Best Practices
for RHEL on System z

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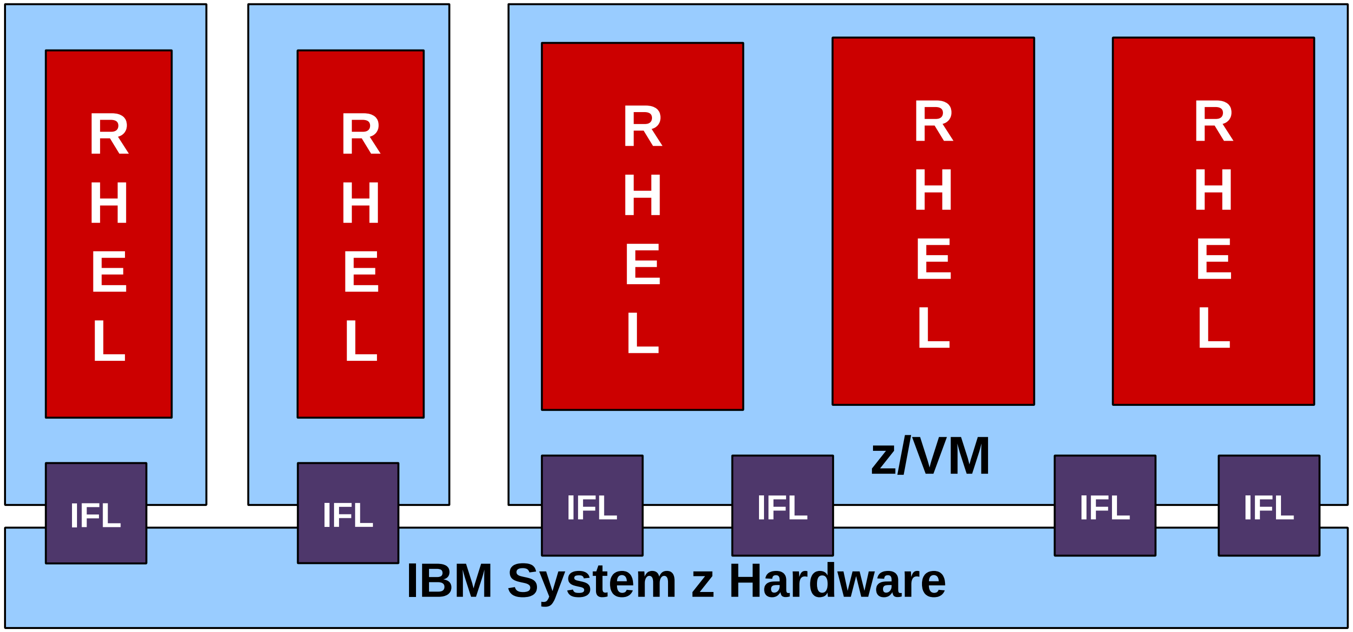
Agenda

- Initial Layout
- Memory Configuration
- Disks
- Networking
- Resource Sharing

Initial Layout

LPAR vs. z/VM

- “Should I install RHEL directly in LPAR, or on top of z/VM?”
- LPAR mode
  - Good for small number of systems, and saves software cost of z/VM, but..
  - Limits scalability, utilization, some dynamic changes
  - Access to thousands of I/O resources system-wide creates its own scalability issues
    - udev allocates resources for each device
    - Don't forget possibility of human error

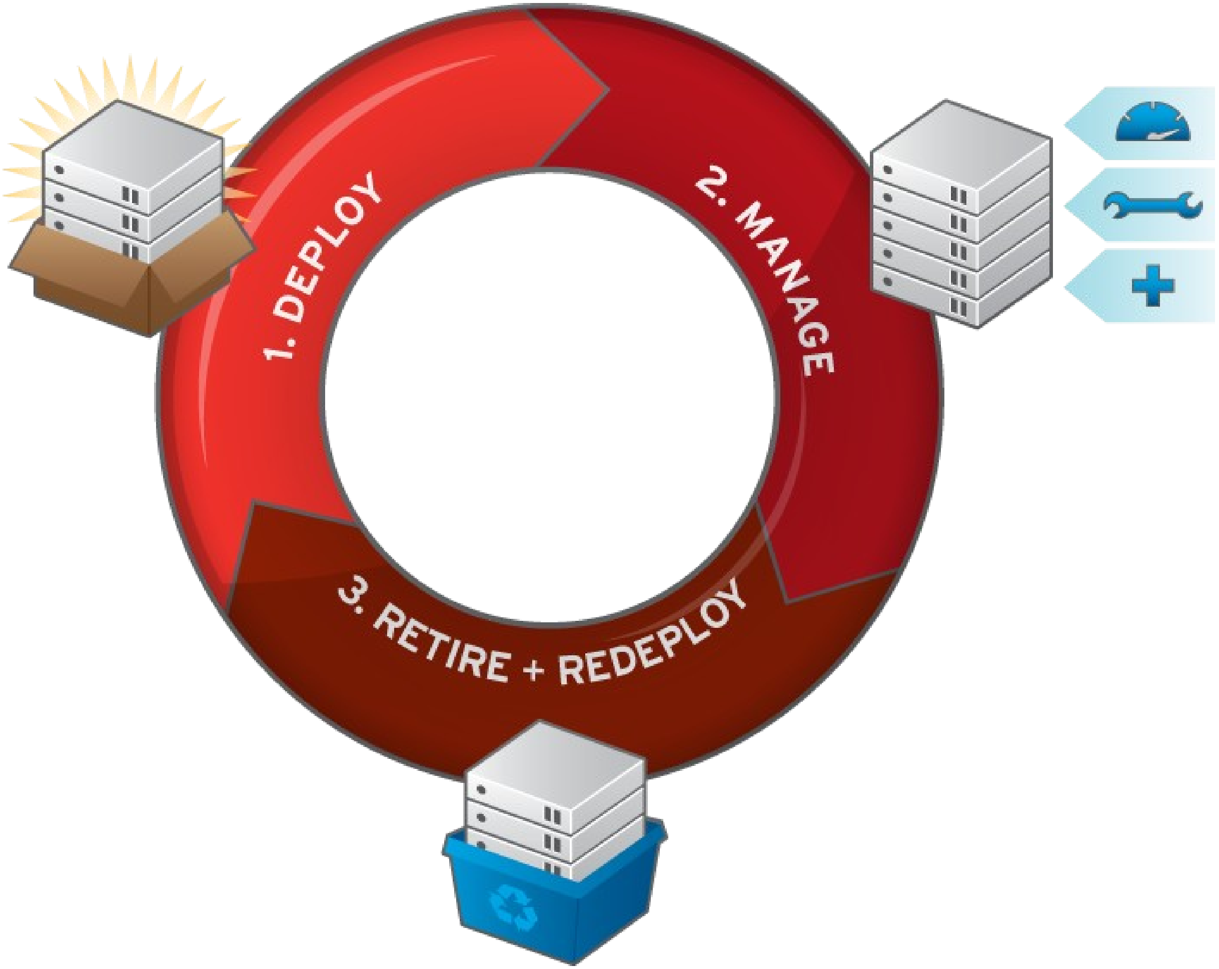


LPAR vs. z/VM

- z/VM
  - Some estimate 5% virtualization overhead, probably lower, but benefits outweigh overhead
  - Better utilization with VM scheduler
  - Advanced virtualization features
    - Virtual networking
    - Memory management
    - Hypervisor network services
  - Staging environment
    - Run z/VM inside z/VM

