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shaping tomorrow with you

AER functionality of pass-throughed PCI-e device in Qemu

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Outline

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- Background knowledge
- What’s the problem
- Solution
- Current status and future work

PCI device error mechanism

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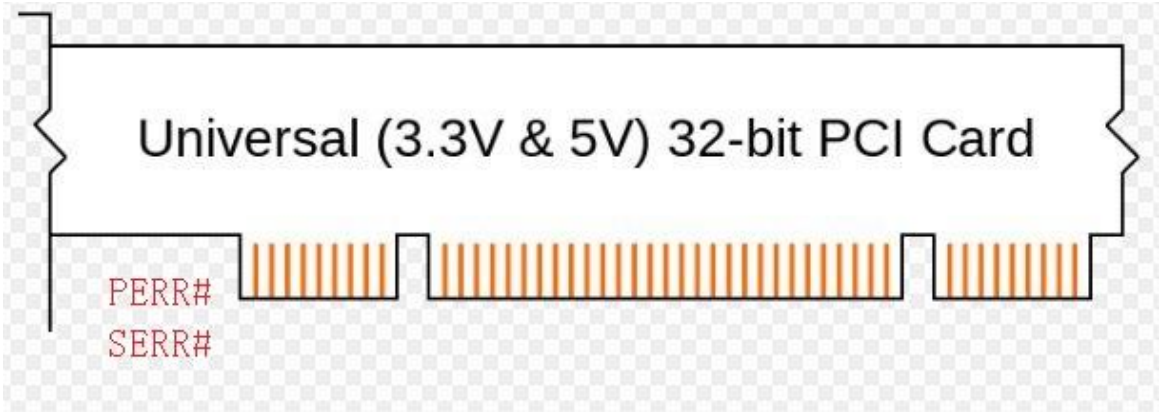
- PCI device is poor



- 2 kinds of errors
  - PERR: Parity Error. Used for signaling data parity errors on all transactions except Special Cycle transaction
  - SERR: System error. Used for signaling address parity error, and data parity error in Special Cycle transaction

PCI Express device error mechanism

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- AER: Advanced Error Reporting
  - PCIe proprietary, optional extended capability
  - Support Error classification
    - Correctable Errors
    - Uncorrectable Errors
      - Non fatal errors
      - Fatal errors
  - Support severity programming for uncorrectable errors

