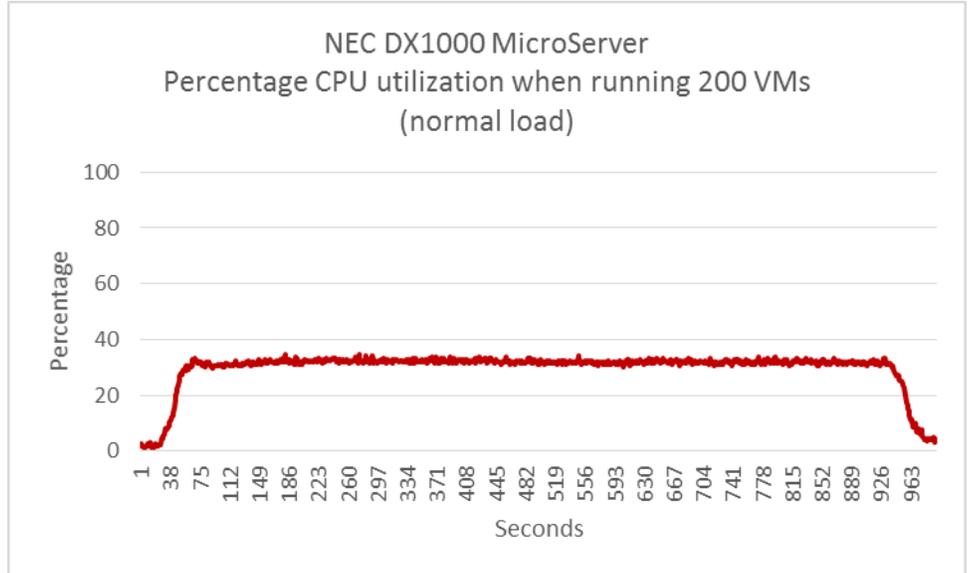
Figure 12: Power usage of the NEC DX1000 running 200 VMs.

NEC DX1000 MicroServer
Power usage running 200 VMs
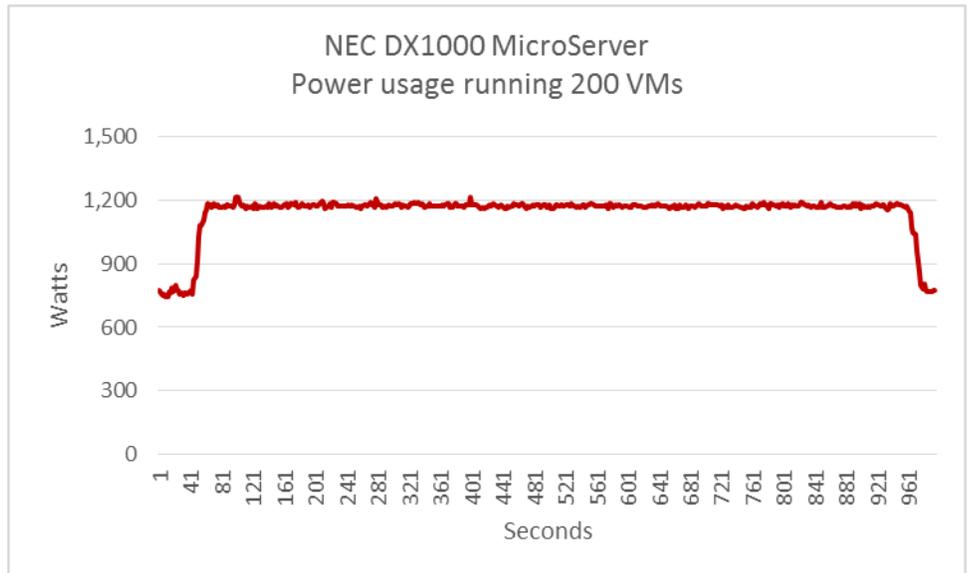
NEC DX1000 – 200 VMs at higher CPU utilization

Finally, we adjusted the workload on the NEC DX1000 to push the server to greater utilization. Our CPU utilization target range was 65 percent to 70 percent. We achieved this by decreasing the think time from 0.04 seconds to 0.02 seconds and increasing the number of threads from two to six. In this test, the NEC DX1000 handled 697,588 OPM. Figures 13 and 14 show the CPU utilization and power usage during this run.

