# Networking with Linux® on zSeries
## (Part 2 of 2)

### Session 9268

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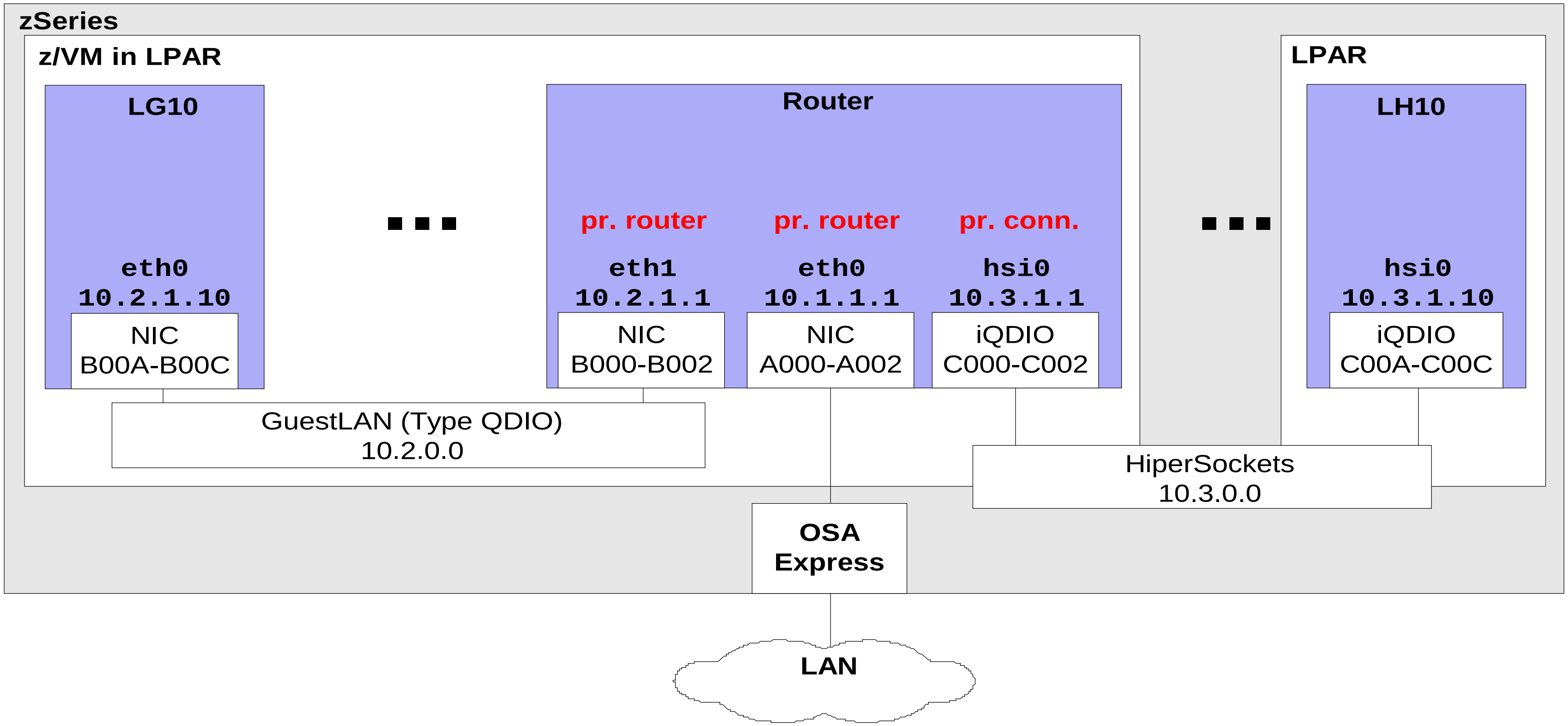
# Agenda

- Router setup for Linux on zSeries
- Failover and availability solutions:
  - IP Address Takeover
  - Virtual IP Addresses (VIPA)
  - Proxy ARP
- The qethconf tool
- The qetharp tool
- HiperSockets Network Concentrator (HSNC)

# Routing Types




| | OSA Express | VM GuestLAN QDIO | VM GuestLAN Hiper | HiperSockets |
|---|---|---|---|---|
| primary router | X | X (IPv4 only) | | |
| secondary router | X | X (IPv4 only) | | |
| multicast router | X | | | |
| primary connector | | | | X |
| secondary connector | | | | X |

# How OSA handles Router Settings

Ethernet packet

| **Dest. MAC** | Src MAC | prot | **...** | Src IP | **Dest. IP** | payload |
|---|---|---|---|---|---|---|

Ethernet Header | IP Header

Packet reaches OSA Card with destination MAC address

OSA Card

Is the packet's destination IP address set by any client OS image?

YES NO ?

**OSA Address Table (OAT)**

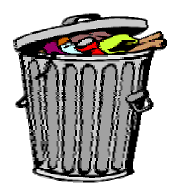
| Device Number | IP Address | Router? |
|---|---|---|
| A000 | 10.1.1.1 | primary |
| A00A | 10.1.1.10 | secondary |
| ... | ... | |
| A0AA | 10.1.1.100 | |

Is there a primary router? ?

YES NO ?

Is there a secondary router?

YES NO



Give packet to OS image

discard packet

**Linux**

IP packet

| **...** | Src IP | **Dest. IP** | payload |
|---|---|---|---|

A **multicast router** also receives **all** multicast packets

# How HiperSockets handles Router Settings

IP packet

| ... | Src IP | **Dest. IP** | payload |
|---|---|---|---|

IP Header

GuestLAN is analogous

OS Image sends IP packet via its iQDIO device

HiperSockets Microcode

Is the packet's destination IP address set by any client OS image?

YES

NO

?

| **Address Table** | | |
|---|---|---|
| **Device Number** | **IP Address** | **Connector?** |
| C000 | 10.3.1.1 | primary |
| C0A0 | 10.3.1.30 | secondary |
| ... | ... | |
| C0AA | 10.1.1.100 | |

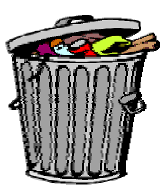
Is there a primary connector? ?

YES

NO

?

Is there a secondary connector?



