Light Weight Virtualization with QEMU/KVM

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Outline

Background

Optimization for VM Launch Time

Memory Footprint

Integration with Intel Clear Container

Upstream

Status & TODO

Container vs. Traditional VM

	Container	Traditional VM
Launch Time	✓	
Resource Efficiency	✓	
Density	✓	
Deployment	✓	
Security		✓

Light Weight VM

	Container	Traditional VM	Light Weight VM
Launch Time	✓		✓
Resource Efficiency	✓		✓
Density	✓		✓
Deployment	✓		✓
Security		✓	✓

QEMU Lite

- Target for container-like usage scenarios
- Optimized for the launch time
  - 1276 ms ➔ 335 ms
- Smaller memory footprint
  - More optimization on the way
- Integrated with Intel Clear Container
  - Docker-like engine

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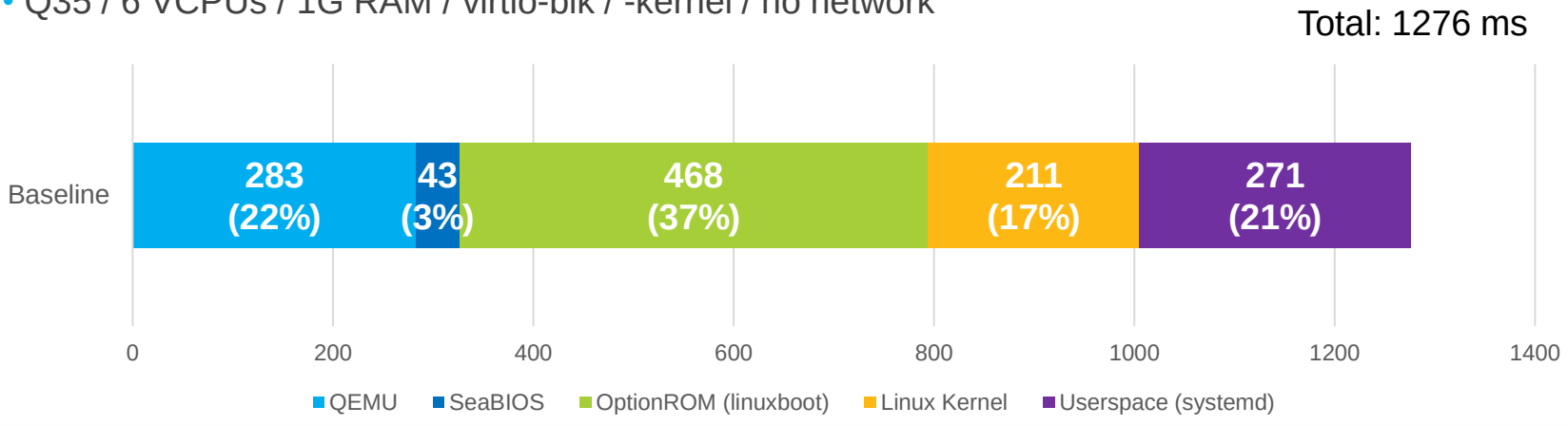
Baseline

- Host
  - Intel Xeon E5-2698 v3 @ 2.30 GHz / [Memory]
- Guest (QEMU configurations)
  - Q35 / 6 VCPUs / 1G RAM / virtio-blk / -kernel / no network



Tweak QEMU & Kernel Configurations

- Disable QEMU features at compile time
  - https://github.com/chao-p/qemu-lite-tools/blob/master/qemu-config.sh
- Tune guest kernel boot parameters
  - rcupdate.rcu_expedited=1
  - pci=lastbus=0
  - …

QEMU Optimizations

- Cache KVM_GET_SUPPORTED_CPUID
  - 5922 duplicated calls during QEMU initialization
  - QEMU commit 494e95e “target-i386: kvm: cache KVM_GET_SUPPORTED_CPUID data”
  - QEMU: 272 ms ➔ 90 ms
- Parallelize VCPU initialization
  - QEMU: 90 ms ➔ 54 ms