Advanced Error Reporting

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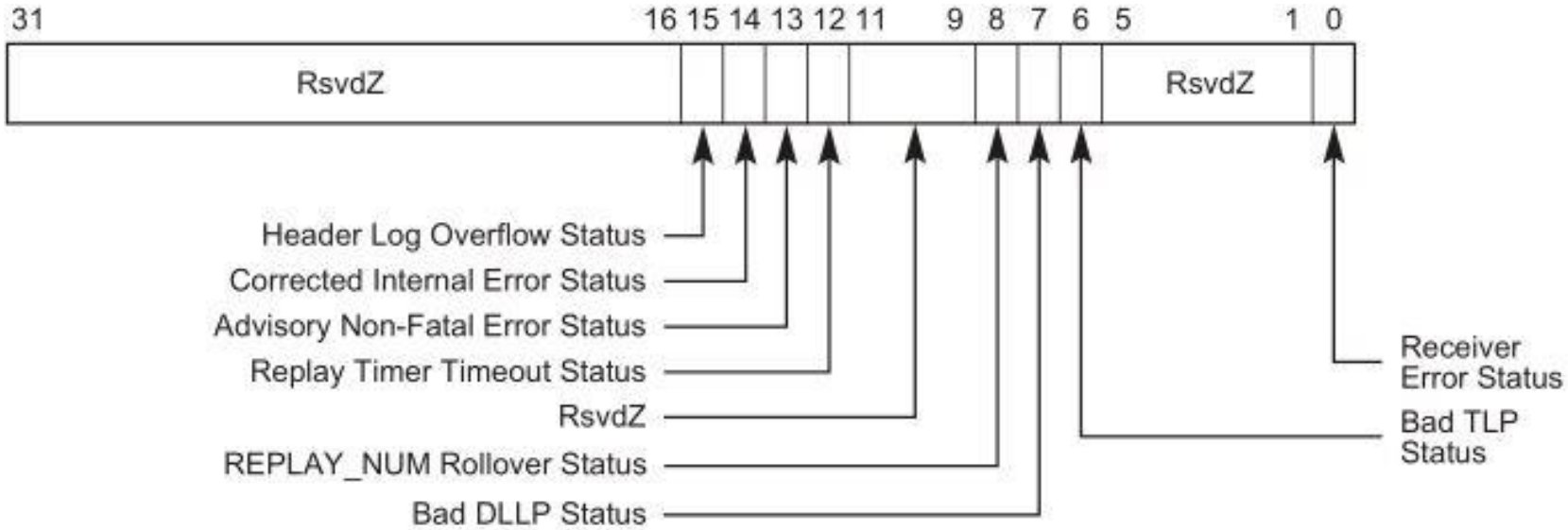
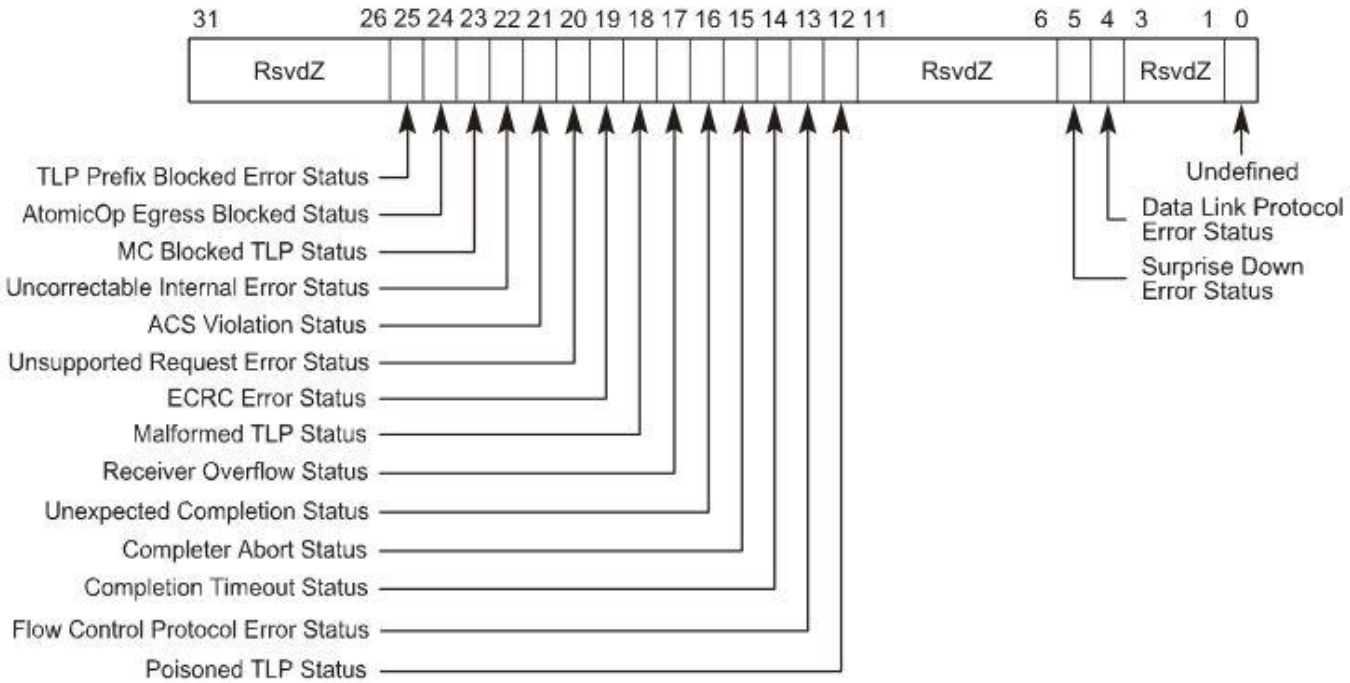
Correctable Errors

The errors that hardware can recover without any loss of information. Hardware corrects these errors without software intervention.