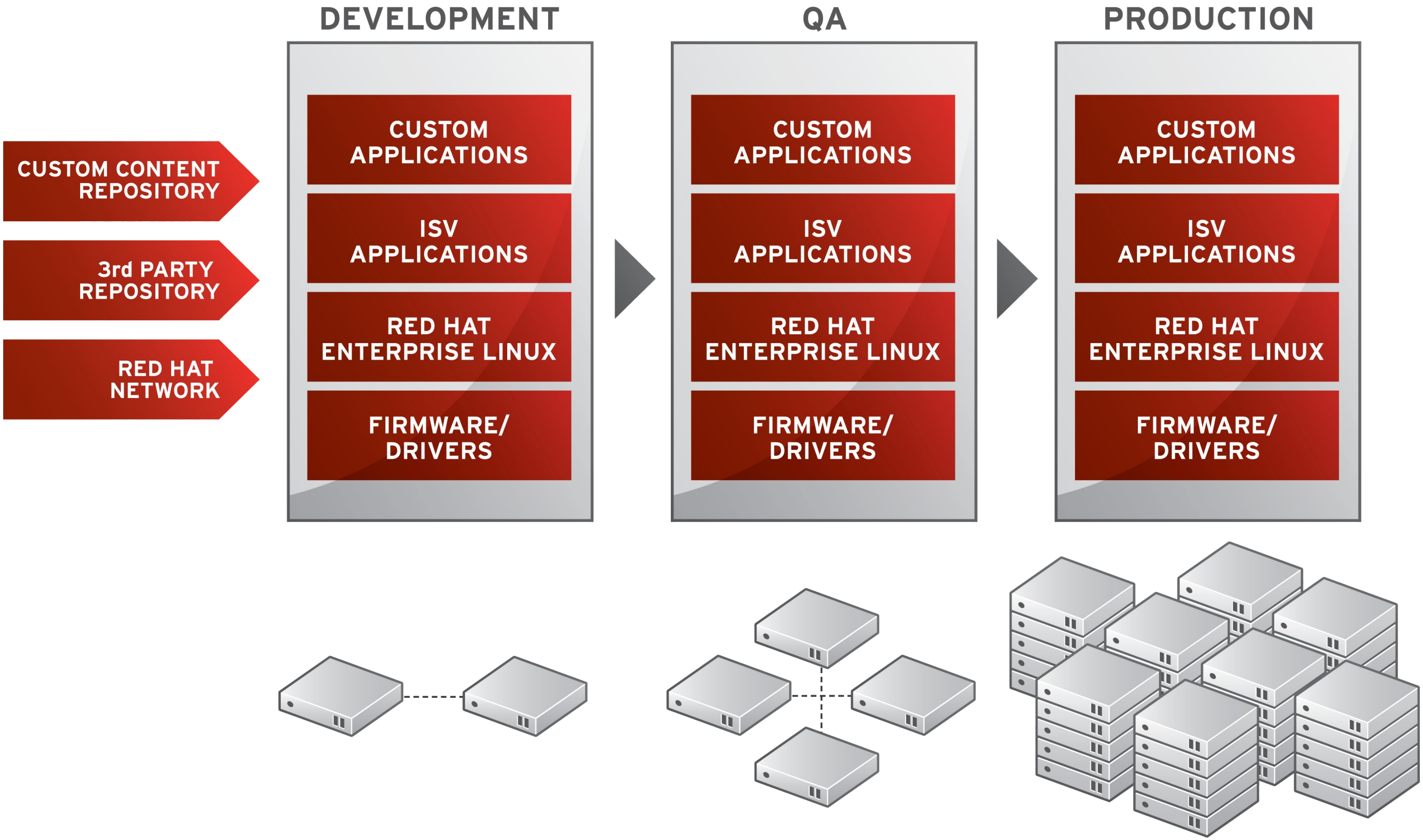
Installing Additional Guests

- RHN Satellite
  - A system management platform designed to provide complete lifecycle management of the operating system and applications.



Installing and Managing Guests

- Replicated Environments



CUSTOM CONTENT REPOSITORY

3rd PARTY REPOSITORY

RED HAT NETWORK

DEVELOPMENT

CUSTOM APPLICATIONS

ISV APPLICATIONS

RED HAT ENTERPRISE LINUX

FIRMWARE/ DRIVERS

QA

CUSTOM APPLICATIONS

ISV APPLICATIONS

RED HAT ENTERPRISE LINUX

FIRMWARE/ DRIVERS

PRODUCTION

CUSTOM APPLICATIONS

ISV APPLICATIONS

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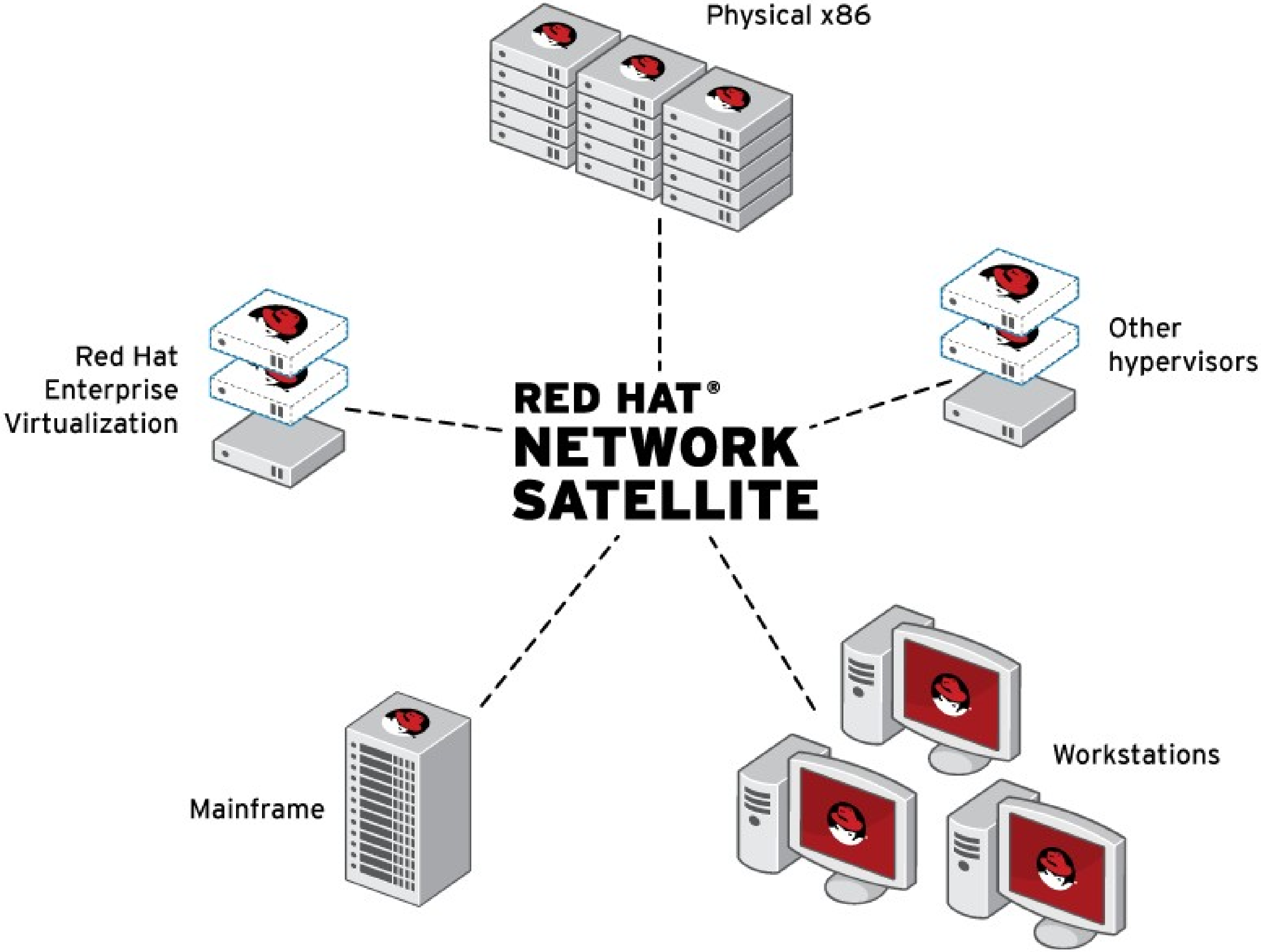
FIRMWARE/ DRIVERS

Installing and Managing Guests

- RHN Satellite: Manage multiple platforms from single interface



Memory Configuration

Resource Allocations

- “What are the minimum/maximum system requirements for a RHEL guest?”
- Memory
  - Minimum
    - 512 MB for NFS install, 768 MB for HTTP/FTP
    - After install, minimum 256 MB, except special cases
      - For example, router or firewall can be 64 MB
  - Maximum
    - z/VM: 256 GB real, 1 TB virtual (real + swap)
  - Recommended
    - Rule of thumb: Divide memory on Unix/x86 by 4
      - In one case, Oracle was moved from 32GB system to 4GB z/VM guest

Resource Allocations

- “What is the ideal swap configuration?”
  - Linux Swap
    - VDISK: Virtual disk in memory, allocated on use, backed by Expanded memory allocated to LPAR
    - Increase limits in z/VM SYSTEM CONFIG

```
Vdisk ,
  Userlim infinite ,        /* user */
  Syslim  infinite          /* system */
```

