Megasas megasas
An efficient SCSI HBA emulation for KVM/Qemu

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Qemu device emulation goals

- Emulate existing hardware
- Emulate common drivers
- Device multiplication
  - Network drivers
  - Storage drivers
- Supports various platforms
KVM device emulation goals

- Efficient emulation on Linux
- Paravirtualisation: virtio
- One device only, but efficient
- Main focus on x86 platform
- (Alex Graf it ported to PPC and S/390 :-)


SCSI device emulation

- Two types: scsi-disk, scsi-generic
  - Scsi-disk emulates disk access
    - Translates every command
    - Using bounce-buffers to transfer data
    - Using bdrv_XXX functions to access backing device
  - Scsi-generic for everything else
    - No command translation
    - SG_IO to pass commands to backing device
SCSI HBA emulation

- Emulates NCR/LSI 53c8xx
- SCSI parallel HBA
- All devices are emulated as SCSI parallel devices
- Emulates on HBA level:
  - Scripts engine
  - SCSI parallel protocol quirks
- Prone to breakage
The search for an HBA
HBA emulation goals

• Should be a SCSI driver
  – I want to use all the nifty sg_XX tools

• Existing driver / hardware
  – Emulate only one side, use existing driver for the guest

• Simple driver / HBA interface
  – Efficient implementation, less coding

• Protocol independent interface
  – All type of devices should be passed/emulated
  – Full protocol handling cumbersome
Protocol independent interface

• Excludes protocol-specific drivers
  – SAS/FC HBA
• Possible HBA types:
  – LSI MPT driver
  – I2O driver
  – RAID driver
Simple HBA interface

- LSI MPT interface rather complex, so not doing it
- I2O … well
- RAID driver:
  - Aacraid: Can't stand Adaptec …
  - Hpsa: new development, not readily available
  - Megaraid: Old interface horrible
  - 3Ware: SATA mainly, not really multiprotocol
- Megaraid_SAS has a pretty simple interface
  - Protocol independent
  - Simple structure
Updating KVM/Qemu
Qemu/KVM SCSI implementation

• Very old style:
  - Requests are opaque, access via 'tag'
  - Sequential processing
  - Call ->send_command() to evaluate CDB
  - Receive completion on tag
  - Call ->read_data() / ->write_data() to fill buffer
  - Receive completion
  - Access the buffer via ->get_buf()
  - Finish command
  - Sense data has to be requested separately
Megasas cmd handling

• Receive command
  - Two type of commands: SCSI Passthrough and direct I/O (Read/Write) commands
  - Data is passed via SGLs

• Handle command
  - Process command
  - Process I/O
  - Handle exceptions

• Send back status & sense code
First try: Rewrite SCSI stack

- Expose the SCSI request to SCSI driver
- Allow driver to pass scatter-gather list to the block driver
- Allow the driver to access sense data directly
- Update existing driver to the new interface
- Quite intrusive ...
Scatter-gather list passing
Scatter-gather list handling

- Scatter-gather list is received by the HBA
- Convert and pass down to backing device
- File-backed:
  - Using aio to write data / sgl to disk
- Device-backed:
  - Using SG_IO to write data/sgl to device
- SG list might be misaligned
- No definite indication for this
  - A priori checking required
Misaligned sg lists

• Request queues on host and guest might have different parameter
• Passing misaligned sg list results in I/O error
• Ideally: queue parameter are aligned
  – No guarantee
• Pass host queue parameter up to the guest
  – megaraid_sas reads parameter off the hba, so we can be passing the information
HBA – disk mapping

- Request queue reflects the HBA settings
- Connecting devices from different HBAs to megasas emulation will not work
- Disallow, have a 1:1 (host)disk / (guest) HBA mapping initially
Developing the driver
Linux driver as template

- Quite complete interface description in megaraid_sas.h
- Implement target side to match linux driver expectations
- Simple frame interface:
  - Driver allocates ring buffer and passes location of head and tail pointer to HBA
  - Driver writes frames, updates head pointer, and notifies HBA via mmio
  - HBA processes frames, updates tail pointer, and notifies driver via doorbell register & interrupt
Windows booting