YES

NO

Copy packet to OS image storage

discard packet

**Linux**

IP packet

| ... | Src IP | **Dest. IP** | payload |
|---|---|---|---|

# SUSE SLES 9 Network Configuration Basics

Hardware **devices** — Logical **interfaces**

Configuration files:

**`/etc/sysconfig/hardware`**          **`/etc/sysconfig/network`**

**1:1 relationship**

--> A hardware device always gets the right IP address

Naming convention:

**hw/ifcfg-<device type>-bus-<bus type>-<bus location>** or

**hw/ifcfg-<device type>-id-<identifier>** (e.g. for IUCV)

e.g. **hwcfg-qeth-bus-ccw-0.0.a000**

**ifcfg-qeth-bus-ccw-0.0.a000**

# Setting up a Router

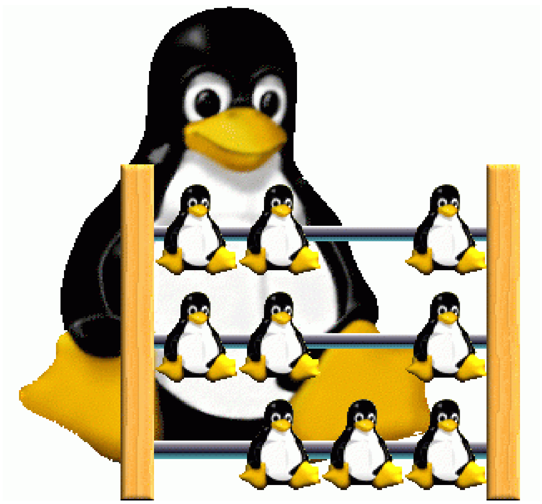
1. Enable IP forwarding:

```
#> sysctl -w net.ipv4.conf.all.forwarding=1
#> sysctl -w net.ipv6.conf.all.forwarding=1
```

or enter the following lines in `/etc/sysconfig/sysctl`:

```
IP_FORWARD=”yes”
IPV6_FORWARD=”yes”
```

to keep the setting persistent.



# Setting up a Router (cont.)

2. Set the router status for your device, e.g. eth0 of the Router (see above):

```
                                                                  *
#> echo primary_router > /sys/class/net/eth0/device/route4
#> echo primary_router > /sys/class/net/eth0/device/route6
```

or enter the following line in the appropriate hwcfg-file to keep the setting persistent:

```
QETH_OPTIONS='route4=primary_router *
              route6=primary_router'
```

*) Other possible values:

```
secondary_router
multicast_router
primary_connector
secondary_connector
no_router
```

(to reset)

# Querying the Router Status

Router status is displayed in `/proc/qeth`:

```
#> cat /proc/qeth                                                            *
devices                    CHPID interface  cardtype       ... rtr4 rtr6
-------------------------- ----- ---------- --------------     ---- ---- ...
0.0.a000/0.0.a001/0.0.a002 xA0   eth0       OSD_1000           pri  pri
0.0.b000/0.0.b001/0.0.b002 x01   eth1       GuestLAN QDIO      pri  pri
0.0.c000/0.0.c001/0.0.c002 xC0   hsi0       HiperSockets       p+c  no
```

or can be retrieved from sysfs:

```
#> cat /sys/class/net/eth0/device/route4*
primary router
#> cat /sys/devices/qeth/0.0.a000/route6
primary router
```

note the alternative ways to your device

*) All possible values:

| procfs | sysfs | Description |
|---|---|---|
| pri | primary router | Primary Router |
| sec | secondary router | Secondary Router |
| mc | multicast router | Multicast Router |
| mc+ | multicast router+ | Multicast Router with broadcast filtering |
| p.c | primary connector | Primary Connector |
| p+c | primary connector+ | Primary Connector with broadcast filtering |
| s.c | secondary connector | Secondary Connector |
| s+c | secondary connector+ | Secondary Connector with broadcast filtering |

# Setting up a Router on Linux 2.4

Set the router status for your device via `/proc/qeth`:

```
#> echo primary_router4 > /proc/qeth*
#> echo primary_router6 > /proc/qeth
```

or enter the following lines in `/etc/chandev.conf`:

```
qeth0,0xa000,0xa001,0xa002                    *
add_parms,0x10,0xa000,0xa002,primary_router4
add_parms,0x10,0xa000,0xa002,primary_router6
```

*) Other possible values: `secondary_router[4|6]`
`multicast_router`
`primary_connector`
`secondary_connector`
`no_router[4|6]` (to reset)

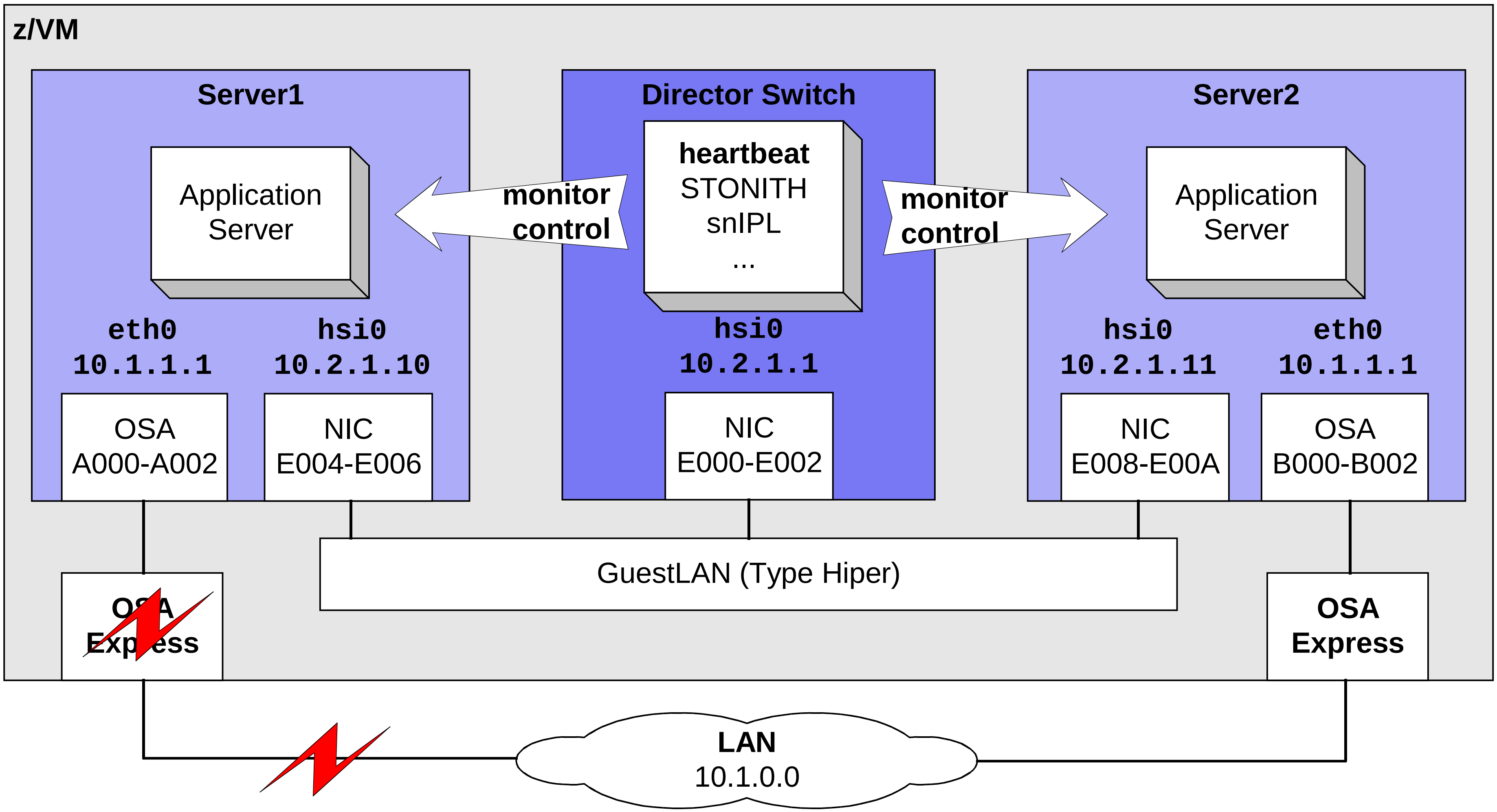
Query router status: `cat /proc/qeth`

# IP Address Takeover

- Idea of IP Address Takeover:
  - Setting an IP address on Linux always succeeds
  - No failure due to ARP (Address Resolution Protocol) conflicts
  - On shared OSA cards, HiperSockets or GuestLAN IP addresses are really taken away from previous owner (in OSA Address Table)
- Takeover must be enabled on both systems
- Takeover of IP addresses is secured by keys:
  Only systems with same key can take over their IP addresses