    - SWAPGEN.EXEC: Define VDISK swap
    - http://www.sinenomine.net/products/vm/swapgen
    - ftp://www.redbooks.ibm.com/redbooks/SG247492/SG24-7492.tgz
    - Put on shared disk (preferred) or copy to each guest

Resource Allocations

- Swap configuration
  - Linux Swap
    - Usage in PROFILE EXEC for each user
      - SWAPGEN <virtual_disk> <size in 512 byte blocks>
      - Example: SWAPGEN 300 524288
        - Define disk 300, size 256 MB
    - Small VDISK for high priority swap space: 256 MB
      - */etc/fstab*: /dev/dasdX1 swap swap **pri=-1** 0 0
      - To find X, use 'lsdasd' and look for disk 300
    - Next VDISK is twice the size of the first: 512 MB
      - */etc/fstab*: /dev/dasdX1 swap swap **pri=-2** 0 0
    - Finally, add some ECKD DASD for emergency
      - */etc/fstab*: /dev/dasdX1 swap swap **pri=-3** 0 0

Resource Allocations

- “How should I size the guest based on the expected workload?”
  - Linux memory usage
    - Check /proc/meminfo:
      - Buffers: xxx kB
      - Temporary storage for raw disk blocks. Sometimes gets filled with directory entries (dentries) when apps scan many directories.
      - Solution: /proc/sys/vm/vfs_cache_pressure
      - More info
        - http://www.linuxinsight.com/proc_sys_vm_vfs_cache_pressure.html
        - Recommended: set to 10,000
      - More dangerous but immediate
        - http://www.linuxinsight.com/proc_sys_vm_drop_caches.html

Resource Allocations

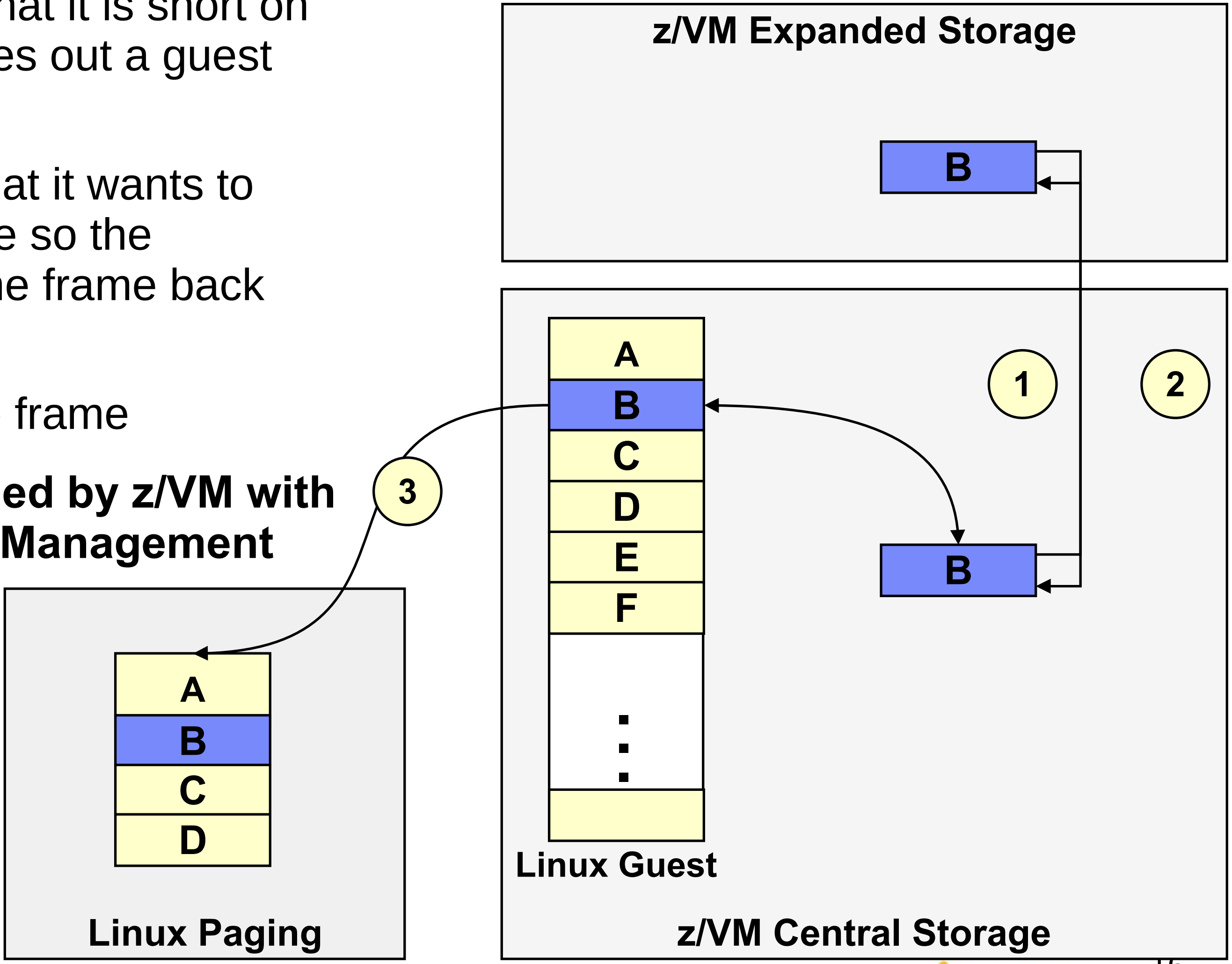
- Memory
  - Linux memory usage
    - Check /proc/meminfo:
      - Cached: xxx kB
      - Pagecache. Think of this as memory cache for applications/processes. Linux should swap these out over time, but sometimes this grows to a large number.
      - Solution: /proc/sys/vm/swappiness
      - How aggressively the kernel swaps pagecache to disk. Default value 60 is reasonable for most workloads. Increase value (i.e. 70) to make Linux more inclined to swap, leaving more memory free for caches. Decrease value (i.e. 50) to make Linux less inclined to swap, and improve application responsiveness.
      - More info
        - http://people.redhat.com/nhorman/papers/rhel4_vm.pdf

Resource Allocations

- Memory
  - Linux memory usage
    - Check /proc/meminfo:
      - Committed_AS: xxx kB
      - An estimate of how much RAM/swap you would need to make a 99.99% guarantee that there never is OOM (out of memory) for this workload. Use this as a guideline for how much memory/swap to define.
- “How much memory can I safely overcommit in z/VM?”
  - Overcommit in z/VM
    - 1.5:1 to 2:1 for production, 4:1 for development
    - Don't forget to add z/VM swap, “q alloc page” for current usage