Advanced Error Reporting

- Uncorrectable Errors
  - Fatal: render the particular link and related hardware unreliable
  - Non fatal: cause a particular transaction to be unreliable but the link is otherwise fully functional



Advanced Error Reporting

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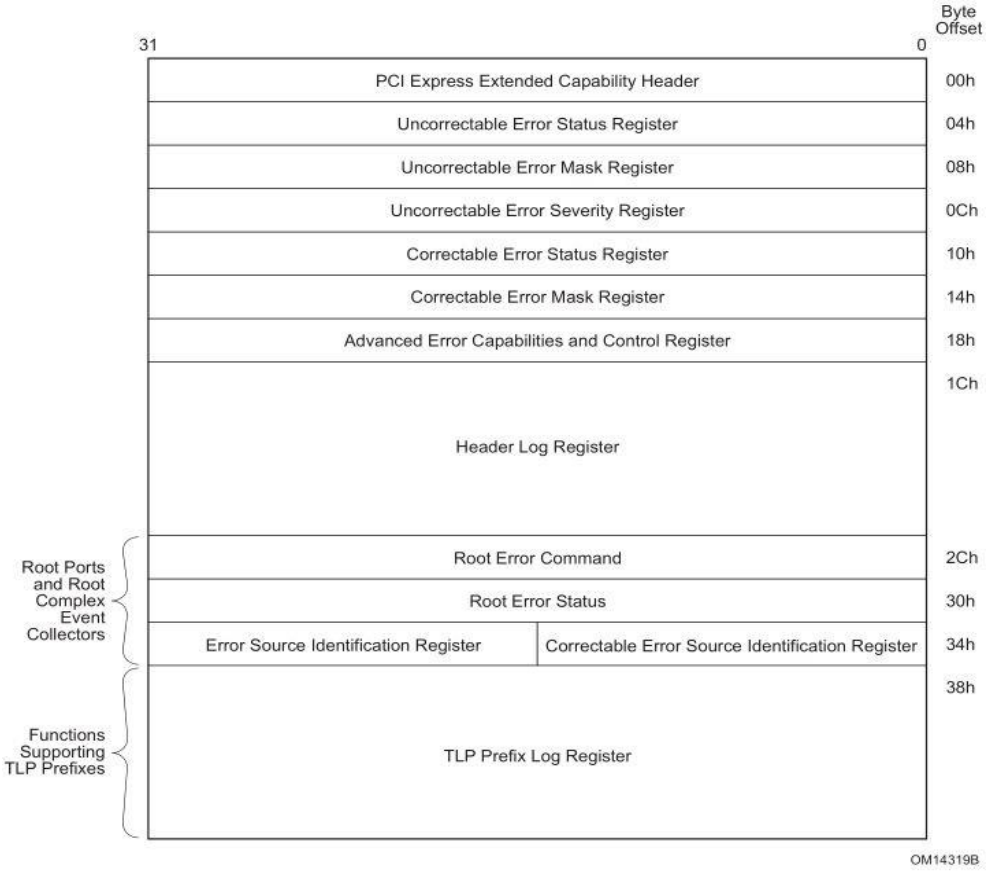
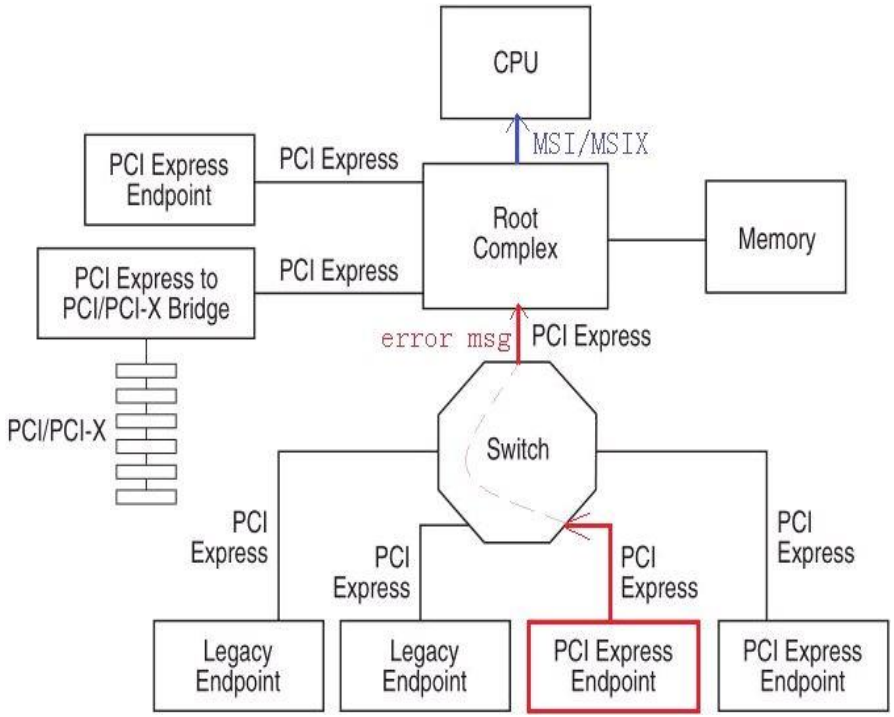
- Error logging & signaling



