INTRODUCING KVM VIRTUALIZATION ON DGX-2

KVM BENEFITS

• SECURE MULTI-TENANCY
• IMPROVE SYSTEM AVAILABILITY
• EASY TO USE

HOW WE ENABLE KVM
DGX-2 has Immense compute

1. NVIDIA Tesla V100 32GB
2. Two GPU Boards
   - 8 V100 32GB GPUs per board
   - 6 NVSwitches per board
   - 512GB Total HBM2 Memory interconnected by Plane Card
3. Twelve NVSwitches
   - 2.4 TB/sec bi-section bandwidth
4. Eight EDR Infiniband/100 GigE
   - 200 GB/sec Total Bi-directional Bandwidth
5. Two Intel Xeon Platinum CPUs
6. 1.5 TB System Memory
7. 30 TB NVME SSDs
   - Internal Storage
   - 25GB/s seq read (fio)
8. Two High-Speed Ethernet
PROBLEM STATEMENT WITH GPU VIRTUALIZATION

SECURE MULTI-TENANCY

“Launch secure tenants with different number of GPUs targeting Healthcare, CSPs, Higher Education use cases

IMPROVED SYSTEM AVAILABILITY

“Hypervisor assisted Hardware health management with no down time
Secure Multi-Tenancy
DGX-2 KVM VIRTUALIZATION

Enable your own private DL Training Cloud for your Enterprise

- KVM hypervisor for Ubuntu Linux
- Enable teams of developers to simultaneously access DGX-2
- Flexibly allocate GPU resources to each user and their experiments
- Full GPU’s and NVSwitch access within VMs – either all GPU’s or as few as 1
DGX-2 KVM provides secure Multi-tenancy

- Run many popular deep-learning frameworks - GPU-tuned by NVIDIA
- Pre-configured templates for various sized GPU tenants
- Optimized drivers and libraries for maximized multi-GPU performance
- Easy VM lifecycle management with NVIDIA tools
- Clean, minimal O/S Guest OS image
- Non-disruptive updates for software and security
Many Users For Improved Utilization

Multiple Users on one DGX Server
- 16 x1-GPU VMs
- Many non-GPU VMs

Schedule Multi-DL apps on available HW
ML/DL training, NGC containers, RAPIDS
Healthcare, Higher Education
Cloud / Datacenters deployment

Ex: Data Science team within Fortune 500 organization

Virtual Machine Users
## GPU VMs Can Run Different CUDA & Drivers

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<td>CUDA 8.0</td>
<td>CUDA 9.0</td>
<td>CUDA 10.0</td>
<td>CUDA-X</td>
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<td>Guest OS</td>
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**HYPervisor**

**Good for:** Developing apps across CUDA
# GPU VM Can Have Different Guest OS

Good for: Developing apps across OSes

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<td>DGX OS 4.x</td>
<td>Stock Ubuntu</td>
<td>Stock RHEL</td>
<td>Stock Cent OS</td>
<td>Any other OS</td>
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<tr>
<td>CUDA RT</td>
<td>Guest OS</td>
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GPU VMs Can Run Different Apps: DL & Data Analytics

- TF Tuned SW
- CNTK Tuned SW
- Caffe2 Tuned SW
- Pytorch Tuned SW

Ex: Demo RAPIDs in a 16-GPU VM
Secure Multi-tenancy Considerations

- Each tenant gets dedicated HW i.e. CPUs, Mem, GPUs etc.
- HW is isolated across tenants
- GPUs, NVSwitches are passthrough
- NVLINKs are isolated
- Cannot “reset” PCI HW
- Cannot download malicious “code” to HW
VMs Get Complete Isolation Of GPUs & NVLINKs

Provide Secure Multi-Tenancy across two 2-GPU VMs over NVLINKs

HR team’s VM

IT teams’ VM
Improved System Availability
Baremetal: HW Fault Can Impact Entire Server

A System Hardware Fault Occurred

Server Reboots

DGX Server Users
Fault Inside A VM Doesn’t Impact Entire Server

Hardware Fault Occurred

VM 0  VM 1  VM 2  VM 3
VM 4  VM 5  VM 6  VM 7
VM 8  VM 9  VM 10 VM 11
VM 12 VM 13 VM 14 VM 15

No Server reboot

Other VMs keep running

Virtual Machine Users

DGX GPU Server
Track Unhealthy HW In Hypervisor

Cache Health State in HV
HW is “not-ok”

Hypervisor keeps track of HW health state
Cannot launch VM with unhealthy HW
One Faulted HW Is RMAed - We Recover

Once bad HW is replaced, our SW auto-assimilates

Hardware state is reset to “ok”

VM can be relaunched safely

Cache Health State in HV HW is “ok”
What We Did To Enable KVM
Modified System SW For KVM

- **SBIOS**: Enable HW extensions
  - VT-x, VT-d

- **Bootloader**: New GRUB options
  - intel_iommu=on
  - iommu=pt

- **Linux**: Kernel Module Changes
  - Use vfio-pci Blacklist drivers

- **systemd**: Disable Services
  - NV fabricmanager cachefilesd
Modified “qemu” & Guest OS

