ARM virt 3.0 and beyond: towards a better scalability

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Overview

• Mach-virt Introduction
• Scalability Issues
  • VCPU count (qemu 3.0)
  • PCIe bus count (qemu 3.0)
  • RAM size (WIP)
• Conclusion
Virt Machine
What it is, what it isn't

• mach-virt does not correspond to real SOC/Board
• Preferred generic machine for running guests compatible with ARMv7/ARMv8 architectures
• Server-class resources:
  • PCIe and virtio-pci ecosystem
  • GICv3, ITS, SMMU
  • Significant amount of CPUs and RAM
• Not fully SBSA compliant (see “SBSA ref QEMU platform” thread)
Virt Scalability Issues
(< qemu 3.0.0 )

- Physical machines
  - hundreds of cores
  - large number of PCIe devices
  - TBs of RAM
- Virt Machine
  - Max 123 vcpus
  - Max 16 Pcie buses
  - Max 255 GB Initial RAM
QEMU 3.0: Lift the 123 VCPU Limit

- Limiting single redistributor region
- DT/ACPI allow several discontiguous redistributor regions
- 4.18+ kernel now allows to register multiple VGICv3 redistributor regions
- New 64MB GICv3 redistributor region
  - up to 512 VCPUs
QEMU 3.0: Lift the 16 PCIe Bus Limit

- Limiting 16MB ECAM/MMCFG region
- A new 256MB ECAM region (default)
  - not compatible with 32b FW or guest without LPAE (-machine virt,highmem=off)
- More complex topologies and increase in the number of hotpluggable end-points
WIP: Lift the 255GB RAM limit

- Memory optimized VM workloads for large databases/caches, in-memory analytics, ...
- Lift 40b GPA limit
- Device Memory wanted
- Choose a future-proof layout
Lift 40b IPA Limit

- 4.20+: GPA size chosen per VM
  - “kvm: arm64: Dynamic IPA and 52bit IPA”
  - Per VM stage 2 geometry & control register
  - depends on host config and physical CPU (ID_AA64MMFR0_EL1.PARange)

- Still EDK2 ArmVirtQemu also currently limits the PA space to 40 bits by default
Initial RAM / Device Memory

- Initial Ram (-m)
  - ram_size, allocated at boot time
- Device Memory
  - maxmem=<>, slots=<> qemu options
  - maxram_size - ram_size provisioned
  - BE objects/FE memory devices cold-pluggable or hot-pluggable
  - FE devices: pc-dimm, nv-dimm, virtio-mem, virtio-pmem
  - nv-dimm passthrough, DAX on guest, cache page optim, ballooning alternative, ...
- arm64 does not support memory hot-plug/unplug yet
  - [PATCH v2 0/5] Memory hotplug support for arm64 - complete patchset v2 (Nov 17)
  - memory can be cold-plugged though
RAM Layout: Split Memory Model

- Legacy initial RAM and new device memory at 2TB
- "ARM virt: PCDIMM/NVDIMM at 2TB" series
- Pros
  - easy QEMU integration
  - no change to the FW
- Cons:
  - initial memory capped at 255GB
  - no device mem below 1TB
  - static memory map (bad experience on PC)
**RAM Layout: Floating RAM Base**

- Single memory region with floating RAM base
- Part of a larger refactoring strategy
  - Uses only device memory
    - Internal memory devices
    - Usual external memory devices
- **Pros**
  - Easier to fit/carve out new GPA regions
  - Opportunity for NUMA cleanup
- **Cons**
  - FW impact
  - Larger QEMU impact
Floating RAM Base Issue

- EDK2 ARMVirtQemu currently assumes
  - DRAM starts at 1GB and starts with DTB
- Floating RAM base → EDK2 rework:
  - Pass info from QEMU to FW
  - Remove hardcoded addresses in FW code
- Decode where the RAM starts:
  - Pass the dtb base address in one reg and parse it in asm as there is no stack (~ 250 LOC, maintenance issue)
  - pass the RAM base address through fw_cfg (~ 50 asm LOC, no stack either). fw_cfg must be at a fixed address though.
  - keep a small 1MB SRAM region used as a temporary RAM for Pre-EFI at 1GB to fit the dtb, used as initial stack. RAM base is parsed from dtb.
Host IOVA Reserved Regions

- VFIO maps the whole guest RAM through iommu and guest programs the assigned device for DMA with GPA
- Some GPAs cannot be used:
  - not reaching the IOMMU
  - bypassed by the IOMMU (MSI regions)
  - identify mapping enforced by BIOS (RMRR)
  - reserved for host kernel usage
- QEMU should identify them & carve them out
  - [v6,0/7] vfio/type1: Add support for valid iova list management
  - [RFC v2 0/6] hw/arm: Add support for non-contiguous iova regions
  - GFX/USB RMRR integration to be reworked
Conclusion

- VCPU count and PCIe topology Improvements
- WIP related to RAM expansion
  - Rework of the memory layout
  - Floating RAM base experiment
  - Single device memory region experiment
  - New memory device use cases for ARM
- ARM still does not offer
  - VCPU hotplug
  - Memory hotplug
- Host IOVA reserved regions not properly handled
References / Credits

- [PATCH v6 00/18] kvm: arm64: Dynamic IPA and 52bit IPA
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  - Shameerali Kolothum Thodi, Huawei, April 2018
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- [RFC PATCH 0/3] add nvdimm support on AArch64 virt platform
  - Kwangwoo Lee, SK group, July 2016
- [PATCH v2 0/5] Memory hotplug support for arm64 - complete patchset v2
  - Andrea Reale, Maciej Bielski, Scott Branden, Nov 2017
- [RFC v4 00/16] ARM virt: PCDIMM/NVDIMM at 2TB
  - Eric Auger, Red Hat, Oct 2018