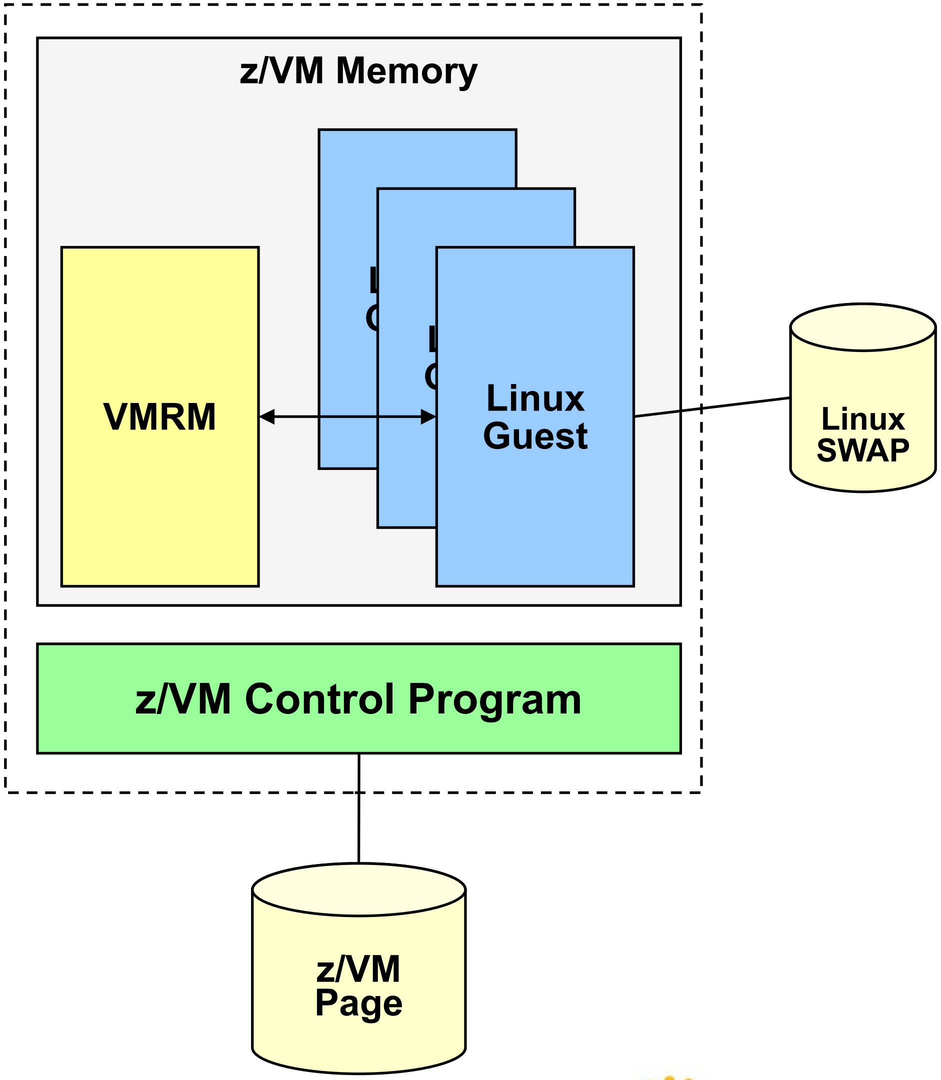
Problem: Double Paging

- Issue for virtual memory Hypervisors
  - Hypervisor determines that it is short on central storage and pages out a guest page
  - The guest determines that it wants to page out the same frame so the Hypervisor must page the frame back into central storage
  - The guest pages out the frame
  - **This has been addressed by z/VM with Collaborative Memory Management**



Cooperative Memory Management (CMM)

- Problem scenario:
  - Virtual memory utilization exceeds real memory availability
  - z/VM paging operations become excessive
  - Overall performance suffers
- Solution:
  - Real memory constraint detected by z/VM Virtual Machine Resource Manager
  - Linux images signaled to reduce virtual memory consumption
  - Demand on real memory is reduced, improving performance and throughput



Cooperative Memory Management (CMM)

- First enable in z/VM
  - Login as user VMRMSVM
  - Create VMRM CONFIG, add 1 line
    - NOTIFY MEMORY LNX* RH*
      - (assuming VM names begin with “LNX” and “RH”)
  - Add XAUTOLOG statement to AUTOLOG1's PROFILE EXEC
    - 'CP XAUTOLOG VMRMSVM'

Cooperative Memory Management (CMM)

- Now enable in RHEL
  - Insert CMM module (driver)
    - # modprobe cmm
  - Monitor/set values with /proc/sys/vm/cmm_*
  - Even better, let cpuplugd service set it dynamically
  - Load cmm at every boot
    - /etc/rc.local, last line: modprobe cmm

Disks

z/VM disks

- Shared vs. Dedicated volume for 191 (home)
  - Individual 191-A disk good for development environment, prepare multiple install environments
  - Shared 191-A disk good for production
    - Share installation kernel, initial RAMdisk, easily copy PARM and CONF files and/or use template
    - Dis(?)advantage: read-only 191-A disk for each user

z/VM disks

- Minidisk vs. Dedicated volumes for Linux use
  - MDISK uses minidisk caching (expanded memory), Dedicated does not
    - Debated topic, was true on older hardware, need to confirm
    - Explicitly disable minidisk caching in z/VM user directory (i.e. for Oracle)
      - MINIOPT NOMDC
  - MDISK lets you use part of a disk, more flexibility
  - MDISK can share/link disks between VMs
  - MDISK can (and should) define start at 2nd cylinder (cyl 1) to avoid changing label

Disks for Linux Use

- 2 Kinds of Disk
  - DASD or ECKD (Extended Count Key Data)
    - Fixed sizes
      - Mod-3: 3339 cyl, approximately 2.2 GB formatted
      - Mod-9: 10017 cyl, approximately 6 GB formatted
      - Mod-27: 30051 cyl, approximately 22 GB formatted
      - Mod-54 (rare)
      - Mod-108 (now possible with RHEL 5.4 and later)
    - Some z/VM system admins more familiar with ECKD
    - May fit into some existing backup solutions
    - Need LVM to create larger file systems suitable for databases

DASD Tools

- lsdasd: Display z/VM address to Linux block device mapping

```
# lsdasd
Bus-ID     Status      Name      Device  Type  BlkSz  Size      Blocks
===============================================================
0.0.0100   active      dasda     94:0    ECKD  4096      7042MB       1802880
0.0.0101   active      dasdb     94:4    ECKD  4096      7042MB       1802880
0.0.0102   active      dasdc     94:8    ECKD  4096      7042MB       1802880
0.0.0103   active      dasdd     94:12  ECKD  4096      7042MB       1802880
0.0.0300   active      dasde     94:16  FBA    512       256MB        524288
```

DASD Tools

- dasdfmt: Low level format
  - -d cdl: Specify compatible disk layout
    - Alternative is “-d ldl” for Linux layout
  - -b 4096: 4k block size
  - -p : Display progress
    - Omit if running in background with “&”
  - -y : Answer “yes” to all questions, use with care
  - -F : Force if in use, use with care
  - -f /dev/dasdX : Specify DASD device

```
# dasdfmt -d cdl -b 4096 -p -y -F -f /dev/dasdd

cyl 10016 of 10016 |#########################################| 100%

Finished formatting the device.
Rereading the partition table... ok
```

DASD Tools

- fdasd: Partition tool
  - fdasd -a /dev/dasdX : Create one partition and exit, use with care
  - fdasd /dev/dasdX: Enter menu similar to “fdisk”

```
# fdasd -a /dev/dasdd
reading volume label ..: VOL1
reading vtoc ..........: ok

auto-creating one partition for the whole disk...
writing volume label...
writing VTOC...
rereading partition table...
```

- After partitioning, use “mke2fs -j **-b 4096** /dev/dasdX1” to create file system or “pvcreate” to make LVM

DASD

- Add a new disk
  - Update dasd= in /etc/modprobe.conf
    - – Use comma or dash to create list, no spaces
      - Example: 100-103,200,300-302
  - Rebuild initial RAMdisk

```
# mkinitrd -v -f /boot/initrd-$(uname -r).img  $(uname -r)
```

  - – Check output for “dasd=” parameter
  - Run zipl to update MBR

```
# zipl -V
```

  - Bring online immediately

```
# chccwdev -e 300
```

  - Preallocate dasd= to save these steps

Disks for Linux Use

- 2 Kinds of Disk
  - SCSI or zFCP (Fiber Channel Protocol)
    - Use LUNs of any size, best for database partitions
    - Point-to-Point supported, but Fibre switch recommended
    - Not managed by z/VM, managed from Linux
    - NPIV: Virtualization of WWPN and LUN, recommended for DR site
    - EDEV: FBA DASD emulation using FCP LUNs
      - Multipathed

Why FCP?

