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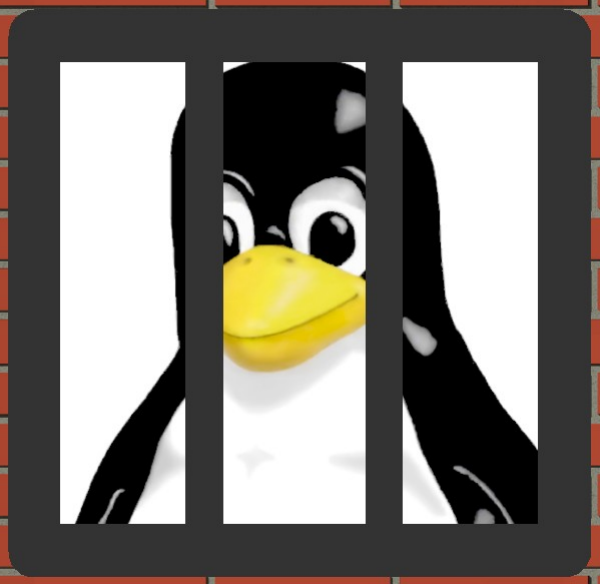

Siemens Corporate Technology | July 2016

IPC for the Partitioning Hypervisor Jailhouse

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Agenda

- **Jailhouse introduction & philosophy**
- IPC requirements and status quo
- Inter-partition networking prototype
- Demonstrations
- Summary

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What is Jailhouse?

A tool to run

… real-time and/or safety tasks

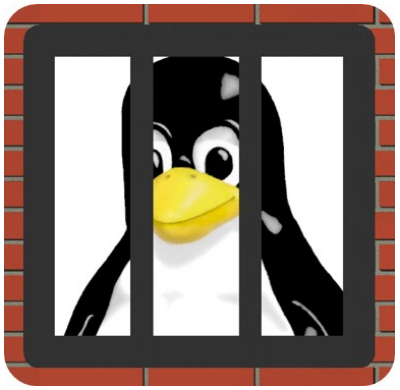
… on multicore platforms (AMP)

… aside Linux

It provides

- **strong & clean isolation**
- **bare-metal-like performance & latencies**
- **no reason to modify Linux** (well, almost)

… and it's open source (GPLv2)