PCI Express Advanced Error Reporting Extended Capability Structure



AER process in typical PCIe topology

1. AER capability register is implemented by PCIe element who supports AER
2. Root complex is a abstract concept in spec. In practice, it equals **root port** in X86.

Error recovery on Linux

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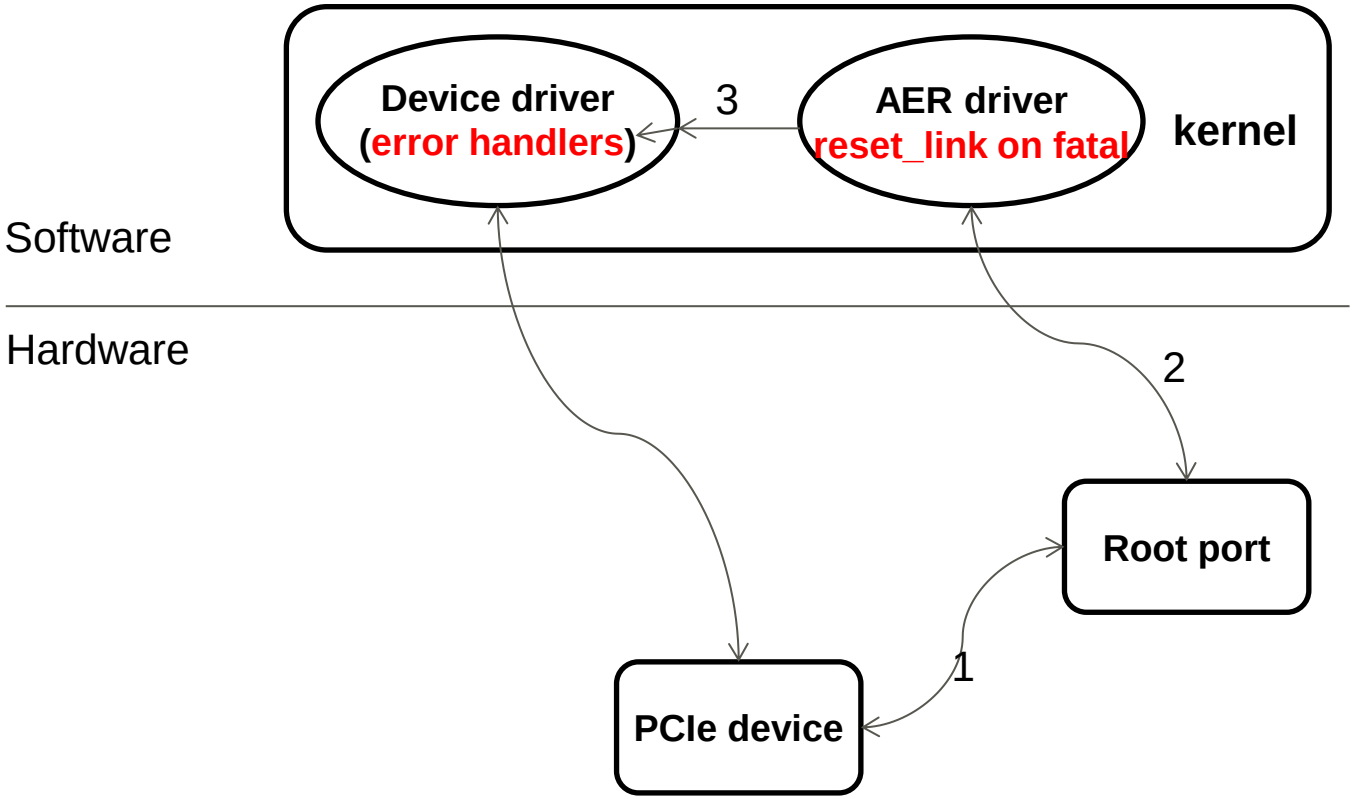
- Recovery is platform specific
  - Documentation/PCI/pci-error-recovery.txt
    - Provide error recovery infrastructure for linux. Error recovery API:

```
struct pci_error_handlers
{
    int (*error_detected)(struct pci_dev *dev, enum pci_channel_state);
    int (*mmio_enabled)(struct pci_dev *dev);
    int (*link_reset)(struct pci_dev *dev); // Deleted recently, AER driver will do link reset
    int (*slot_reset)(struct pci_dev *dev);
    void (*resume)(struct pci_dev *dev);
}
```