- HBA detection failed; frame analysis didn't reveal anything
- Analyse qemu traces: driver checks for the number of available frames and aborts??
- Disassemble windows driver:
  - Driver reads the number of frames from the driver
  - If this number is not 1000 → abort
- (How stupid can one get …)
- Fix frame number to 1000
- Windows boots :-)
Management interface

• Most of the protocol given to management functions
• Stand-alone management CLI 'MegaCLI'
• Implement rudimentary functions to make CLI work
• ¼ of calls undocumented
• 'Educated guesswork' to implement missing functions
• CLI now runs without errors
• (without functionality, too)
Initial results
I/O performance

• Bonnie run on LSI:
  • Writing with putc()... done: 33 MB/s 51.3 %CPU
  • Rewriting... done: 27 MB/s 3.4 %CPU
  • Writing intelligently... done: 23 MB/s 4.1 %CPU
  • Reading with getc()... done: 30 MB/s 45.8 %CPU
  • Reading intelligently... done: 1063 MB/s 62.3 %CPU

• Bonnie run on Megasas:
  • Writing with putc()... done: 28 MB/s 45.1 %CPU
  • Rewriting... done: 27 MB/s 3.2 %CPU
  • Writing intelligently... done: 34 MB/s 5.5 %CPU
  • Reading with getc()... done: 51 MB/s 67.0 %CPU
  • Reading intelligently... done: 1220 MB/s 81.0 %CPU
I/O performance (contd.)

• Bonnie run on virtio:
  • Writing with putc()... done: 54 MB/s 80.6 %CPU
  • Rewriting... done: 47 MB/s 5.3 %CPU
  • Writing intelligently... done: 52 MB/s 8.8 %CPU
  • Reading with getc()... done: 58 MB/s 74.8 %CPU
  • Reading intelligently... done: 1318 MB/s 66.9 %CPU

• Bonnie run on Megasas:
  • Writing with putc()... done: 28 MB/s 45.1 %CPU
  • Rewriting... done: 27 MB/s 3.2 %CPU
  • Writing intelligently... done: 34 MB/s 5.5 %CPU
  • Reading with getc()... done: 51 MB/s 67.0 %CPU
  • Reading intelligently... done: 1220 MB/s 81.0 %CPU
Smartd weirdness

• Log during boot:
  • Starting SSH daemon  
    done
  • Starting cupsd  
    done
  • Starting irqbalance  
    unused
  • Starting Name Service Cache Daemon  
    done
  • Starting mail service (Postfix)  
    done
  • Starting CRON daemon  
    done
  • Starting smartd megasas: xfer length mismatch, frame 512 cdb 256  
    unused
  • Master Resource Control: runlevel 3 has been reached
  • Skipped services in runlevel 3:  
    nfs smbfs irq_balancer smartd
LSI legalese

- Got in touch with LSI to get legal clearance
- Legal review at LSI
- Rejected in the sense that LSI will not endorse any HBA virtualisation
- “This would allow you to run LSI driver on a non-LSI hardware” … well, yes … that was the whole point...
- Discussions ongoing.
Multipath testing

- 'Real' SCSI HBA, no problems with multipath setup
- Using LIO-target to emulate disks
- Testing and implementing advanced multipath scenarios:
  - Dynamic ALUA
  - Multipath with Referrals
Upstreaming it

- Fighting with Qemu community
- Main points of contention:
  - SG list mismatch
  - Limited I/O size
- Original LSI HBA emulation transfers data in chunks of 128k, thus allowing for (in theory) unlimited data size
- SGL lists are limited by the hardware / HBA emulation, thus the total I/O size is limited, too.
- But the OS will only allow I/O which matches to hardware limits, hence quite a pointless argument
Next try: Updating existing stack

- Rearrange patchset to send 'real' enhancements first
  - Sense code handling
  - INQUIRY fixes
  - Use SCSIRequest directly instead of referencing it via 'tag'
  - Add possibility to pass in SG Lists
  - Rewrite megasas emulation to match the updated interface

- Leaving existing drivers intact, thus objections should be resolved

- Sending it upstream shortly
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