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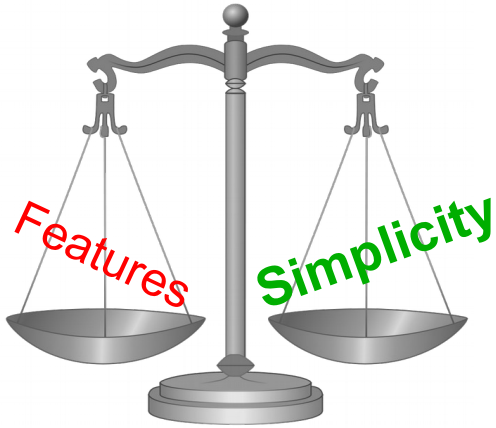
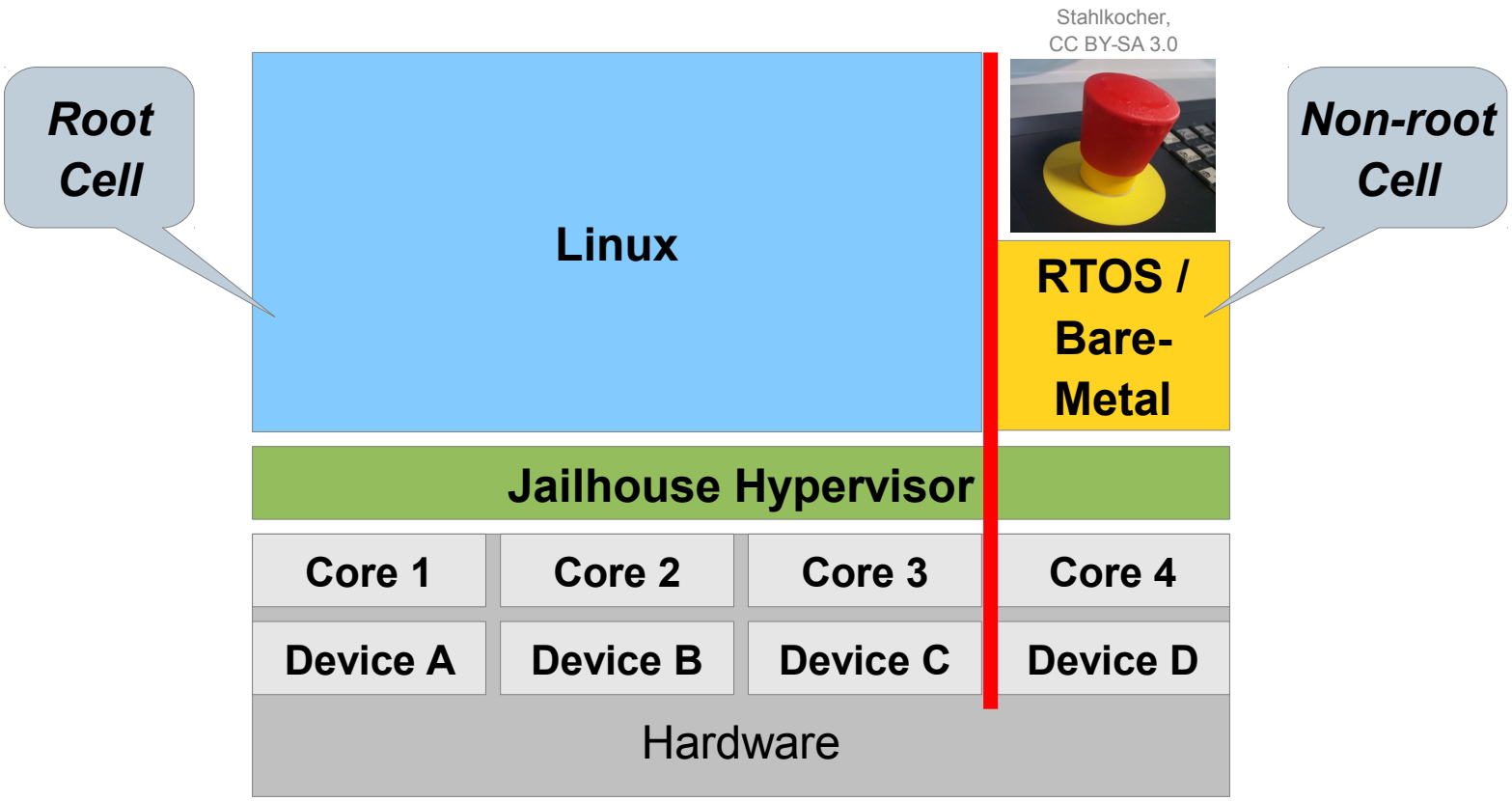
What makes Jailhouse different?

- **Use virtualization for isolation – *ok, nothing new***
- **Prefer simplicity over features**
  - Resource access control
    instead of resource virtualization
  - 1:1 resource assignment
    instead of scheduling
  - Partition booted system
    instead of booting Linux
  - Do not hide existence of Jailhouse
- **Offload work to Linux**
  - System boot
  - Jailhouse and partition (“cell”) loading & starting
  - Control and monitoring