- Performance advantages
  - FCP is much faster than FICON
  - Reason 1: asynchronous I/O
  - Reason 2: no ECKD emulation overhead
- No disk size restrictions
- Up to 15 partitions (16 minor numbers per device)
- SCSI disks do not waste disk space
  (no low-level formatting)

- System z integration in existing FC SANs
- Use of existing FICON infrastructure
  - FICON Express adapter cards
  - FC switches / Cabling
  - Storage subsystems
- Dynamic configuration
  - Adding of new storage subsystems possible without IOCDS change
- Does NOT require more CPU than FICON

FCP

- Requires 3 Fields in /etc/zfcp.conf
    - Create this file if it doesn't exist
    - <FCP_device> <WWPN> <LUN>
        - Example: 0.0.010a 0x5005...073d 0x4020...0000
    - Run /sbin/zfcpconf.sh, okay to run repeatedly
    - Save time, use this instead of sysfs

FCP

- Multipath
  - First add additional entries to /etc/zfcp.conf
    - Copy/paste, change WWPN to multipath channel (recommended)
    - Copy/paste, change FCP_device to multipath device (less popular, but still useful)
  - /etc/multipath.conf, comment “blacklist” statement with “#”
  - Create multipath

```
# multipath -v2
```

- Configure multipath to start on boot

```
# chkconfig multipathd on
# service multipathd start
Starting multipathd daemon: [  OK  ]
```

FCP

- Multipath
  - Give the LUN a recognizable name
    - /etc/multipath.conf:

Get this number from output of “multipath -v2 -ll”

```
multipaths {
        multipath {
                wwid                    36005076305ffc73d000000000000201a
                alias                   test_lun
                no_path_retry            5
        }
}
```

Make up this name

  - Result
    - Instead of /dev/mapper/mpathX, you have /dev/mapper/test_lun

FCP

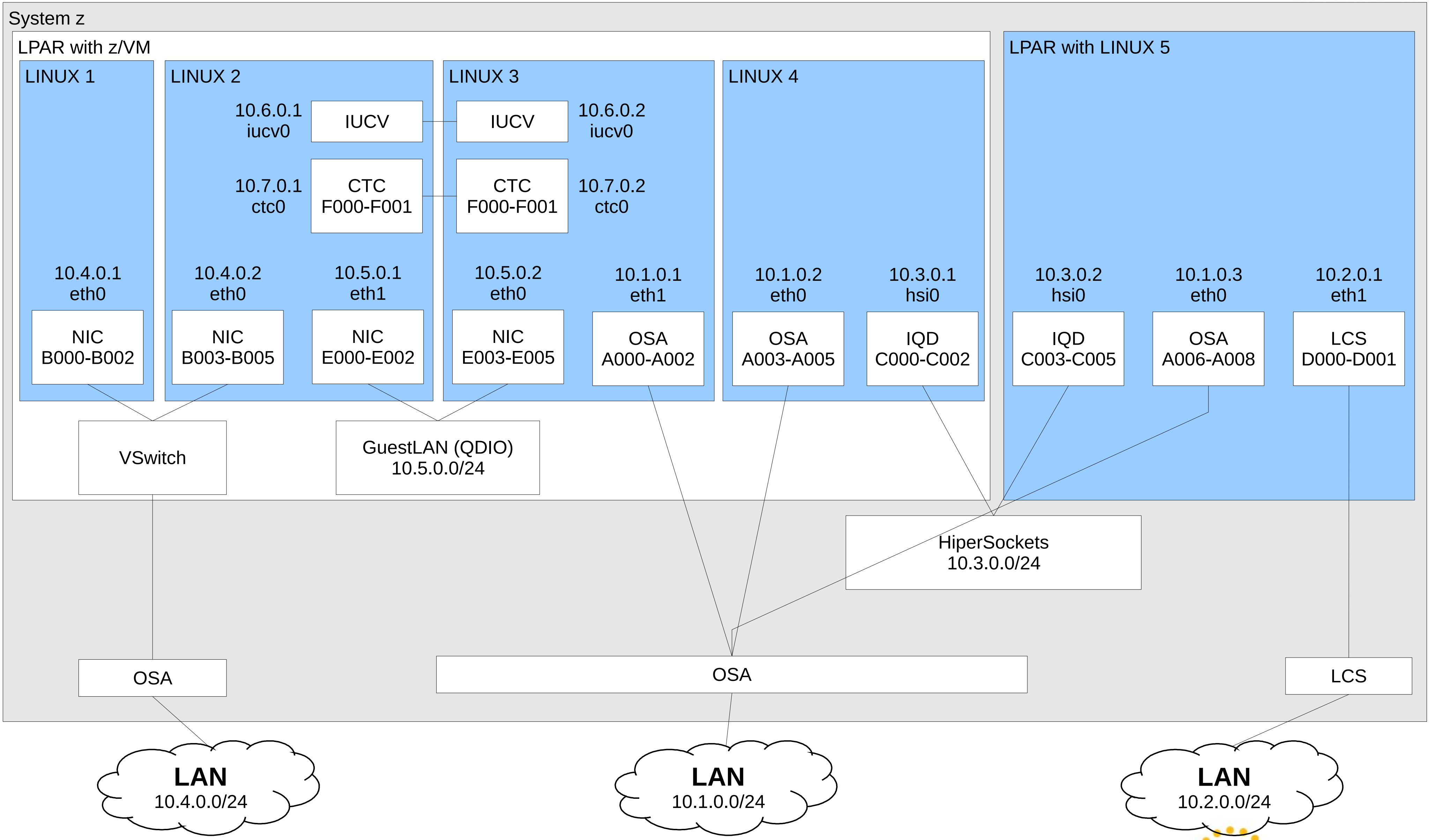
- NPIV
  - Virtualize WWPN and LUN
  - Clone or kickstart a guest, use the same /etc/zfcp.conf
  - NPIV for disaster recovery
    - z/VM will virtualize FCP device, same at both sites
    - At DR site, WWPN may change
      - Solution: Use both primary and offsite entries in zfcp.conf
      - Offsite entries will silently fail
      - In DR, offsite entries will work, primary entries will silently fail

Backup

- Never backup a running Linux system. Data in memory cache won't be written to disk, backup will be inconsistent
  - Either shutdown and backup, and use external imaging/cloning software...
    - FDR/Upstream z/OS product
  - Either shutdown and backup, or use a backup product at the file system level
    - FDR/Upstream Linux product
    - Tivoli Storage Manager (TSM)
    - Veritas NetBackup (resource intensive)
    - Open Source
      - Amanda, Bacula, Linux rsync

