Live Migration of vGPU

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Agenda

• GPU Virtualization and vGPU Live Migration
• vGPU Resources
• Design and Solution
• Current Status
• Summary
GPU Virtualization Usage Cases

- **IT**
  - 2D/3D Office Productivity

- **Desktop**
  - CADs
  - Media Process

- **Media Could**
  - 3D/Media Acceleration

- **Desktop#N**
  - VDI

Remote Framebuffer Streaming

Network
XENGT Architecture – Mediated Pass-through

- pass-through for performance critical resource
- Trap and emulate for privileged resource
- Time-shared among VMs
vGPU Live Migration

Live Migration: Load balance, Maintenance, Fault recovery
Unfortunately most of vGPU solutions do not support migration except Intel® GVT-g

Typically a GPU pass-through solution

Guest vGPU
Hypervisor
HW
GPU

Typically a GPU SROV solution

Guest vGPU
Hypervisor
SRIOV HW
GPU PF VF ...
VF

Intel® GVT-g with mediated pass-through

Host Linux
VM2
VM1
GFX Driver

Intel® GVT-g architecture (Mediation) make it possible for seamless live migration
Live Migration of vGPU in Intel® GVT-g

Highlight feature:

- Intel® GVT-g is Open Source project, upstream ongoing
- vGPU Live Migration follows existing hypervisor migration flow
- 3D/2D/Media graphics workload seamless migrated between Servers or Local machine
- Support Linux/Windows Guest
- Live Migration Service downtime latency < 0.3 sec (Guest RAM 2GB, assigned 512MB vGPU memory, 10Gpbs adapter)
Demo: vGPU Live Migration with 3D workload

Demo Video

Intel® Graphics Virtualization Technology for virtual GPU (Intel® GVT-g)

Live Migration

https://www.youtube.com/watch?v=y2SkU5JODIY
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Inside of vGPU instance

- pass-through for performance critical resource
- Trap and emulate for privileged resource
- Time-shared among VMs
Challenge of Migrating vGPU Instance

• When and how to migrate Graphics Memory
• When and how to migrate Guest Graphics Page Table
• When and how to migrate Render Engine State
Migration Policies for Different vGPU Resources

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Guest GTT Page Table Migration

- Both GGTT and PPGTT are shadowed for Guest
- GGTT required rebasing due to GGTT partition among VMs
- Migration process actually:
  A. Copy entire Guest GTT page table
  B. Re-create the shadow page table for Guest on Target side
  C. Rebasing GGTT for GPU commands

Graphics Memory Address rebasing:
All vGPU cmds from Guest need to be rebased on new address in GVT-g before send to real GPU HW
Guest Graphics Memory Migration

- **Pre-copy**: Logging dirty graphics memory pages
- **Stop-and-Copy**: Migrate contents to target
- **Resume/Post-copy**: Recreate GTT page table based on target mfn

**Problem:**
Intel® GPU page table entities has no Dirty or Accessed flags to track dirty pages

**Solution:**
Copy all used graphics memory to target.
Render Engine State Migration

- Intel® GPU HW is context based
- CTX locates in GGTT memory
- Render engine state is contained within CTX

GGTT address

vGPU Guest submitted CTX

Context in queue

Server1
Render Engine

Context1 completed
Context0 completed

HW in idle

Server2
Render Engine

HW in idle

CTX N

Render Context required to be migrated

Migration happens at this point
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Current Status

- Experimental support both KVMGT and XENGT
- Platforms: Intel® 5th /6th Generation Intel® Core™ Processors
- Benchmarks covered:
  Windows guest: Heaven, 3Dmark06, Trophic, Media encoding/decoding, Linux guest: lightsmark, 2D
- Quality: 12hours overnight testing, migrating every 30sec
- Timing: (Guest RAM 2GB including 512MB Graphics memory, 10Gbps adapter)
  - Service downtime ~0.3sec
  - Total migration time: ~1.7sec
Summary

- Need 3D/2D/Media workload in virtualization?
  GVT-g is the choice

- Need GPU virtualization with migration support?
  GVT-g is the choice 😊
Resource Links

• Project webpage and release: https://01.org/igvt-g

• Project public papers and document: https://01.org/group/2230/documentation-list

• Intel® IDF: GVT-g in Media Cloud: https://01.org/sites/default/files/documentation/sz15_sfts002_100_engf.pdf


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