Asymmetric Multiprocessing with Jailhouse



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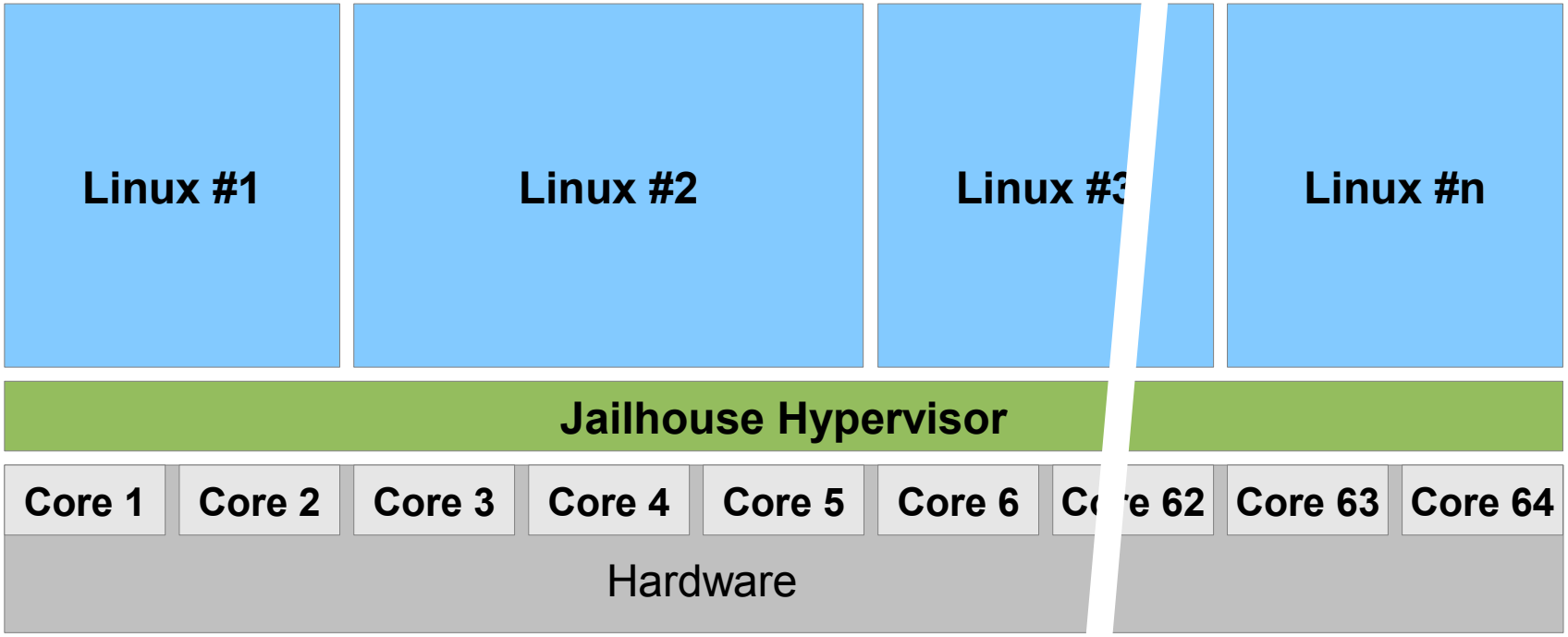
Hard Partitioning of Linux



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Requirements on Inter-Partition Communication in Jailhouse

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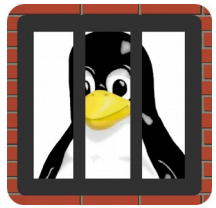
- **Local peer-to-peer channels**
  - Hardware independent, portable
  - Focus on two cells, multicast not (yet) in scope
- **Minimal work for hypervisor**
  - Static setups, no dynamic reconfigurations
  - Agnostic to communication protocols
- **Untrusted peers**
  - One side safety-related, the other not
  - Both sides safety-related, but validating each other
  - Secure isolation: one side hides secret from the other
- **Performance matters, but does not rule**
  - Try hard to be fast, low overhead
  - But when in conflict, strict isolation and simplicity win

Adapting ivshmem

- **Inter-VM shared memory (ivshmem) device in QEMU**
  - Designed for shared memory based communication
  - Works between applications inside VMs
  - Multiple peers
  - Doorbell interrupt
  - Supports VMs on different hosts → live migration
  - Modeled as PCI device with 3 resources:
    shared memory, control registers, MSI registers
- **Jailhouse variant**
  - Shared r/w memory region of two cells at most
  - Local only, no migration
  - Only MSI-based doorbell (currently)
  - Shared memory not relocatable via BAR