Networking

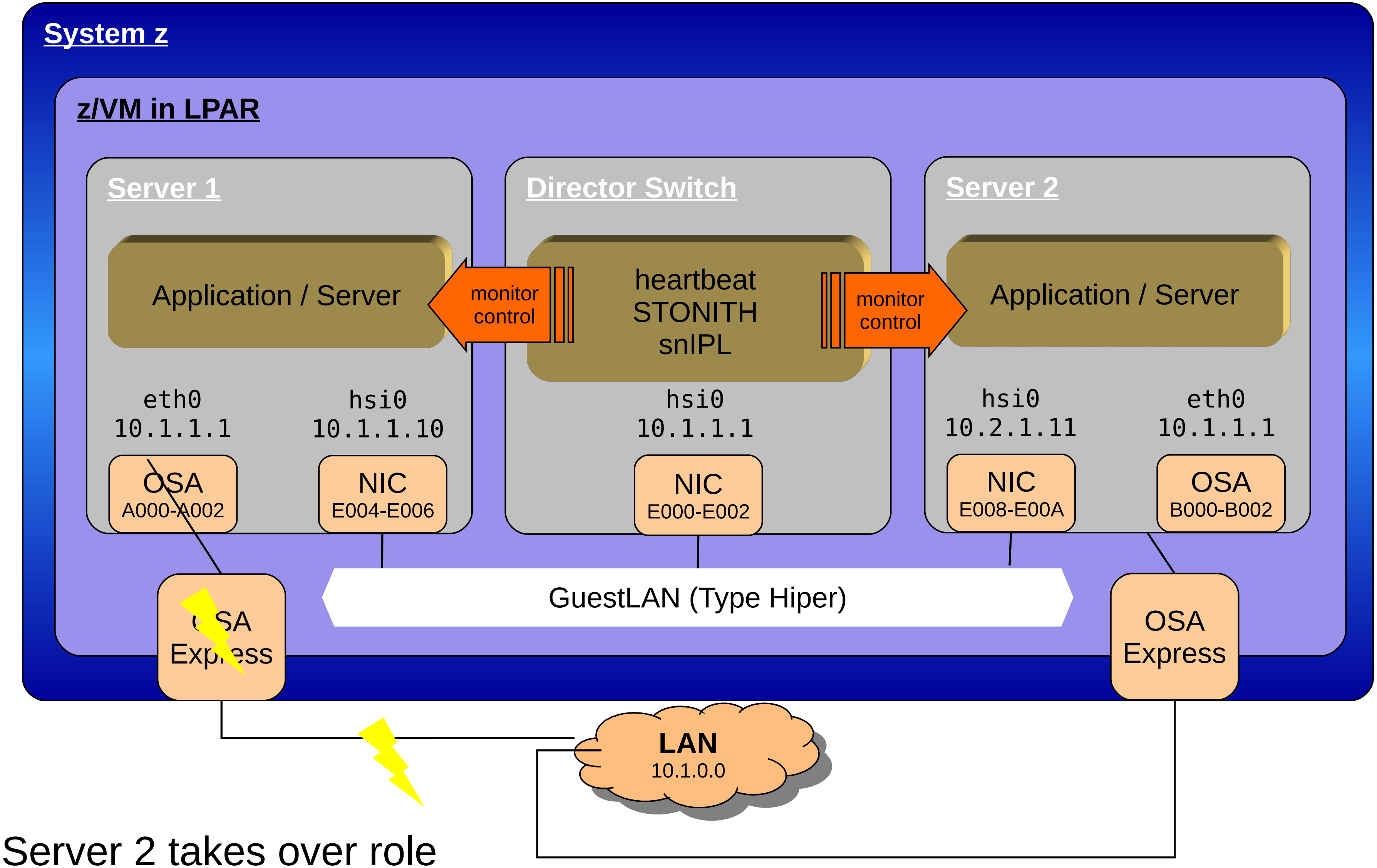
Network Example



Networking with VSWITCH

- Define 2 OSA devices, primary and backup
  - Use different CHPIDs going to separate physical switches
- Define layer 3 (IP mode, default) or layer 2 (Ethernet mode)
  - Layer 3 fine for IP traffic, where there is no need to alter Ethernet header (HTTP, FTP, NFS, most application traffic)
  - Layer 2 required for changes to Ethernet header (DHCP, VLAN, VIPA)
- Layer 2 configuration
  - /etc/sysconfig/network-scripts/ifcfg-eth0:
  - OPTIONS=”layer2=1”
- Layer 3 configuration when network capture required
  - OPTIONS=”fake_ll=1” for fake Ethernet header
  - z/VM VSWITCH config for AUTOLOG1
    - 'CP SET VSWITCH vswname GRANT username PRO'

IP Address Takeover / STONITH



Server 2 takes over role
of Server 1 in case of connectivity problems

Setting Up IP Address Takeover

- Activate IP address takeover

```
# echo 1 > /sys/bus/ccwgroup/driver/qeth/0.0.b000/ipa_takeover/enable
```

- Add the IP range that can be taken over

```
# qethconf ipa add 10.1.1.0/24 eth0
```

This enables the IP addresses 10.1.1.0 to 10.1.1.255 to be taken over

- Verify the IP address takeover configuration

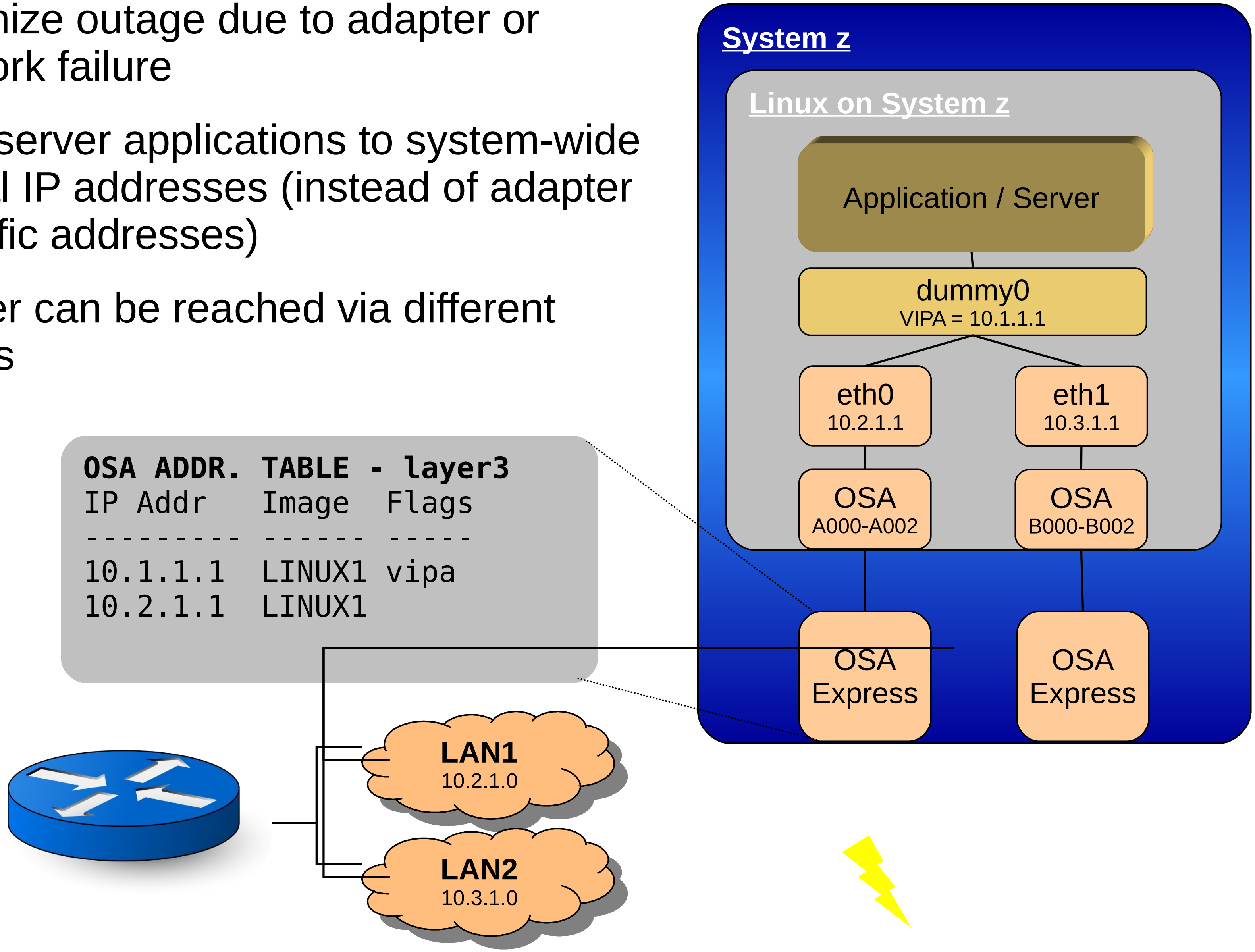
```
# qethconf ipa list
```

- To take over the IP address, issue

```
# ifconfig eth0 10.1.1.1 up
```

Virtual IP Addresses (VIPA) Support

- Minimize outage due to adapter or network failure
- Bind server applications to system-wide virtual IP addresses (instead of adapter specific addresses)
- Server can be reached via different routes



```
OSA ADDR. TABLE - layer3
IP Addr   Image  Flags
--------- ------ -----
10.1.1.1  LINUX1 vipa
10.2.1.1  LINUX1
```

Setting Up Virtual IP Addresses (VIPA)

- Create a virtual interface and adding the VIPA using a dummy interface

```
# modprobe dummy
# ifconfig dummy0 10.1.1.1 netmask 255.255.255.0
```

or use an interface alias

```
# ifconfig eth0:1 10.1.1.1 netmask 255.255.255.0
```

- Layer3 only: register virtual IP address with physical devices

```
# echo 10.1.1.1 > /sys/class/net/eth0/device/vipa/add4
# echo 10.1.1.1 > /sys/class/net/eth1/device/vipa/add4
```

- Configure the routes with a dynamic routing daemon such as Quagga
- On the router, add a route to the routing table, e.g.

```
# route add -host 10.1.1.1 gw 10.2.1.1             //if LAN1 works
```

```
# route add -host 10.1.1.1 gw 10.3.1.1             //if LAN2 works
```

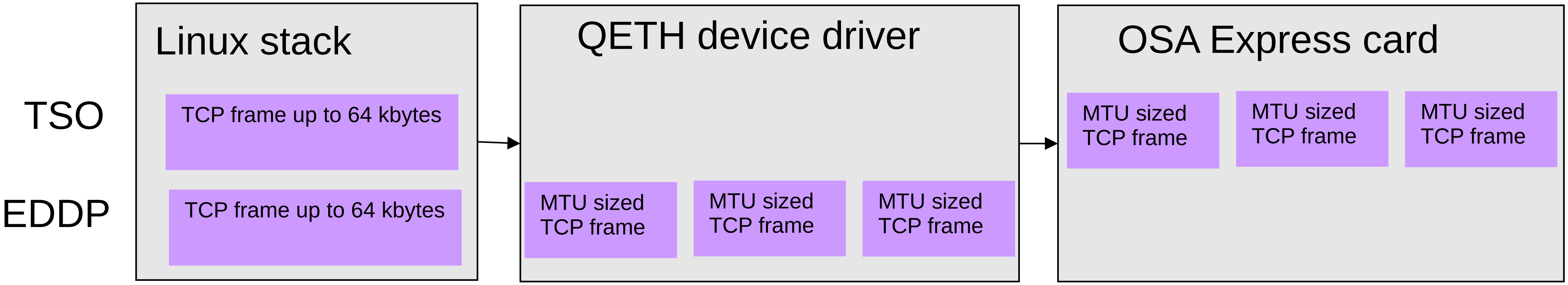
QETH Device sysfs Attribute large_send

- Offload TCP segmentation from Linux stack to OSA-card:
  `OPTIONS='large_send=TSO'` or
  ⇒ move workload from Linux to OSA-Express adapter

```
# echo TSO > \ /sys/devices/qeth/0.0.b004/large_send
```