New Machine Type pc-lite

- Minimum Devices
  - APIC
  - PCI Host
  - Virtio Console
  - NVDIMM
  - …

- SeaBIOS: 43 ms ➔ 29 ms
- Guest kernel: 151 ms ➔ 142 ms

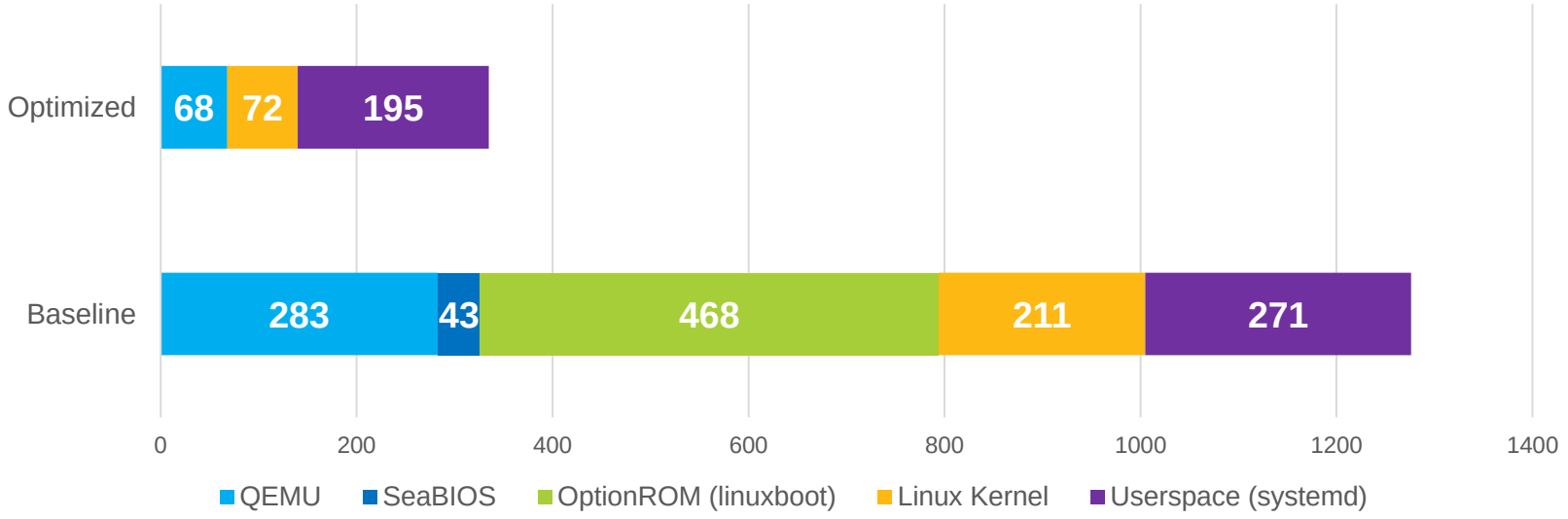
And more …

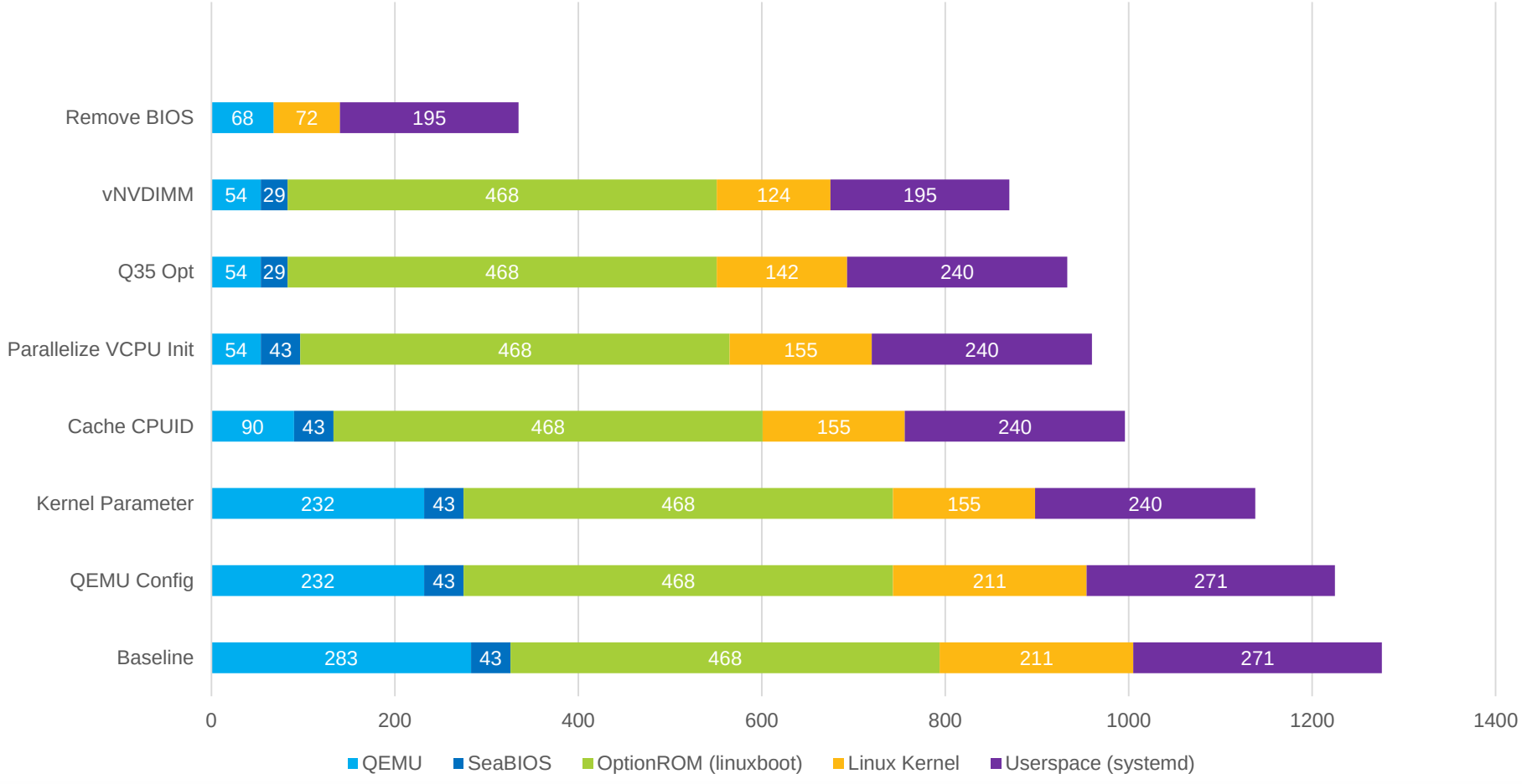
- Use vNVDIMM device as guest disk drive
  - DAX
  - Guest kernel: 142 ms ➔ 124 ms
  - Guest userspace: 240 ms ➔ 195 ms

- Remove guest BIOS completely
  - Patch guest ACPI in QEMU
  - Load guest ELF kernel in QEMU
  - SeaBIOS: 29 ms ➔ 0 ms
  - OptionROM: 468 ms ➔ 0 ms
  - Guest kernel: 124 ms ➔ 72 ms

Final Result

Total: reduced by 74% (1276 ms➔335 ms)




Remove BIOS
68
72
195
vNVDIMM
54
29
468
124
195
Q35 Opt
54
29
468
142
240
Parallelize VCPU Init
54
43
468
155
240
Cache CPUID
90
43
468
155
240
Kernel Parameter
232
43
468
155
240
QEMU Config
232
43
468
211
271
Baseline
283
43
468
211
271
0
200
400
600
800
1000
1200
1400
QEMU
SeaBIOS
OptionROM (linuxboot)
Linux Kernel
Userspace (systemd)