  - Documentation/PCI/pcieaer-howto.txt
    - Describe the basics of AER driver
    - Provides the infrastructure to support PCIe AER capability
    - Gathers the comprehensive error information if errors occurred
    - Performs error recovery actions

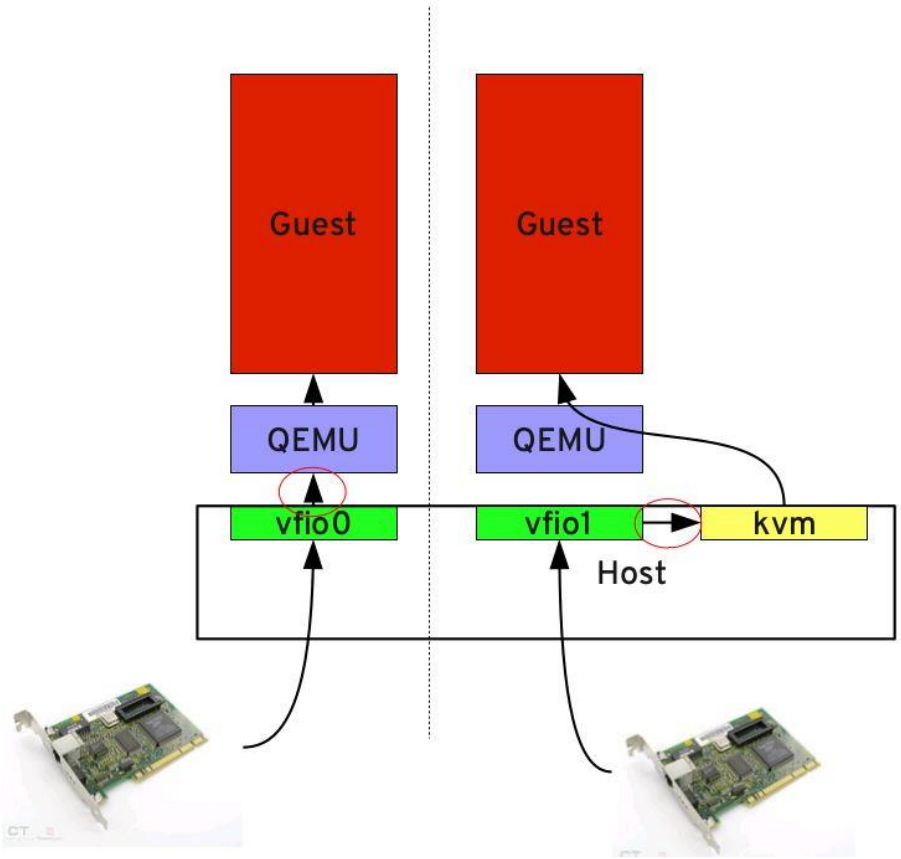
Error recovery process on linux

- 1. Error is detected, logged, then sent to root port
- 2. Interrupt to signal OS via MSI/MSIX
- 3. AER IRQ handler perform recovery mainly via recovery API implemented by device driver