Figure 13: CPU utilization of the NEC DX1000 running 200 VMs.
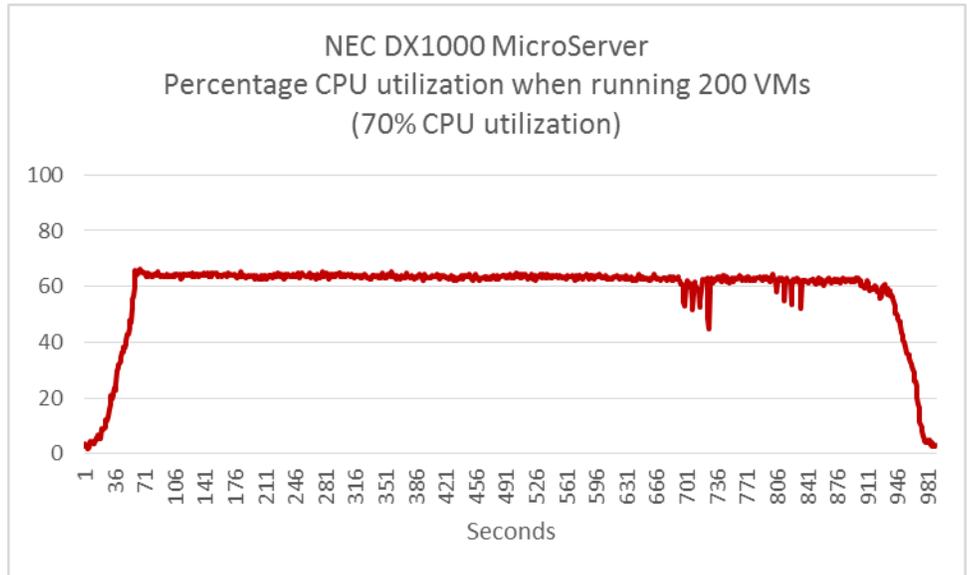
Figure 14: Power usage of the NEC DX1000 running 200 VMs.
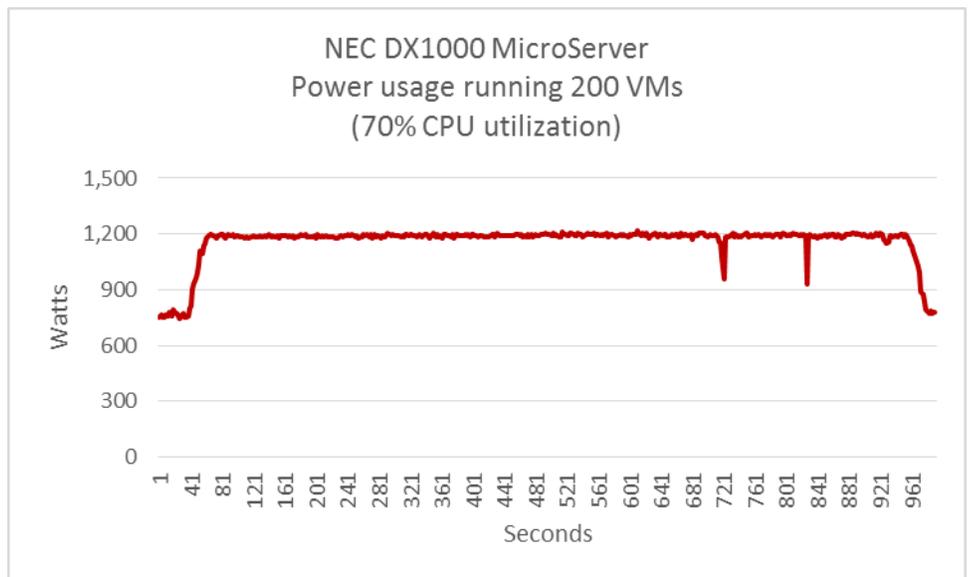
ABOUT PRINCIPLED TECHNOLOGIES

![Principled Technologies logo]

Principled Technologies, Inc.
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.