# IP Address Takeover

Enables implementation of failover strategies




Server2 takes over role of Server1 in case of connectivity problems

# IP Address Takeover Details

- Server images are monitored and controlled by a switch image
- In case of problems the switch initiates takeover
- Management of server nodes done, e.g. via open source **Heartbeat** framework of the High-Availability Linux Project http:/linux-ha.org
- Part of Heartbeat: **STONITH** (Shoot The Other Node In The Head) (http:/linux-ha.org/stonith.html)
- Adaptation of STONITH to fit actual target systems through plugins

# IP Address Takeover Details (cont.)

- STONITH plug in for Linux on zSeries: **snIPL** (simple network IPL)
- snIPL is a Linux image control tool for LPAR and z/VM
  - Can boot, stop, reset Linux images, send and receive OS messages
- On LPAR
  - Uses management application programming interfaces (APIs) of HMC/SE (Hardware Management Console/Support Element)
  - communicates via SNMP (Simple Network Management Protocol)
- On z/VM
  - Utilizes system managements APIs of z/VM 4.4 (or higher)
  - Communicates with z/VM host via RPC (Remote Procedure Call) over internal network connections

# IP Address Takeover Device Attributes

**IP Address Takeover configuration is done per device via sysfs attributes**

```
/sys
|--devices
    |--qeth
        |--0.0.<devno>
            |--ipa_takeover
                |--add4        add/display IPv4 takeover ranges
                |--add6        add/display IPv6 takeover ranges
                |--del4        delete IPv4 takeover ranges
                |--del6        delete IPv6 takeover ranges
                |--enable      enable takeover
                |--invert4     invert IPv4 takeover ranges
                |--invert6     invert IPv6 takeover ranges
```

# IP Address Takeover Setup

1. Enable IP Address Takeover for your device by adding

```
QETH_IPA_TAKEOVER=1
```

to the appropriate hwcfg-file.

- Takeover will be enabled the next time the Linux Image is booted
- To activate the setting on a running Linux:

Stop the device: `#> hwdown qeth-bus-ccw-0.0.a000`

Re-initialize device with new settings:

```
#> hwup qeth-bus-ccw-0.0.a000
```

# IP Address Takeover Setup (cont.)

2. Specify address ranges for IP Address Takeover

```
#> echo <IP address>/<mask> >
   /sys/class/net/eth0/device/ipa_takeover/add4
```

For example, to handle all IP addresses in the range 10.1.1.1 to 10.1.1.254 in takeover mode, issue:

```
#> echo 10.1.1.0/24 >
   /sys/class/net/eth0/device/ipa_takeover/add4
```

Ranges can be inverted, i.e. all addresses except those in a specified range are handled in takeover mode:

```
#> echo 1 >
   /sys/class/net/eth0/device/ipa_takeover/invert4
```

# IP Address Takeover Setup (cont.)

3. To check current IP Address Takeover ranges, issue

```
#> cat /sys/class/net/eth0/device/ipa_takeover/add4
10.1.1.0/24
10.1.2.0/25
```

--> All IP addresses from 10.1.1.1 to 10.1.1.254 and from 10.1.2.1 to 10.1.2.127 are handled in takeover mode when being set with '**`ifconfig`**' or '**`ip addr add`**'

4. Takeover ranges can be deleted by writing to the del4 attribute:

```
#> echo 10.1.2.0/25 >
   /sys/class/net/eth0/device/ipa_takeover/del4
```

IPv6 is analogous, i.e. add/delete ranges via `add6/del6`

# IP Address Takeover Setup on Linux 2.4

1. To enable takeover on a device, add this line to `/etc/chandev.conf`:

```
qeth0,0xa000,0xa001,0xa002
add_parms,0x10,0xa000,0xa002,enable_takeover
```

2. Takeover ranges are set via `/proc/qeth_ipa_takeover`:

```
#> echo add4 <addr in hex>/<mask>[:interface] >*
   /proc/qeth_ipa_takeover
```

e.g.

```
#> echo add4 0a010100/24:eth0 > /proc/qeth_ipa_takeover
```

*) Other possible commands:

```
del4 <addr>/<mask>[:interface]
add6 <addr>/<mask>[:interface]
del6 <addr>/<mask>[:interface]
inv4
inv6
```

If the interface parameter is omitted a range is applied to all interfaces.