>1000 LOC

340 LOC



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Alternative Inter-VM Communication Mechanisms

- **Classic virtio-based**
  - Well established in QEMU/KVM context and beyond
  - Allows networks, consoles and even more
  - Focused on hypervisor ↔ guest setups
    (hypervisor can freely access guest)
  - Requires copying between VMs
- **vhost-user**
  - Replaces hypervisor with separate user-space process
  - Does not resolve the access requirements
- **vhost-pci**
  - Proposal for NFV scenarios, aims at highest performance
  - Builds on top of virtual IOMMUs to reduce copies
  - Very complex because of IOMMU emulation

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Alternative Inter-VM Communication Mechanisms (2)

- **Xen grant table**
  - Simpler than vhost-pci
  - Requires runtime remappings for safe / secure operation
- **remoteproc / rpmsg**
  - virtio-derived, focusing AMP scenarios
  - Assumes that co-processor can access whole host-processor address space
  - Currently too asymmetric
  - Pattern to copy: reuse virtio queues!
- **...**

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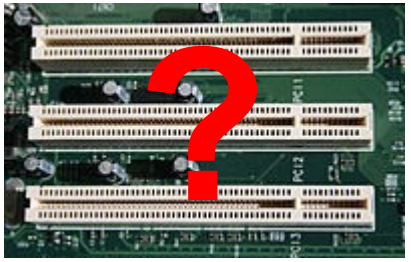
Enabling PCI-free Targets for ivshmem

- **How to bring ivshmem to ARM?**
  - Often, there is no physical PCI host bridge, thus no place to inject ivshmem virtual devices
  - ivshmem as platform device?
  - Or rather add a virtual PCI host bridge?

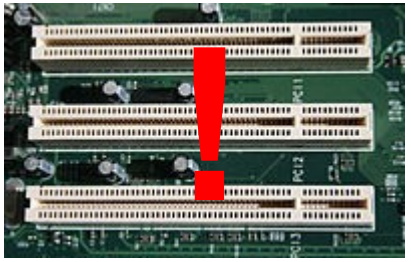



```
core: pci: Add virtual host controller
...

 hypervisor/include/jailhouse/cell-config.h | 2 +-
 hypervisor/pci.c                           | 8 ++++++----
 2 files changed, 5 insertions(+), 5 deletions(-)
```

Enabling PCI-free Targets for ivshmem (2)

- **How plug in the virtual PCI host bridge?**
  - Not yet available during boot-up,
    only after Jailhouse is enabled
    → cannot be part of device tree
  - Linux does not expect such bridges to be hot-plugged
- **What about those device tree overlays?**
  - Invented to address reconfigurable hardware
    like FPGAs, extension boards (for the Pi or BeagleBone)
  - Support already in upstream – well, almost...
- **What is missing?**
  - No overlay-aware DTC in upstream
    → use Pantelis Antoniou's DTC branch
  - No easy way of injecting DTB overlay blobs
    → use Pantelis' configfs patch



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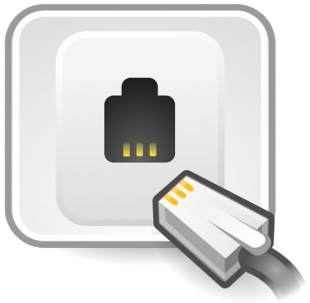
ivshmem-net – Networking over shared memory

- **Build upon ivshmem support in Jailhouse**
  - Register on PCI device
  - Use shared memory as transport
- **Reuse virtio**
  - Not the device layer
  - ...but the queues: mature data structures and access protocols
- **Early prototype by Måns Rullgård is working**
  - linux/drivers/net/ivshmem-net.c: 470 line of code
  - iperf3 throughput room ↔ non-root cell: 2.2 Gbit/s
  - Round-trip latency: ~20 µs
  - To optimize: too many interrupts under high load
  - Life-cycle management lacking: what if one side restarts?
  - Zero-copy RX?