- Apps and VMs
- GPUs
- Hypervisor
- QEMU on Server

**Guest OS Support**
- NVDA SW stack for DL apps
- Perf knobs, VM lifecycle tool
- Collect telemetry
- Manage GPU Health

**Make GPU VMs Secure**
- EOU tools, Telemetry, Health Mgmt, Perf
- MMIO filtering
- Isolate NVLINKs
- No FW download

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Pre-Configured Templates for Optimal Performance:

- Only support power-of-2 GPU VMs
- Select IO devices Using PCIe and NVLINK topology
- Select CPU cores and Memory based on NUMA
- Pin vCPU cores with Core-affinity for Hyper Threads

NOTE: Pre-Configured Templates can be easily modified
How To Use KVM
One Command To Change to KVM "Mode"

Bare-metal Mode

apt install dgx-kvm-sw

KVM Mode

Apps & VMs

GPUs

Hypervisor or

Server
Creating & Deleting GPU VMs Is Easy

nvidia-vm create --gpu-count 1

nvidia-vm delete <vm>

DGX GPU Server

Virtual Machine Users

KVM Mode

VM0 VM1 VM2 VM3
VM4 VM5 VM6 VM7
VM8 VM9 VM10 VM11
VM12 VM13 VM14 VM15
One Command To Revert To Bare-metal Mode

Bare-metal Mode

Day Use as KVM Server, Night for HPC workloads

apt remove dgx-kvm-sw

KVM Mode

Apps & VMs

GPUs

Hypervisor

Server
Near Bare-Metal Performance
Apply Performance “Knobs”

1. Leverage HW topology to get near Bare-metal Perf
   - NVLINK & PCI topology to select GPUs & NVSwitches
   - NUMA to select Memory and CPU cores

2. Multiple queues for Network and Block Devices
Before Performance “Knobs”

Typically Virtualization has ~ 20-30% performance overhead*

DGX TensorFlow from a VM

87 % Perf

DGX TensorFlow from Baremetal

78 % Perf

ResNet152, Batch 16 Training

82 % Perf

* See OpenBenchMarking.org: KVM vs Baremetal Benchmarks
After Performance “Knobs”

DGX performance tuned Virtual Machines show minimal impact

DGX TensorFlow from a VM

DGX TensorFlow from Baremetal

ResNet152, Batch 16 Training
Where To Get KVM Software

1. By default, not installed
2. Download repository pre-configured on DGX
3. Need to explicitly install
   1. dgx-kvm-sw package
   2. Guest OS images available as separate package
   3. Multiple Guest OS versions available

4. Air Gapped Customers : Reach NVIDIA Enterprise Experience
DGX-2 KVM Demo

- See [DGX2 KVM Demo Page](#)
Can Use OSS Tools To Monitor VMs

https://github.com/dholt/openstack-lab
References

● **DGX2 User Guide**  
  ■ See chapter 11

● **DGX Best Practices**  
  ■ [https://docs.nvidia.com/dgx/bp-dgx/index.html#topic_2](https://docs.nvidia.com/dgx/bp-dgx/index.html#topic_2)  
  ■ See Chapters 10, 11

● **KVM Questionnaire**:  [http://tinyurl.com/y4d3y6xm](http://tinyurl.com/y4d3y6xm)
SUMMARY

- Secure Multi-tenancy
- Improved System Availability
- Easy to Use
- Near Bare-metal Performance
DGX-2 KVM Team

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Newton Liu
Haiduong Vo
# NVIDIA LED DGX SESSIONS AT GTC 2019

NOTE: For details on all DGX-related sessions, visit: [GTC site](https://www.gtc.org) and search for “DGX” or look-up session ID

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<th>Product Featured</th>
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| S91003 Wed 3/20, 2pm | Convention Center Room 210A | **MXNet Computer Vision and Natural Language Processing Models Accelerated with NVIDIA TensorCores**  
- Przemyslaw Tredak (DevTech Engineer) and Cyrus Vahid (Principle Evangelist AWS Deep Engine) | ![NVIDIA DGX A100](image) |
| S9417 Wed 3/20, 3pm  | SJ Convention Center Room 211B | **Molecular Generative VAEs: Parallelization, Optimization, and Latent Space Analysis on DGX-1**  
- Ellen Du and Joey Storer, Research Scientists, Dow Chemical Company | ![NVIDIA DGX A100](image) |
| S9469 Wed 3/20, 4pm  | SJ Convention Center Room 231 | **MATLAB and NVIDIA Docker: A Complete AI Solution, Where You Need It, in an Instant**  
- Jos Martin and Joss Knight, Engineering, MathWorks | ![NVIDIA DGX A100](image) |
| S9892 Wed 3/20, 4pm  | SJ Convention Center Room 220A | **Deep Learning for Autonomous Driving at BMW**  
- Alexander Frickenstein, PhD Candidate, BMW | ![NVIDIA DGX A100](image) |
| CE9153 Wed 3/20, 4pm | SJ Convention Center Hall 3 Pod D | **Connect with Experts: How to effectively use GPGU VMs on DGX-2**  
- Anish Gupta, Varinder Singh, Raaghav Hebbar, Ranen C and Chris Zankel (Nvidia) | ![NVIDIA DGX A100](image) |
Thank You !!