# IP Address Takeover with OSA Layer2

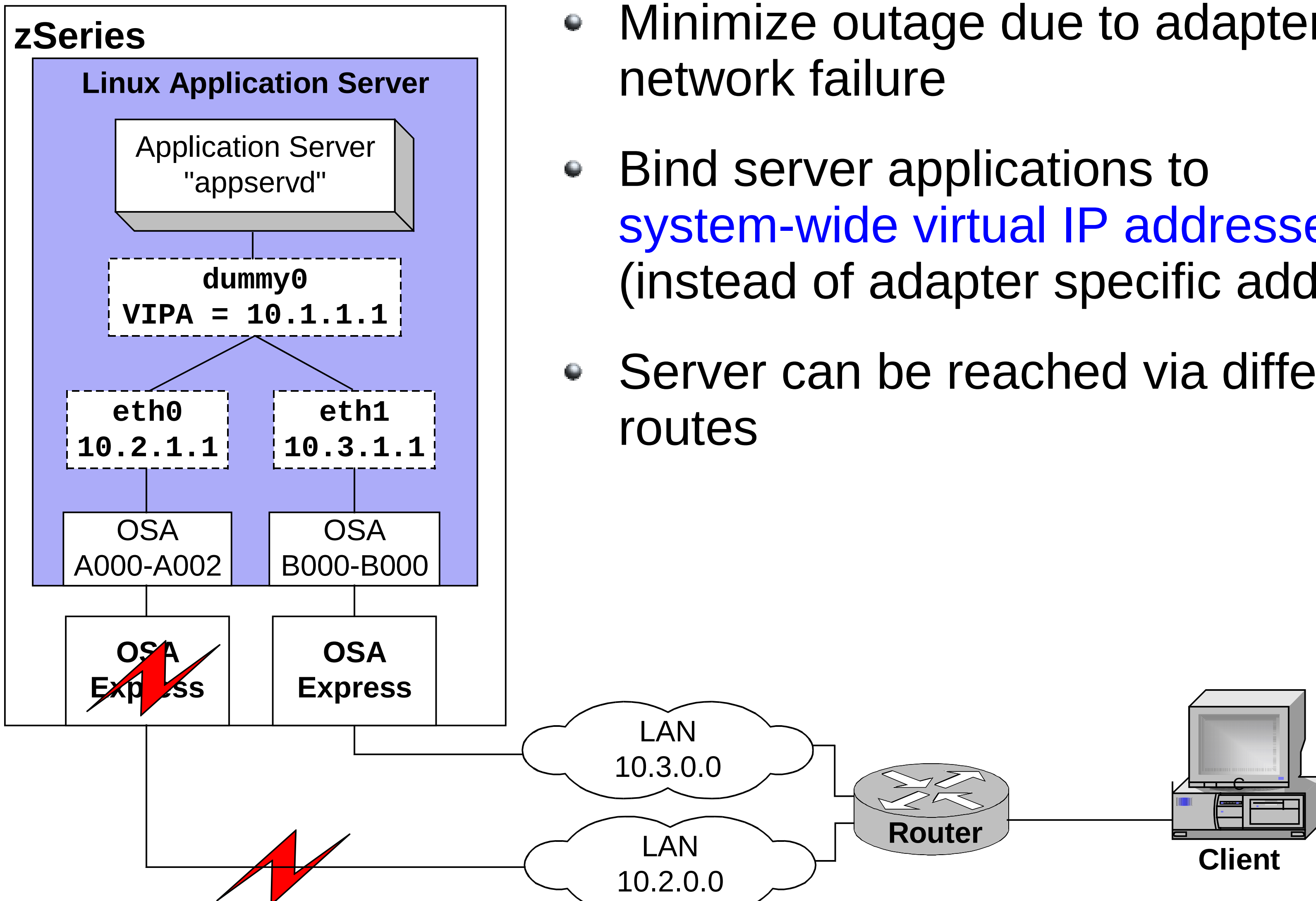
- Echo of IP Address ranges to /sysfs does not work

```
#> cat /sys/class/net/eth0/device/ipa_takeover/add4
10.1.1.0/24
10.1.2.0/25
```

```
QETH_IPA_TAKEOVER=1
```

- Director switch must guarantee that failing system is down
- Director switch must send gratuitous ARP request to refresh ARP tables of connected hosts
- Attention: Some networking hardware does not allow gratuitous ARP !

# Virtual IP Addresses




- 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

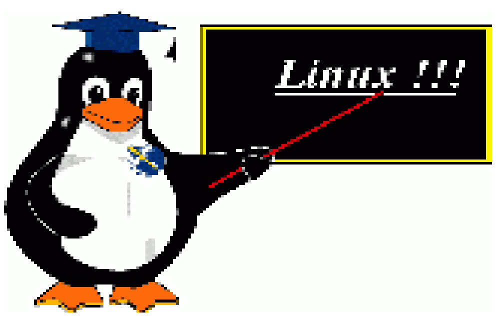
# Virtual IP Addresses (cont.)

- VIPAs are registered with each physical adapter via which a system should be reachable
- Setting a VIPA on an OSA card ensures that packets are handed to Linux image (and are not discarded)
- Linux network stack forwards received packets to configured virtual device (e.g. dummy)
- For outbound use of VIPA the SOURCE VIPA package is required (available at DeveloperWorks)
  - Linux user space layer between application and kernel network stack
  - Sets virtual IP address as source address for sent packets (normally packets get source IP of the interface via which they leave the system)

# Virtual IP Address Device Attributes

**VIPA configuration is done per device via sysfs attributes**

```
/sys
|--devices
    |--qeth
        |--0.0.<devno>
            |--vipa
                |--add4      add/display IPv4 VIPAs
                |--add6      add/display IPv6 VIPAs
                |--del4      delete IPv4 VIPAs
                |--del6      delete IPv6 VIPAs
```



# Virtual IP Address Setup

1. Create a virtual interface and assign the VIPA using a dummy interface:

```
#> modprobe dummy
#> ifconfig dummy0 10.1.1.1 netmask 255.255.0.0
```

or using an interface alias:

```
#> ifconfig eth0:1 10.1.1.1 netmask 255.255.0.0
```

2. Register the 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
```

3. On the router add a route to the routing table:

`#> 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

or, better, configure the routes with a dynamic routing daemon (e.g. zebra: http://www.zebra.org).

# Virtual IP Address Setup (cont.)

- VIPA settings can be checked by reading the `add4` attribute:

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

- VIPAs are deleted by writing to the `del4` attribute:

```
#> echo 10.1.1.1 > /sys/class/net/eth0/device/vipa/del4
#> echo 10.1.1.1 > /sys/class/net/eth1/device/vipa/del4
```

- IPv6 is analogous, using the `add6` and `del6` attributes.

# Virtual IP Address Setup on Linux 2.4

1. Creation of a virtual interface is done like in Linux 2.6
2. Register the virtual IP address via `/proc/qeth_ipa_takeover`:

```
#> echo add_vipa4 <addr in hex>:<interface> >*
   /proc/qeth_ipa_takeover
```

e.g.

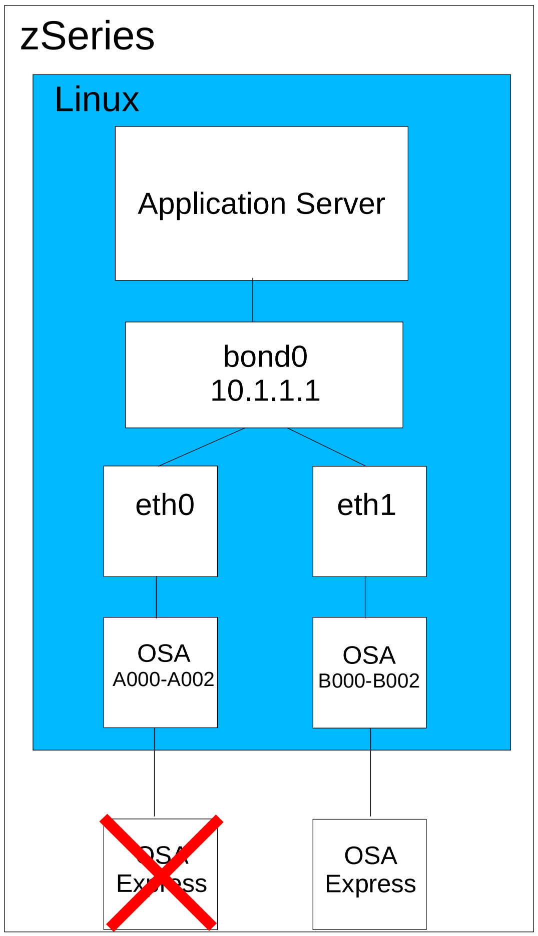
```
#> echo add_vipa4 0a010101:eth0 > /proc/qeth_ipa_takeover
```

*) Other possible commands:

```
del_vipa4 <addr>:<interface>
add_vipa6 <addr>:<interface>
del_vipa6 <addr>:<interface>
```

# Channel Bonding

## Virtual IP Addresses with OSA Layer2




- VIPA functionality with OSA Layer2
- provides failover functionality
- better performance depending on bonding mode
- transparent for LAN infrastructure
- latest setup description:

http://sourceforge.net/projects/bonding/

- Both adapter must be connected to the same LAN !
- Otherwise use Layer 3 approach with routing daemon (e.g. zebra, quagga)

# Channel bonding setup

- Add MAC address to eth0 eth1 (not necessary for GuestLAN)

```
#> ifconifg eth0 hw ether 00:06:29:55:2A:01
#> ifconifg eth1 hw ether 00:05:27:54:21:04
```

- Load bonding module with miimon option (otherwise bonding will will not detect link failures)

```
#> modprobe bonding miimon=1000
```

- Bring up bonding device bond0

```
#> ifconfig bond0 10.1.1.1 netmask 255.255.255.0
```

- connect eth0 & eth1 to bond0

```
#> ifenslave bond0 eth0 eth1
```

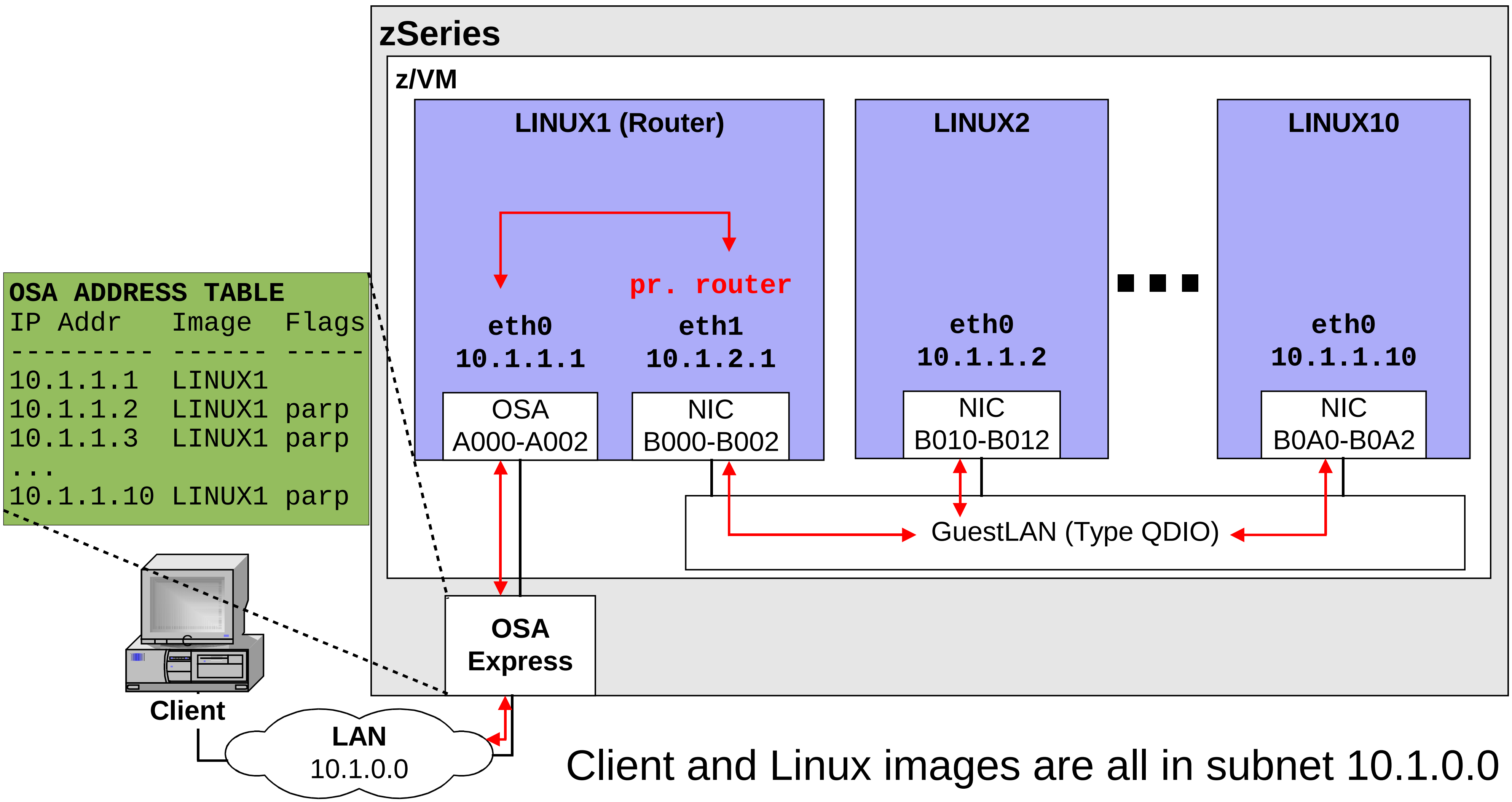
# Channel bonding setup

```
#> ifconifg
bond0     Link encap:Ethernet  HWaddr 00:06:29:55:2A:01
          inet addr:10.1.1.1  Bcast:10.255.255.255 ...

eth0      Link encap:Ethernet  HWaddr 00:06:29:55:2A:01
          UP BROADCAST RUNNING SLAVE MULTICAST  MTU:1500...

eth1      Link encap:Ethernet  HWaddr 00:06:29:55:2A:01
          UP BROADCAST RUNNING SLAVE MULTICAST  MTU:1500 ...
```

```
#> cat /proc/net/bonding/bond0

Bonding Mode: load balancing (round-robin)
MII Status: up
MII Polling Interval (ms): 1000

Slave Interface: eth0
MII Status: up
Permanent HW addr: 00:06:29:55:2A:01

Slave Interface: eth1
MII Status: up
Permanent HW addr: 00:05:27:54:21:04
```

# Proxy ARP

Example: Integration of a virtual LAN into a real LAN




Client and Linux images are all in subnet 10.1.0.0

# Proxy ARP Details

- OSA card handles ARP requests for all configured Proxy ARP addresses
- Gratuitous ARP packets are sent out to advertise Proxy ARP addresses
- Completely transparent to outside clients
- Seamless integration of arbitrary virtual networks (HiperSockets, GuestLAN, IUCV, virtual CTC) into a real LAN

# Proxy ARP Device Attributes

```
/sys
|--devices
   |--qeth
      |--0.0.<devno>
         |--rxip
            |--add4
            |--add6
            |--del4
            |--del6
```

**Proxy ARP configuration is done per device via sysfs attributes**

- add4: add/display IPv4 Proxy ARP entries
- add6: add/display IPv6 Proxy ARP entries
- del4: delete IPv4 Proxy ARP entries
- del6: delete IPv6 Proxy ARP entries

# Proxy ARP Setup

1. Create Proxy ARP entries for leaf nodes (i.e. with no own connection to outside LAN):