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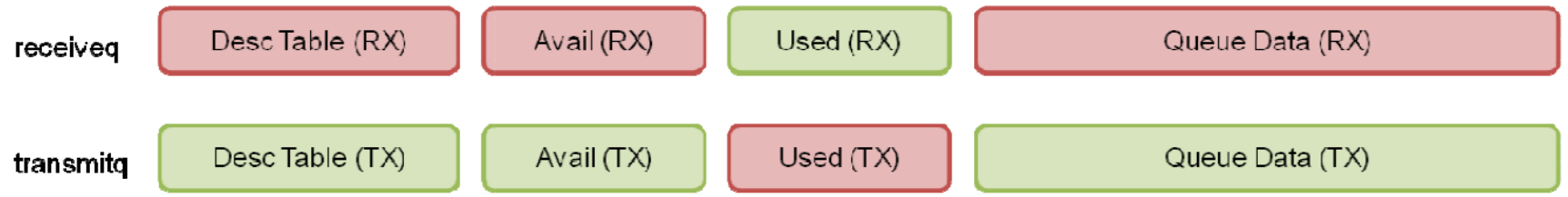
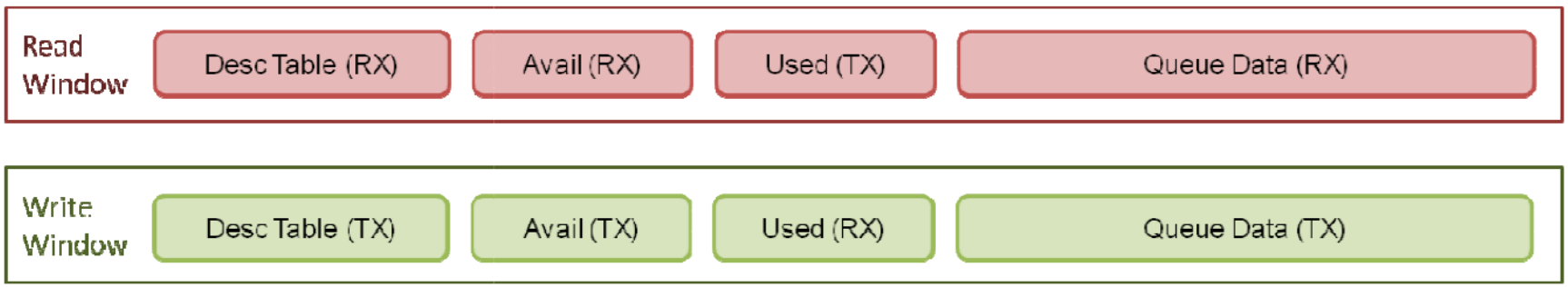
Managing virtio Queue Access More Strictly