- Offload TCP segmentation from Linux stack to device driver:
  `OPTIONS='large_send=EDDP'` or

```
# echo EDDP > \ /sys/devices/qeth/0.0.b004/large_send
```



→ performance advantage with large outgoing packets

QETH Device sysfs Attribute checksumming

- Offload checksumming for incoming IP packages from Linux stack to OSA-card
  `OPTIONS='checksumming=hw_checksumming'`
  or

```
# echo hw_checksumming > \
  /sys/devices/qeth/0.0.b004/checksumming
```

- Available for OSA-devices in layer3 mode only

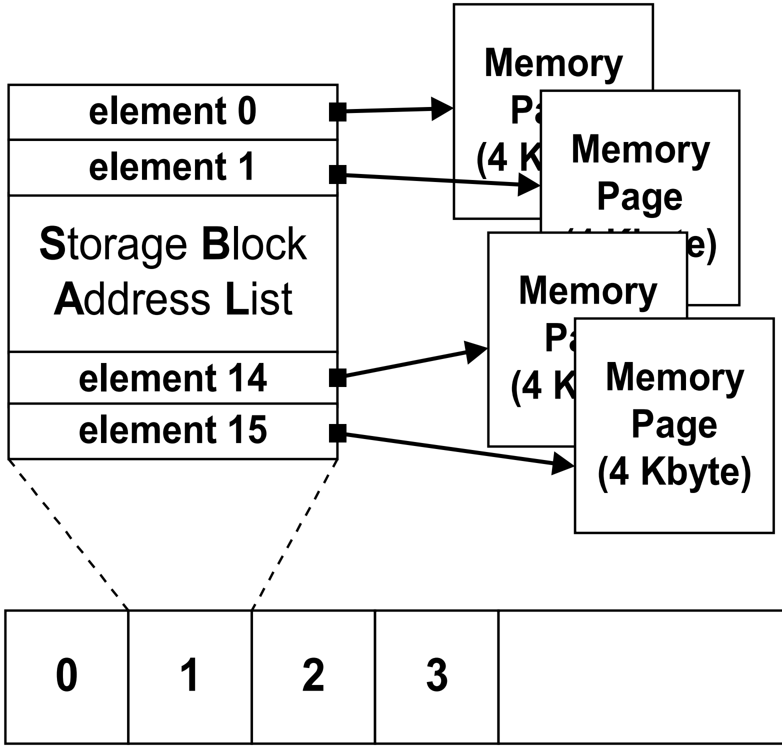
QETH Device sysfs Attribute recover

- enforce recovery of a qeth device

```
# echo 1 > /sys/devices/qeth/0.0.b004/recover
```

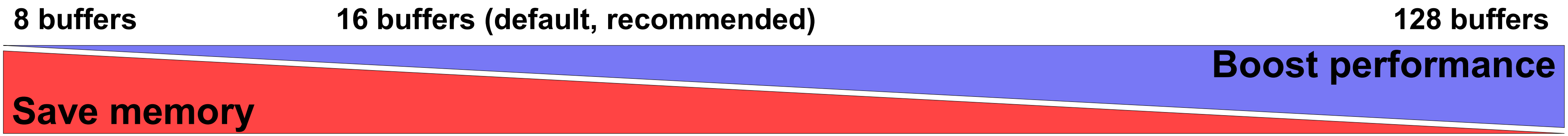
QETH Device sysfs Attribute buffer_count

- The number of allocated buffers for inbound QDIO traffic → Memory usage.



Per QETH device memory usage:

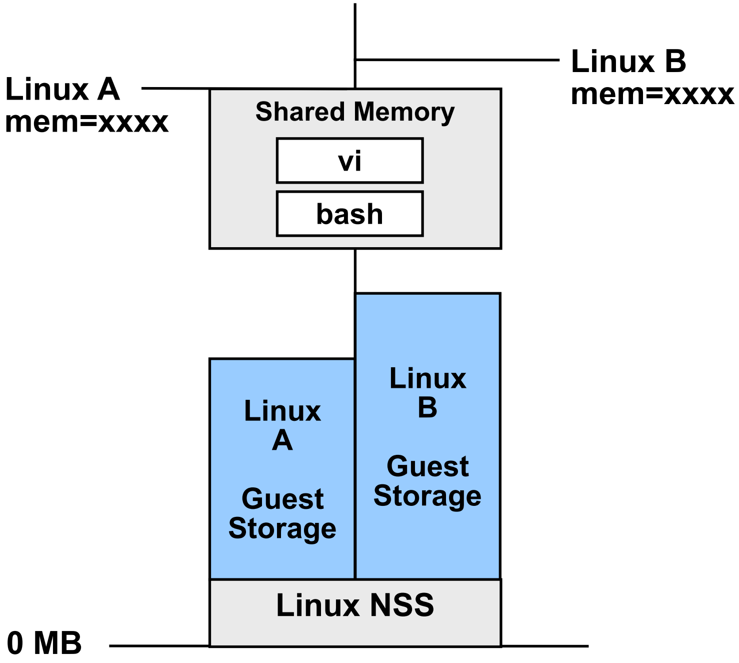
control data structures:	~ 200 KB
memory for one buffer:	64 KB
`buffer_count = 8`	--> ~ 712 KB
`buffer_count = 128`	--> ~ 8.4 MB



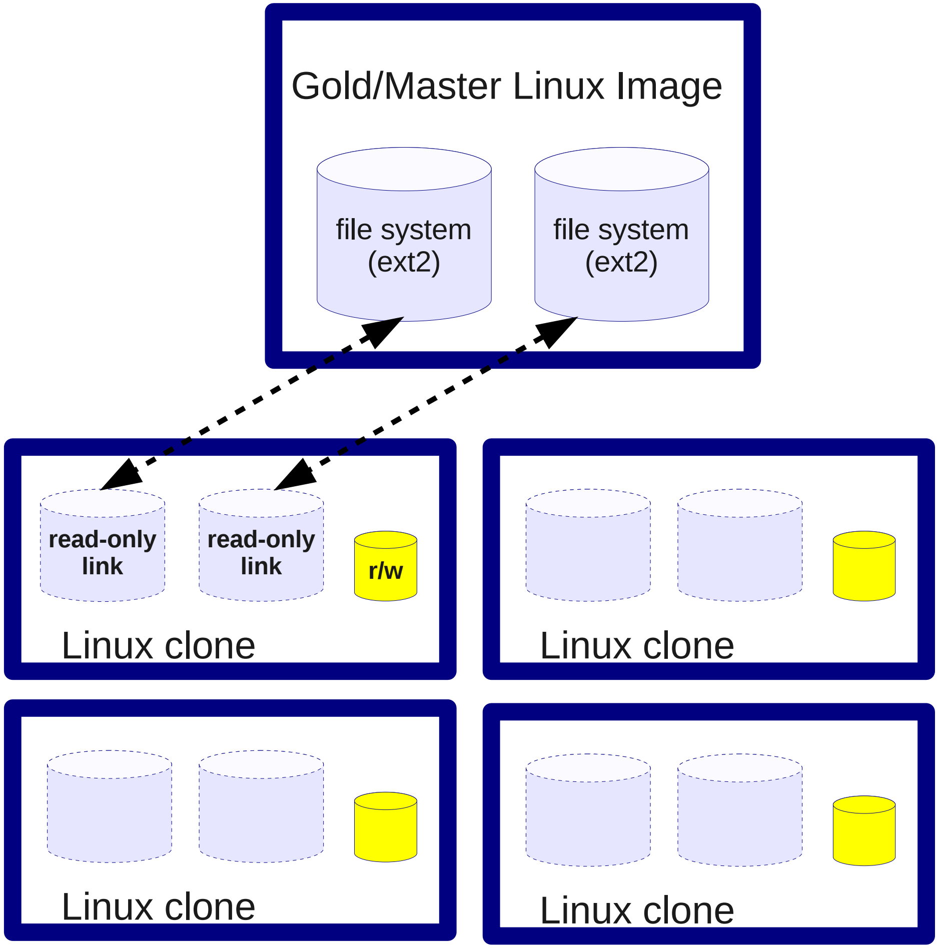
Resource Sharing

Shared Kernel

- Named Saved Segments (NSS)
  - Using NSS, the z/VM hypervisor makes operating system code in shared real memory pages available to z/VM guest virtual machines.
  - Linux guest operating systems using z/VM can boot from the NSS and be run from a single copy of the Linux kernel in memory.



