kvmtool - a QEMU alternative?

ARM

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- Overview
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Native Linux KVM tool - Overview

"kvmtool is a lightweight tool for hosting KVM guests."

What kvmtool does:

- Run Linux guests under KVM
- Provide network and block devices (using virtio)
- Emulate some platform devices (8250 UART, PS/2, RTC, VGA)
- Is portable (i386, x86-64, arm, arm64, mips64, ppc)

What kvmtool does not do:

- Instruction emulation
- Emulate different architectures
- Emulate existing platforms (boards)
- Run Windows
- Run on non-KVM-capable machines
- Live in some kernel tree anymore

Brief History

- 2010ish: first posts into tools/kvm of the Linux tree
- 2011: longish discussion about being merged or not
- end of 2012: gains ARM support
- beginning of 2013: gains AArch64 support
- 2014: gains MIPS support
- 2015: separated from the kernel tree

Disadvantanges

- Missing a lot of features
- Missing platform emulation: ACPI (no poweroff on x86!), UEFI
- Non-Linux guest OSes not really supported
- Much less tested
- Some convenience features missing

Advantanges

- Small: around 1.6 MB code size, 35 KLOC
- Builds in seconds
- Easily(TM) cross-compilable
- Static binary possible (roughly 1MB in size)
- Very small dependency chain
- Easily hackable (Yeah!)
- License (GPL-v2)

Usage

```
$ lkvm run -k bzImage
```

- Loads the kernel, passes through the host filesystem (9pfs/virtio)
- Connects the guest serial console to your terminal
- Provides (user level) networking
- Starts a shell prompt ...

- But disk images, initrds and ptys are supported as well!

```
$ lkvm run -k bzImage -i initrd.img -d disk.img -p "root=/dev/vda"
-c 2 -m 512 --tty 0
```

Memory usage

"If kvmtool is so much lighter than QEMU, can one load more guests on a host?"

- Memory usage is dominated by guest's RAM demand
- Guest RAM consumption is driven by the guest and fulfilled by the kernel
- Multiple instances of the same userland process share resources

- What are those guests supposed to do?
- Is there another limit that we run into (CPU, storage, network)?
- Shall I use virtualization in the first place?

Memory usage: /proc/<pid>/status

	kvmtool	QEMU
VmPeak	943392 kB	599124 kB
VmSize	877856 kB	598352 kB
VmHWM	53472 kB	193412 kB
VmRSS	53472 kB	193412 kB
VmData	840164 kB	476876 kB
VmStk	136 kB	136 kB
VmExe	180 kB	7532 kB
VmLib	4504 kB	14708 kB
VmPTE	292 kB	668 kB
VmPMD	16 kB	12 kB
Threads	17	4

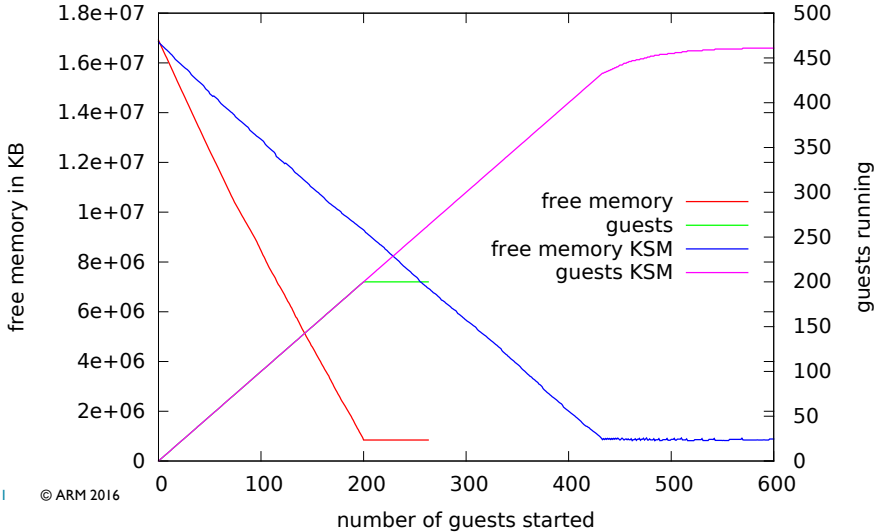
KSM

Kernel same page merging

- Scans memory to find identical pages
- One (physical) page is freed, both VAs now point to the same location
- Marked as read-only, copy-on-write takes care of faults
- `CONFIG_KSM` and `echo 1 > /sys/kernel/mm/ksm/run`
- Works great with many guests, but:
  - Takes CPU cycles to scan the memory
  - Heavy memory over-commitment may invoke OOM killer upon usage