Virtqueue View



Window View



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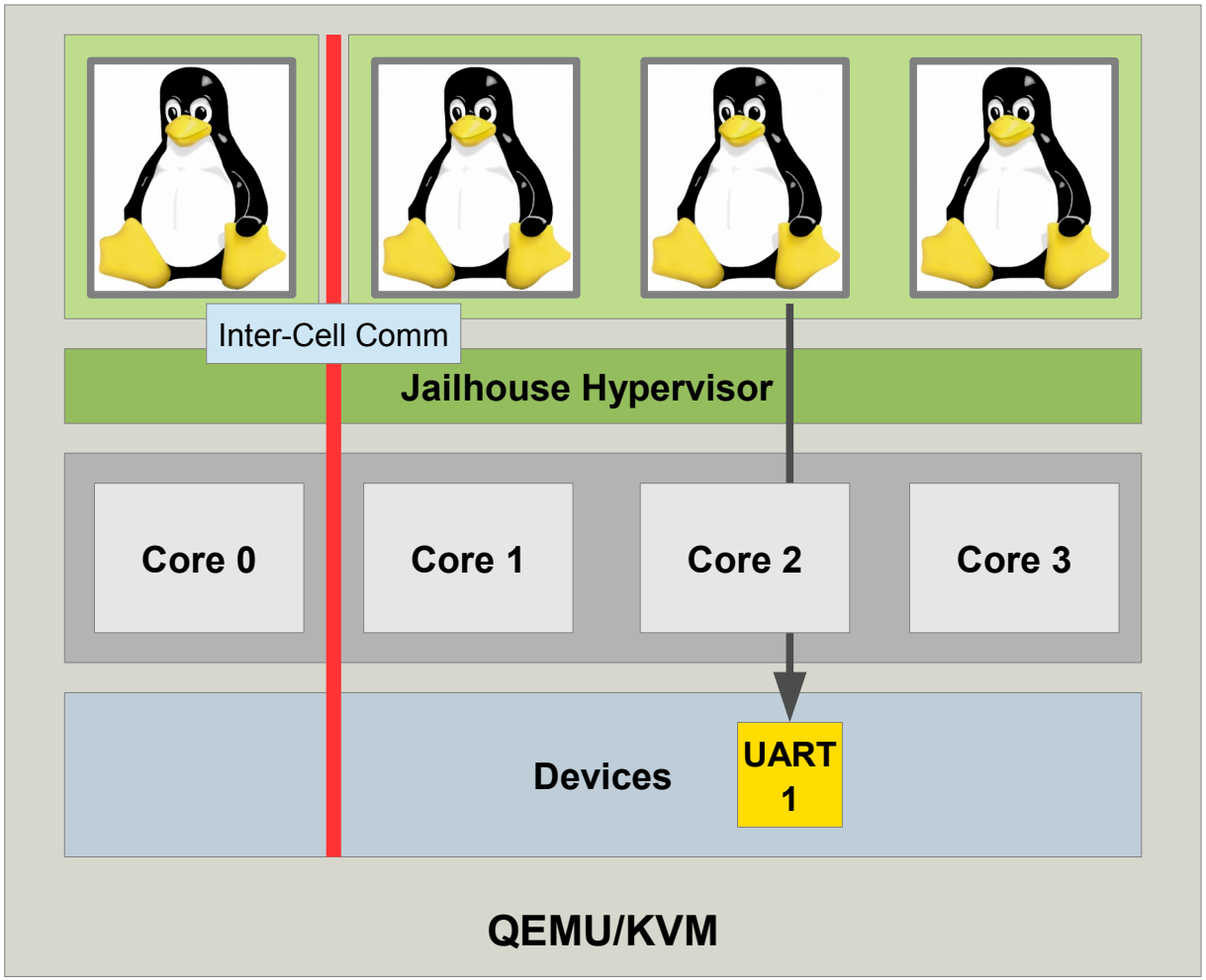
Live Demonstration

Jailhouse booting Linux



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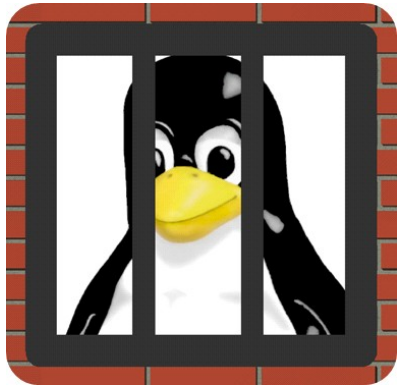
Summary



- **Jailhouse needs guest-to-guest communication**
  - Simpler (for the hypervisor) than usual
  - Still fast enough to address common needs
  - Strict separation mandatory
- **ivshmem-based networking prototype**
  - Reasonable but not yet optimal throughput
  - Ongoing work to enable it also on ARM
- **Outlook**
  - Strict isolation via read/write / read-only split of shared memory
  - Full life-cycle management, likely via some “ivshmem 2.0”

Any Questions?

Thank you!

https://github.com/siemens/jailhouse

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