KVMGT: a Full GPU Virtualization Solution
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Agenda

- Background
- KVMGT
- Status
- Summary
GPU Virtualization Momentum

GPU Accelerated Tasks
- Games
- Video Playback/Edit
- Web Experience
- Office Productivity
- Media Transcoding
- Computer Aided Design
- Visual Analysis

GPU virtualization becomes a fundamental requirement
Requirements of GPU Virtualization

Performance ➔ Direct GPU acceleration

Capability ➔ Consistent visual experience

Sharing ➔ Multiple Virtual Machines
## GPU Virtualization Approaches

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### Pros:
- Performance
- Sharing

### Cons:
- No media/GPGPU
- Compatibility

### Pros:
- Performance
- Capability

### Cons:
- No sharing

### Pros:
- Performance
- Capability
- Sharing

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Intel® GPU Virtualization Technology

- Intel® GVT-s for API Forwarding
  ✓ Make existing API forwarding protocols running best on Intel® platform

- Intel® GVT-d for Direct Pass-through
  ✓ Xen GPU pass-through upstreaming in progress

- Intel® GVT-g for Full GPU Virtualization
  ✓ SW based approach with a good balance of performance, feature and sharing
Full GPU virtualization
✓ Run native graphics driver in VM

Mediated pass-through
✓ Pass-through performance critical operations
✓ Trap-and-emulate privileged operations

KVMGT is the open source implementation of Intel® GVT-g for KVM
✓ Support Intel® Processor Graphics built into 4th generation Intel® Core™ processors
✓ vGT device model is GPL/MIT dual-licensed and VMM agnostic
KVMGT Architecture

Host Linux

- Qemu
  - vPCI layout
  - VGA

- i915
  - Driver Hooks
  - I/O Hooks
  - Address space balloon

vGT

- vGPU
  - Address space balloon

GFX Driver

- Address space balloon

KVM

- MPT Services

VM1

- GFX Driver

VM2

- KVMGT changes

Mediation

Pass-through
Mediated Pass-Through (MPT) Services

- In-kernel device model framework
  - Selectively pass-through
  - Trap-and-emulation
vGT

- Part of host i915 driver
- Maintain 1 vGPU instance for each VM
- vGPU scheduling in a time-shared manner
Qemu Changes

- Present vGPU in the virtual PCI hierarchy
- Request vGPU instance creation/destroy
Host i915 Mediation

- Host i915 accesses are also mediated
  - Hook in i915 I/O interfaces
- Centralized GPU sharing management
  - For both host and VMs
Address Space Ballooning

- Graphics memory partitioning
  - Guest view vs. host view
- Address space ballooning
  - Consistent guest/host views
  - No need for address translation
Implementation Status

- Basic features complete
  - Linux guest works steadily with PPGTT (Per-Process Graphics Translation Table) disabled

- MPT services
  - Trap via kvm_io_device, similar to the in-kernel irqchip
  - Pass-through via a special in-kernel memslot

- vGT and i915 driver
  - Start upstreaming patches to i915 community

- Qemu
  - Provide MCH/PCH emulation similar to GPU pass-through
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TODO

- Implement shadow PPGTT
  - Is a must to support Windows guest

- Clean up and stabilize the prototype code

- Involve with community for architectural discussion

- Work with community for upstreaming
Summary

- Intel® GVT-g provides a good balance of performance, feature and sharing capability
  - Minimum impact on performance critical operations
  - Running native graphics driver in VM
  - Multiplexing capability

- KVMGT implements Intel® GVT-g for KVM, with >80% of native 3D performance
  - RFC code is coming

- Community contribution is highly appreciated!
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