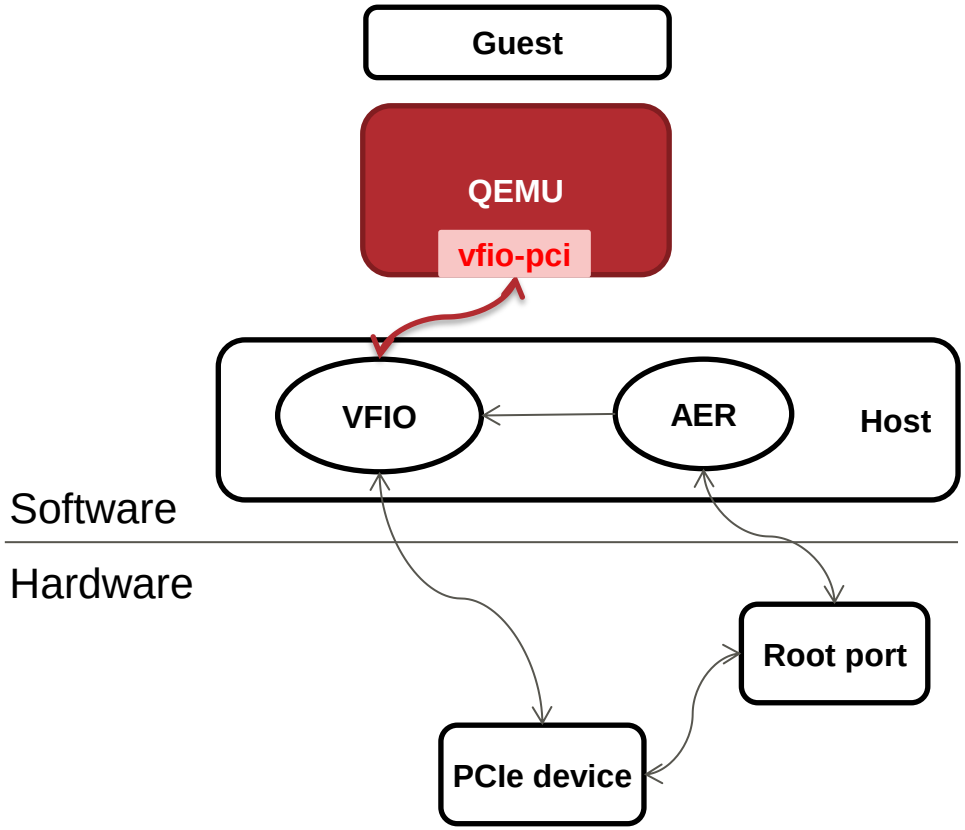
QEMU

- PCI-e device is pass-throughed to VM for performance
  - Via VFIO driver: Documentation/vfio.txt
  - VFIO provides a framework to implement user space driver
  - Qemu acts as the user space driver for the pass-throughed device



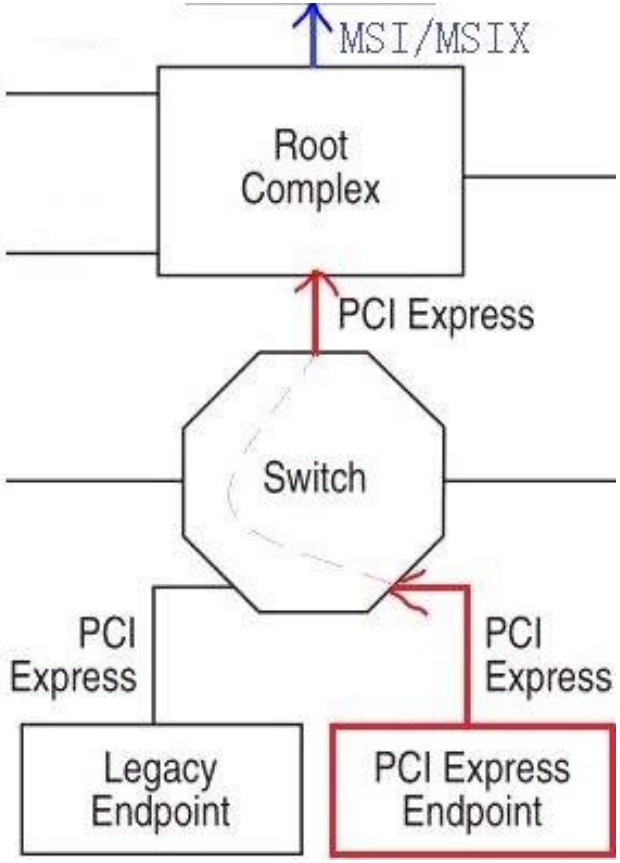
What's the problem

- QEMU VM with pass-throughed PCIe device will vm_stop on any error event



Solutions

- Solution 1 starts with
  - QEMU emulates the hardware logic to signal error message to guest
  - Then just let guest do the recovery