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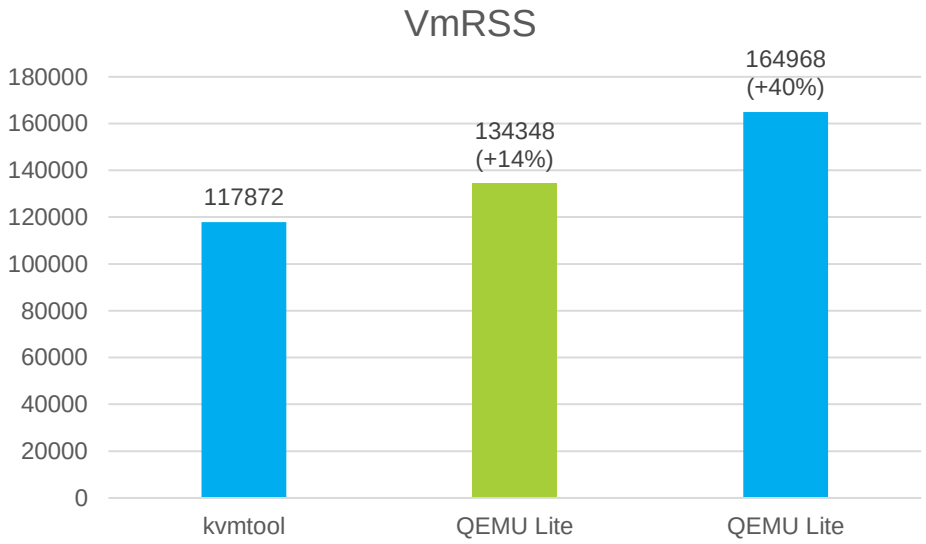
Memory Consumption

- 1 x VM: 6 vCPU, 1G RAM
- Read /dev/$pid/status



Potential Optimizations

- Still ongoing
- Remove unnecessary devices
  - Reduce memory consumption by QEMU itself
- COW share ROM
  - e.g. ROM for guest ELF kernel
  - Reduce duplicated host/guest copies if (almost) no modifications
- Lazy creation of dirty memory bitmap
  - Defer to its first usage (migration)
- KSM
- VMFork/Clone
- Tools to fine-grained profile/trace the memory consumption

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Integration with Intel Clear Container

- QEMU Lite in Intel Clear Container v2.0
  - Replace kvmtool used in Intel Clear Container v1.0
- Benefit from Docker/rkt compatible interface
  - Support docker images
  - Better deployment

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PC-lite or Q35

- [RFC 0/9] Introduce light weight PC platform pc-lite
  - https://lists.nongnu.org/archive/html/qemu-devel/2016-06/msg04842.html
- All optimizations currently go into a new machine type pc-lite.
  - Less pollutions to other machine types
  - Easier to optimize
  - Extra cost for maintenance
- Optimize Q35?
  - Make the work more widely useful
  - Add ability to disable (more) features and devices

No Firmware or Light-weight Firmware

- Completely remove guest firmware currently.
  - Significant speedup
  - Specific to Linux
- Light-weight firmware
  - e.g. qboot
  - Support more guest operating systems
  - More optimizations maybe needed
- Keep no firmware as an option
  - For usage scenarios requiring extreme launch time

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Status

- [RFC 0/9] Introduce light weight PC platform pc-lite
  - https://lists.nongnu.org/archive/html/qemu-devel/2016-06/msg04842.html
- Github repo
  - Patches: https://github.com/chao-p/qemu/tree/pc-lite-v1
  - Tools/Guides: https://github.com/chao-p/qemu-lite-tools
- Integrated in Intel Clear Container v2
- Ongoing
  - More optimizations for launch time
  - Optimizations for memory footprint
  - Upstream

Q & A