KSM memory usage

QEMU guests with 2 cores and 512MB RAM with 9pfs sandboxed shell



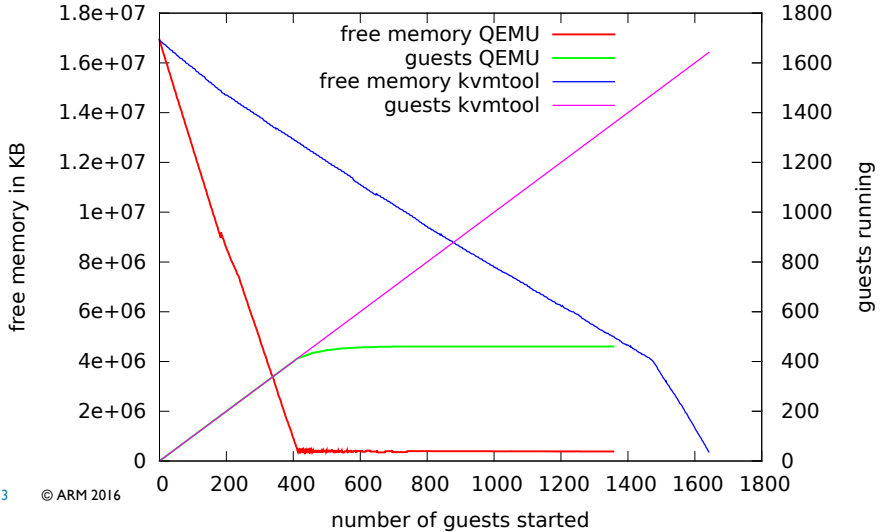
Test

Run as many guests as possible with:

- small RAM size (40 MB)
- two cores
- 9pfs shared filesystem
  - no block device, as disk images consume buffer cache
  - no initrd to allow smaller guest memory
- running with kvmtool (HEAD) and QEMU (2.7.0) on:
  - Core i7 3770 "Ivy Bridge", 16 GB RAM + 8GB swap
  - Calxeda Midway (4 * ARM® Cortex®-A15), 8 GB RAM + 8GB swap
  - (ARM Juno r0 (2 * ARM Cortex®-A57 + 4 * ARM Cortex®-A53), 8 GB RAM + 8GB swap)
- Launch guests until number no longer increases (OOM killer)
- Don't forget to enable KSM!

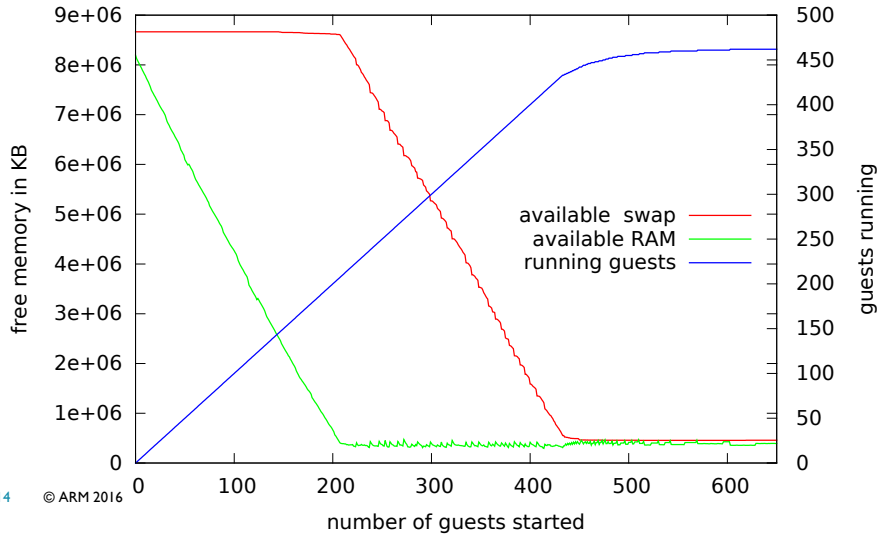
Results: Number of guests

guests with 2 cores and 52MB RAM with 9pfs sandboxed shell



Results: Memory usage

QEMU guests with 2 cores and 512MB RAM with 9pfs sandboxed shell



Known issues

- virtio bug on SMP: guest waits forever for virtio transaction
  - Some race condition in the (heavily multithreaded) virtio implementation
  - Does not manifest with UP guests pinned on a host core
  - Can be observed while booting with NFS root
  - On some host quickly shows even with virtio-blk
  - Debugging and fixes welcome!
- Security issues around file path parsing and string functions
- Some messages have double line endings ;-)
- CPU load of idle guests (observed on x86 only)
- x86 CPUID vendor value is "LKVMLKVMLKVM", prevents some features?

Outlook

- kvmtool works (tm) right now
- Some bugs get fixed, some new (ARM) features added
- Invest in sandboxing feature?
- Adding new features:
  - New emulated devices? No.
  - ACPI emulation? Mmmh.
  - New KVM kernel features? Yes.

Please send bug fixes and reports! Tell about your usecase!

Conclusions

- kvmtool is a different implementation of the KVM ABI
- kvmtool is an easier to handle application (cross compilation, static binary)
  - Does that matter?
- kvmtool is no real competition to QEMU
- kvmtool can show advantages in some cases
  - Wimpy hosts (low memory)
  - Rapid prototyping

Please contribute to QEMU (and help fixing it)!

Questions?

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