Solution 1

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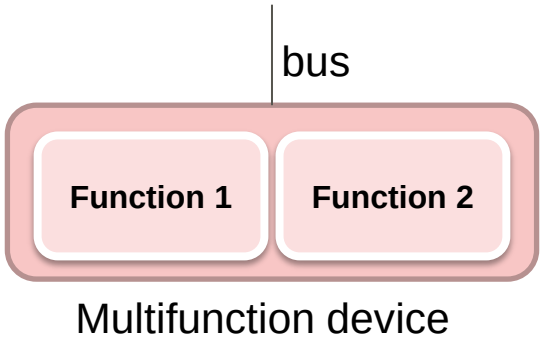
- Problem A
  - Depends on: PCIe Multi-function Hot plug/unplug[*]
    - Causation: all functions of a multi-function device could be assigned
    - Commit: ***0d1c7d88ad*** & ***3f1e1478db*** of QEMU

- Problem B
  - Configuration restraint of multi-function device
    - What: topology of multi-function device should look the same between host and guest.
    - Why: link reset request from one function would reset all functions
    - Result: involve many check during initialization

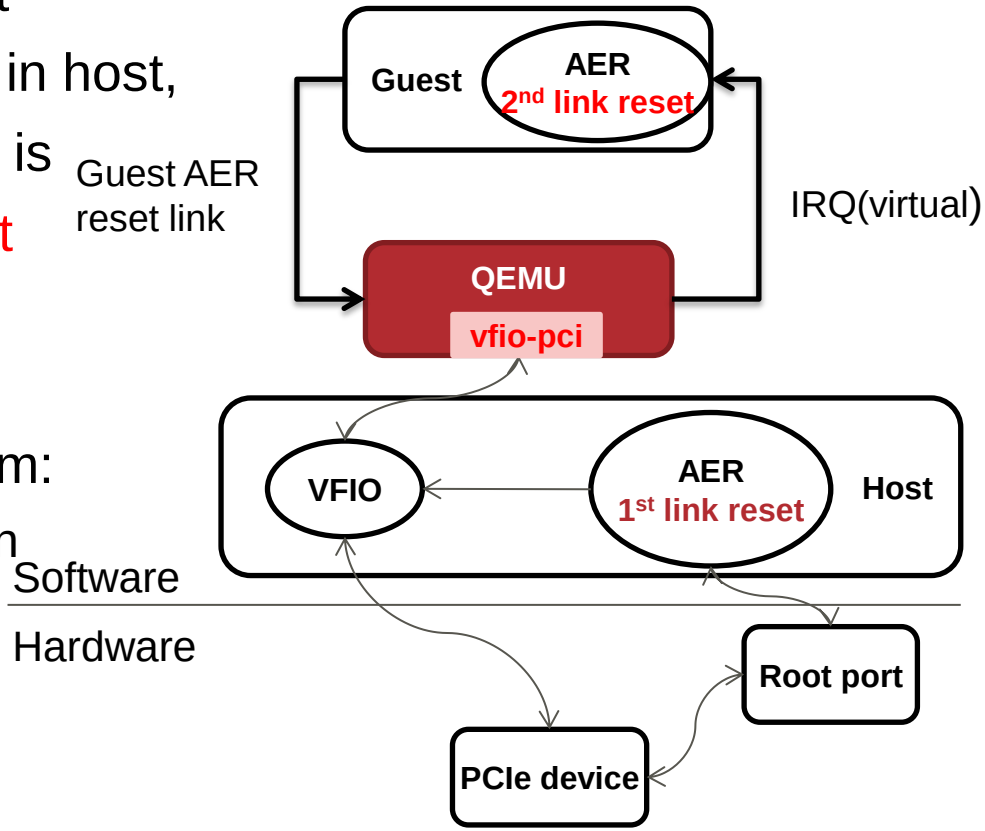


Multifunction device

[*] http://lists.nongnu.org/archive/html/qemu-devel/2015-07/msg05536.html

Solution 1

- Problem C: Link reset 2 times on fatal error.
  - Found during test
  - AER driver in host reset link first
  - vfio-pci device detect fatal error in host, forward these info to guest as it is
  - vfio-pci translate guest link reset to host link reset[*]
  - Effort was made to serialize them: involves vfio_pci driver modification