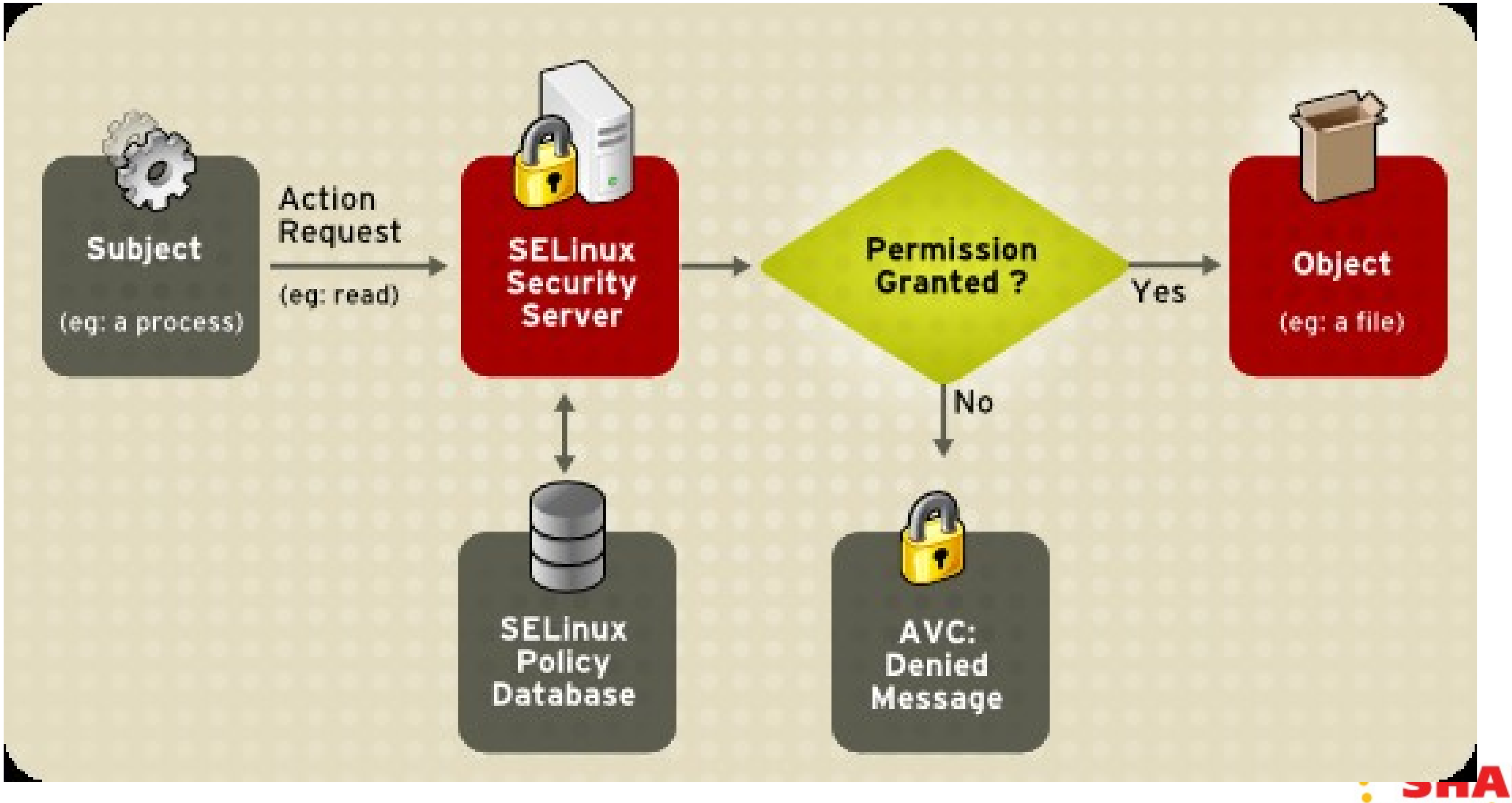
Shared Read-only Root



Security

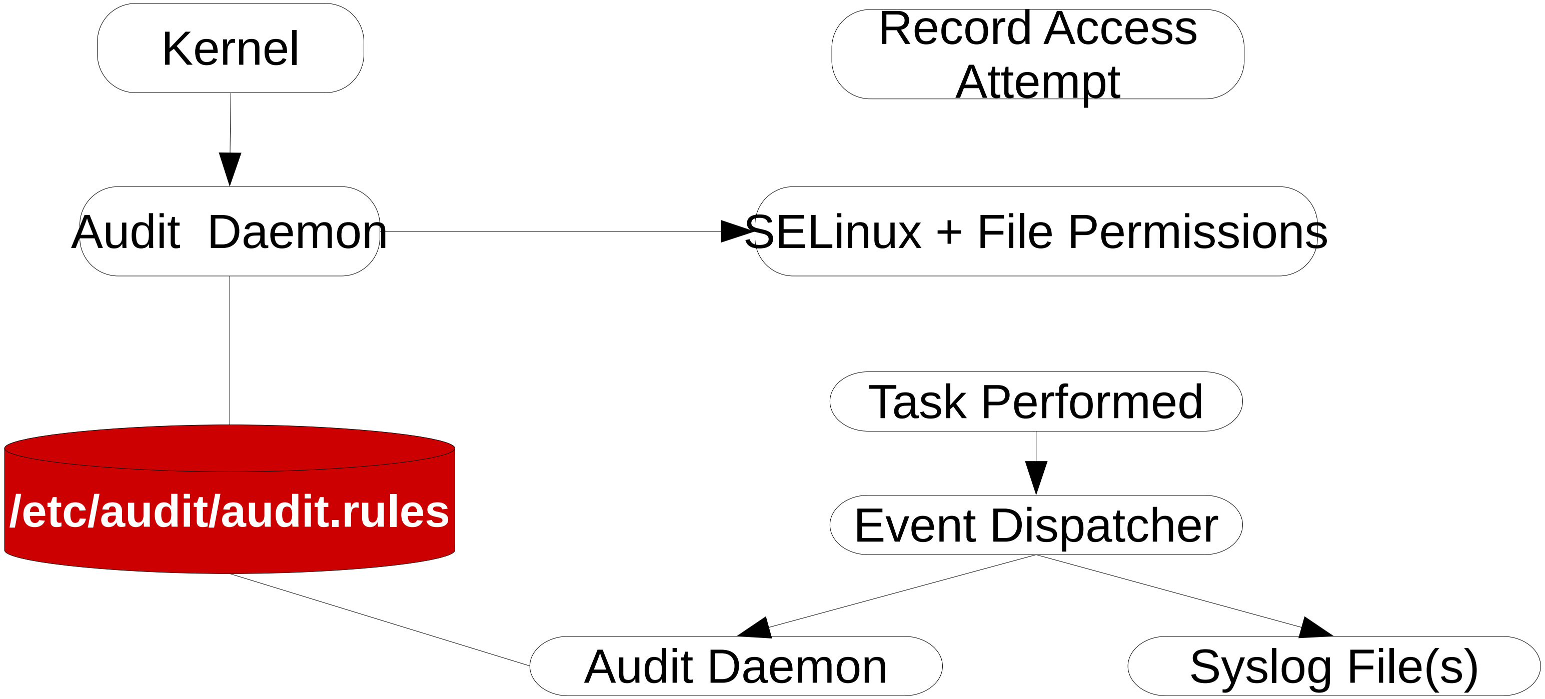
Hardening a System

- SELinux
  - Policy-based security based on roles. Policies are statements that determine whether certain actions are allowed.



Hardening a System

- Other Tools
  - AIDE: Advanced Intrusion Detection Environment
    - Open source equivalent to TripWire.
  - Linux Audit Subsystem



Questions?