```
#> echo 10.1.1.2 > /sys/class/net/eth0/device/rxip/add4
#> echo 10.1.1.3 > /sys/class/net/eth0/device/rxip/add4
#> echo 10.1.1.4 > /sys/class/net/eth0/device/rxip/add4
...
```

2. Proxy ARP settings can be checked by reading `add4` attribute:

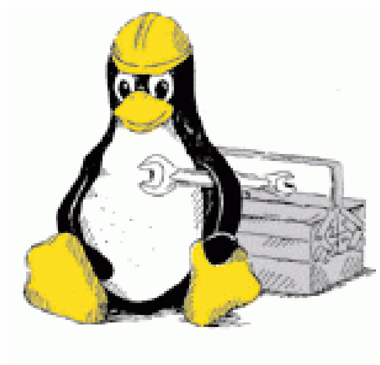
```
#> cat /sys/class/net/eth0/device/rxip/add4
10.1.1.2
10.1.1.3
10.1.1.4
...
```

# Proxy ARP Setup (cont.)

- Proxy ARP entries are deleted by writing to the `del4` attribute:

```
#> echo 10.1.1.2 > /sys/class/net/eth0/device/rxip/del4
#> echo 10.1.1.3 > /sys/class/net/eth0/device/rxip/del4
#> echo 10.1.1.4 > /sys/class/net/eth0/device/rxip/del4
...
```

- IPv6 is analogous, using the `add6` and `del6` attributes.



# Proxy ARP Setup on Linux 2.4

1. Register Proxy ARP entries via `/proc/qeth_ipa_takeover`:

```
#> echo add_rxip4 <addr in hex>:<interface> >*
   /proc/qeth_ipa_takeover
```

e.g.

```
#> echo add_rxip4 0a010102:eth0 > /proc/qeth_ipa_takeover
```

*) Other possible commands:

```
del_rxip4 <addr>:<interface>
add_rxip6 <addr>:<interface>
del_rxip6 <addr>:<interface>
```

# Proxy ARP with OSA layer2

- Echo of Proxy ARP Address ranges to /sysfs does not work

```
#> echo 10.1.2.2 > /sys/class/net/eth0/device/rxip/add4
```

- Enable IP forwarding and Proxy ARP at Linux 2

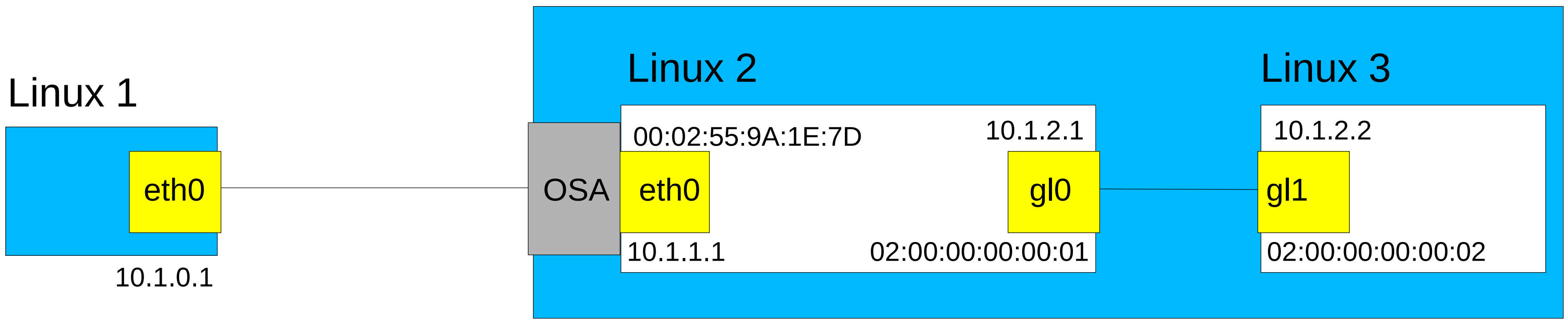
```
#> sysctl -w net.ipv4.ip_forward=1
#> sysctl -w net.ipv4.conf.eth0.proxy_arp=1
```

- Add MAC Address of gl1 to ARP cache of eth0 on Linux 2

```
#> arp -s 10.1.2.2 02:00:00:00:00:02
```

- ARP table of Linux2

```
#> arp -a
? (10.1.2.2) at 02:00:00:00:00:02 [ether] PERM on gl0
```



# The qethconf Tool

- Command line utility to configure IP Address Takeover, VIPA and Proxy ARP
- Part of the **s390-tools** package available at DeveloperWorks
- Consistent user interface on Linux 2.4 and 2.6

| Linux 2.4 | Linux 2.6 |
| --- | --- |
| `qethconf` script | |
| `/proc/qeth_ipa_takeover` | `/sys/.../qeth/0.0.*/ipa_takeover` |
| | `/sys/.../qeth/0.0.*/rxip` |
| | `/sys/.../qeth/0.0.*/vipa` |

- Especially useful: list commands iterate over all devices found in Linux 2.6 sysfs

# qethconf – Examples

IP Address Takeover configuration:

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

Proxy ARP configuration:

```
#> qethconf rxip add 10.1.1.2 eth0
```

VIPA configuration:

```
#> qethconf vipa add 10.1.1.1 eth0
#> qethconf vipa add 10.1.1.1 eth1
```

```
#> qethconf vipa list
vipa add 10.1.1.1 eth0
vipa add 10.1.1.1 eth1
```

Display all IP Address Takeover, VIPA and Proxy ARP settings:

```
#> qethconf list_all
ipa add 10.1.1.0/24 eth0
ipa add 10.1.1.0/24 eth1
rxip add 10.1.1.2 eth0
vipa add 10.1.1.1 eth0
vipa add 10.1.1.1 eth1
```

# The qetharp Tool

- Command line utility to query the ARP cache of OSA and HiperSockets devices
- Part of **s390-tools** package available on DeveloperWorks
- Query of OSA devices returns real ARP cache and entries of local OSA Address Table (OAT)
- Query of HiperSockets devices returns entries of address table associated to a HiperSockets CHPID, i.e. all IP addresses that are currently set on that CHPID
- Currently not supported on VM GuestLAN
- Not working on hosts running with layer2

# qetharp – Examples

Query ARP cache of an OSA Express card:

```
#> qetharp -nq eth1
Address                    HWaddress            HWType    Iface
10.30.151.31               02:00:00:00:29:29    ether     eth1
10.30.30.13                00:09:6b:1a:0c:ed    ether     eth1
10.30.30.7                 00:09:6b:1a:0c:ed    ether     eth1
10.30.130.17               00:09:6b:1a:0c:ed    ether     eth1
10.30.30.9                 00:09:6b:1a:0c:ed    ether     eth1
10.30.130.111              00:09:6b:1a:0c:ed    ether     eth1
```

remote

local OAT

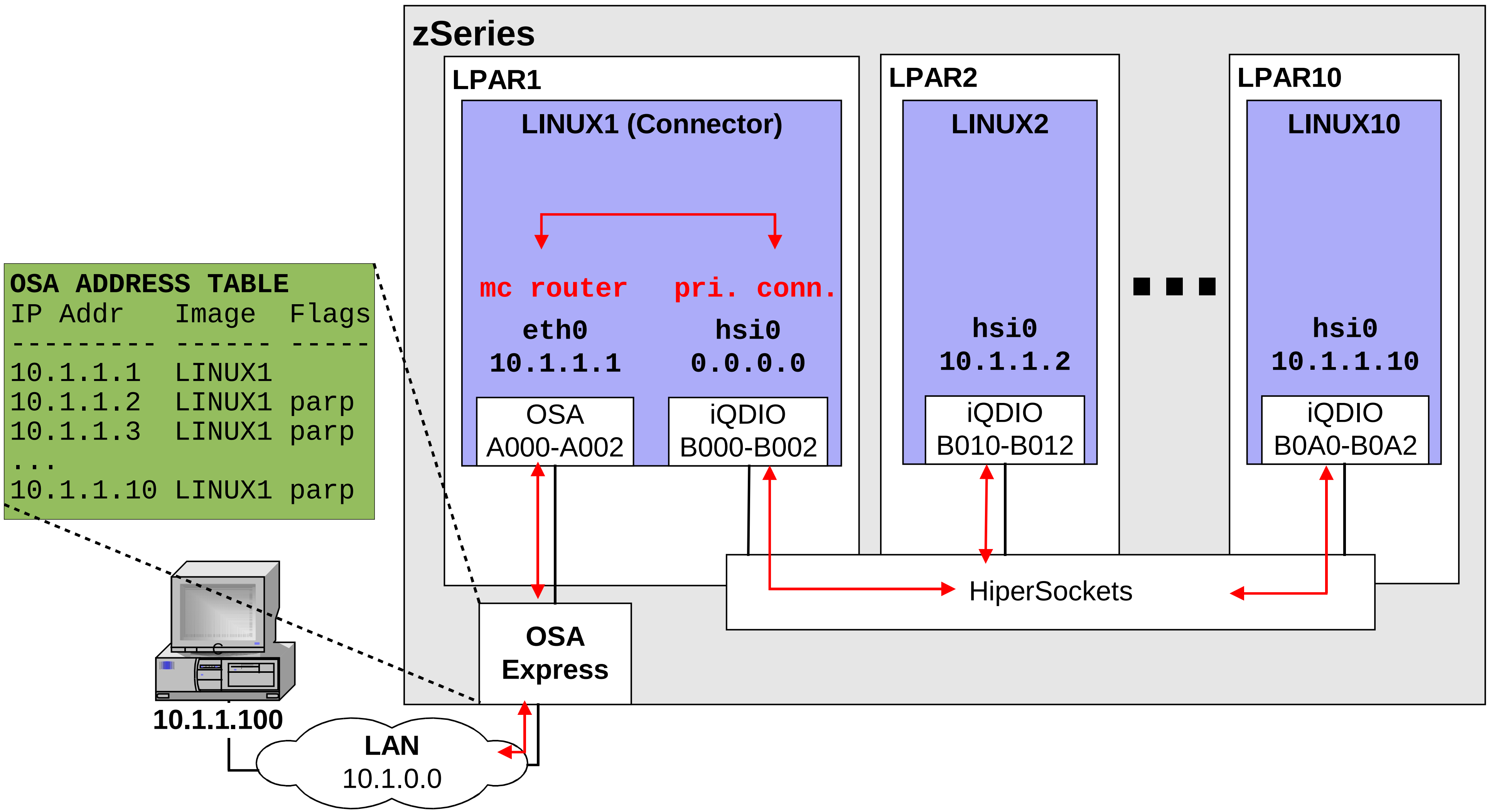
Query address table of a HiperSockets CHPID:

```
#> qetharp -nq hsi0
Address                    HWaddress            HWType    Iface
10.1.3.1                                        hiper     hsi0
10.1.3.2                                        hiper     hsi0
10.1.3.8                                        hiper     hsi0
10.1.3.10                                       hiper     hsi0
```

# HiperSockets Network Concentrator

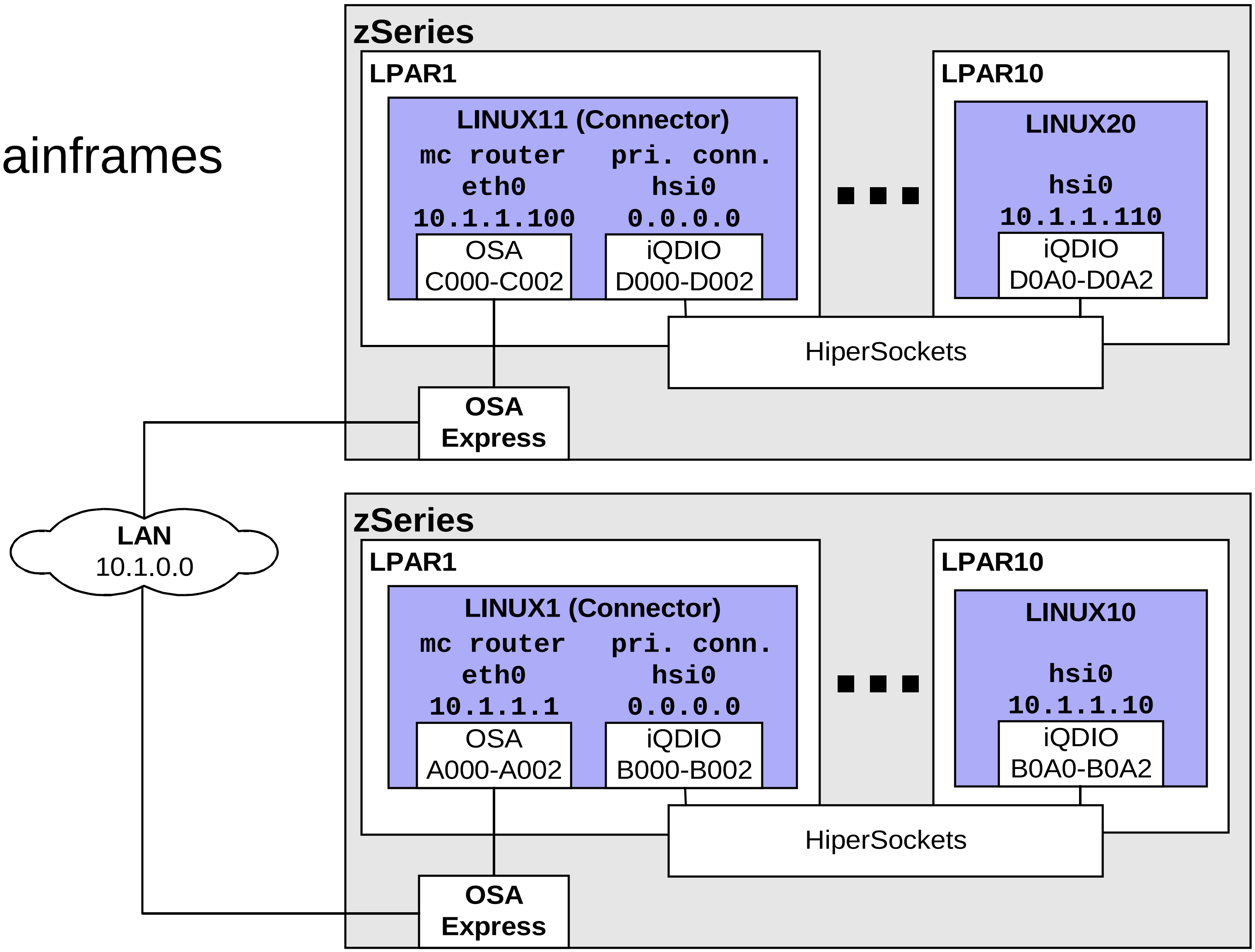
- What is HSNC:
  - A combination of tools for enhanced HiperSockets connectivity
  - Part of **s390-tools** package available at DeveloperWorks
- Enables integration of nodes in a HiperSockets network into an external LAN (i.e. one IP subnet)
- Enables creation of IP subnets across multiple HiperSockets networks on different CECs (Central Electronic Complex) “XCEC HiperSockets”
- Except for connector nodes, completely transparent for attached operating system images
- **Simplification of network topologies** and server consolidation efforts
- Does not work with OSA layer2 at the moment

# HSNC – Topology Example 1

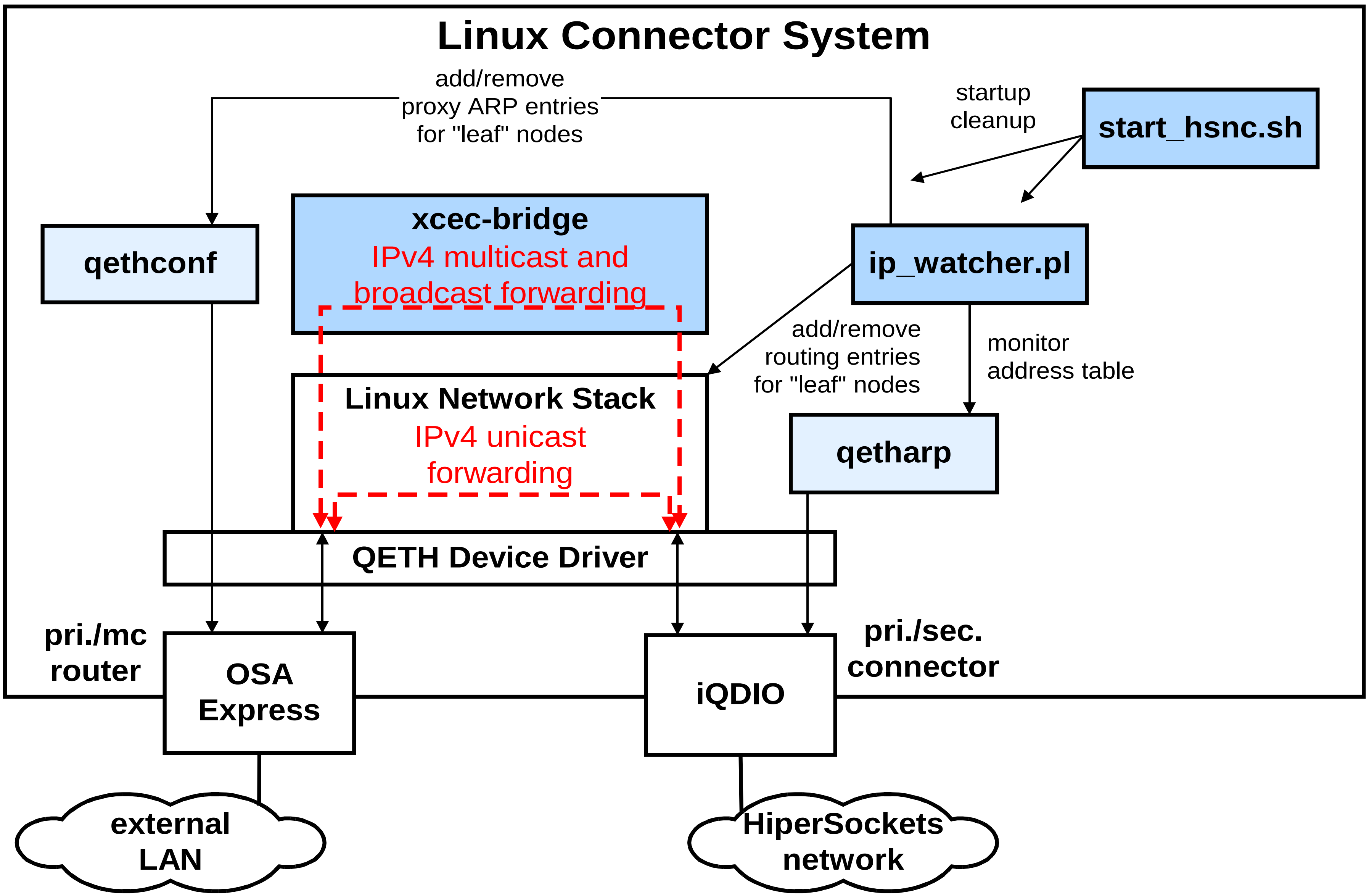


# HSNC – Topology Example 2

Different mainframes or XCEC



# HSNC – How it works



# HSNC – Setup of Connector System

1. Configure your OSA device as multicast router: *

```
#> echo multicast_router > /sys/class/net/eth0/device/route4
```

If no multicast forwarding is desired, use `primary_router`

2. Configure your HiperSockets device as primary connector: *

```
#> echo primary_connector > /sys/class/net/hsi0/device/route4
```

*Optional: You can configure a backup Connector System for failover strategies. Use `secondary_router` for the OSA device and `secondary_connector` for the HiperSockets device on the backup system.

# HSNC – Setup of Connector System (cont.)

3. Check the routing configuration:

```
#> cat /proc/qeth
devices                    CHPID interface  cardtype       ... rtr4 rtr6
-------------------------- ----- ---------- --------------     ---- ---- ...
0.0.a000/0.0.a001/0.0.a002 xA0   eth0       OSD_1000           mc+  no
0.0.b000/0.0.b001/0.0.b002 xB0   hsi0       HiperSockets       p+c  no
```

The '+' sign indicates broadcast filtering capability. This is required for broadcast forwarding.

4. Enable IP forwarding:

```
#> sysctl -w net.ipv4.ip_forward=1
```

5. Start HSNC:

```
#> start_hsnc.sh
```

The OSA device can be specified as start option. This enables unicast forwarding only.

# References

- Linux for zSeries and S/390 on DeveloperWorks

  http://www-128.ibm.com/developerworks/linux/linux390/index.html

- Linux for zSeries and S/390 Documentation

  http://www-128.ibm.com/developerworks/linux/linux390/april2004_documentation.html

- Linux for zSeries and S/390, useful add-ons

  http://www-128.ibm.com/developerworks/linux/linux390/useful_add-ons.html