[*]If there is ever a case where a driver within the guest could trigger a link reset for the purposes of error recovery when the host has not, I think this must be the case – Alex Williamson <alex.williamson@redhat.com>

Solution 1

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- Problem D: guest will oops by igb driver during recovery
  - We use Intel 82576 NIC for test
  - Our patchset exposed the issue of igb driver, also exposed that 2 link reset are not fully separated
  - Fix guest oops issue with ***629823b872*** of kernel

- Problem D solved, but still can’t recover
  - Hardware resetting from host link reset is parallel with guest recovery
  - Guest recovery involves many register access(cfg&mmio)
  - Guest register reading got invalid value

Solution 1

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- After much investigation, finally got a really workable version
  - Key point: skip host link reset for fatal error
    - In regular environment, a standard fatal error recovery steps look like:

      error_detected→ …→ reset link →…→ resume
    - In our case, it becomes

      reset link(host) → error_detected(guest) → … → reset link(guest) → … → resume(guest)
  - Don’t translate a guest link reset to a host link reset
    - Why : guest link reset should reset the virtual link inside Qemu, a virtual link represented by software would never be broken.
    - So, only virtual devices under the link need to be reset. In our case, vfio-pci device’s reset will be translate into a FLR(Function level reset)

workable version: http://lists.nongnu.org/archive/html/qemu-devel/2016-11/msg04825.html

Solution 1

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- Comments on the workable version
  - If skip host link reset, how guarantee vfio's user will do the link reset?
    - VFIO's user is not necessarily a VM, could be dpkg, etc.
    - User is not reliable.
  - Function Level Reset(FLR) doesn't equal to link reset.

- Conclusion
  - Hard issue, Need re-consideration for complete solution

Solution 2

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- Non fatal recovery only
  - From Michael S. Tsirkin <mst@redhat.com>
  - Could workaround the link reset issue for fatal error
  - Also take multi-function device which has different drivers into consideration

- Community Sounds?
  - Fatal error has witness, but non fatal error?
  - Extensibility(fatal error support in the future)?

Current status and future work

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- For solution 2
  - Can we find a real scenario that could trigger real non-fatal error?
    - Hardware error mainly results from heat, humidity, dust, vibration and bad electrical connections.
    - It is hard to trigger real hardware errors.
    - AER driver debugging uses aer_inject tools to fake error(include driver & user space application)
- For solution 1, continue the investigation
  - SR-IOV: enterprise use case, VF doesn’t have link reset issue
  - Optimization to fully skip the back-to-back link reset

Design principles – Alex Williamson

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- Do the right thing for the guest
  - Don't presume that different reset types are equivalent
  - leaving gaps where we expect the guest/host to do a link reset and don't follow through on other reset requests.
  - Notify the guest immediately for the error.

- Do the right thing for the host
  - Should not give the user the opportunity to leave a device in a state where we haven't at least performed a bus reset on link error (which means host link reset is necessary).

Q & A

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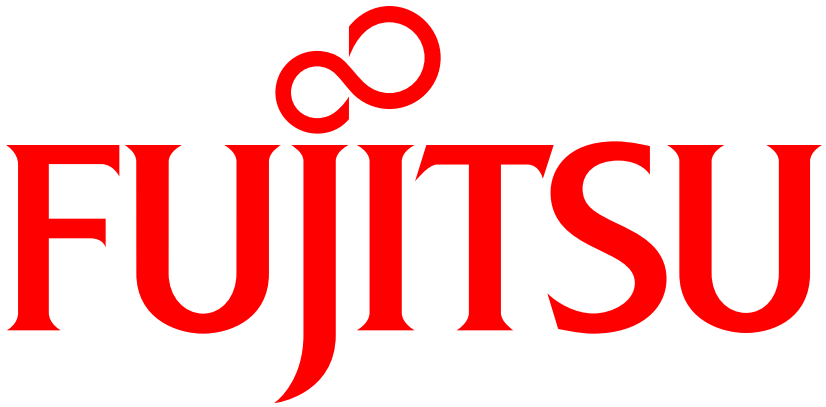

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