9267 - Networking with Linux® on System z

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Schedule: Thursday 11:00 AM

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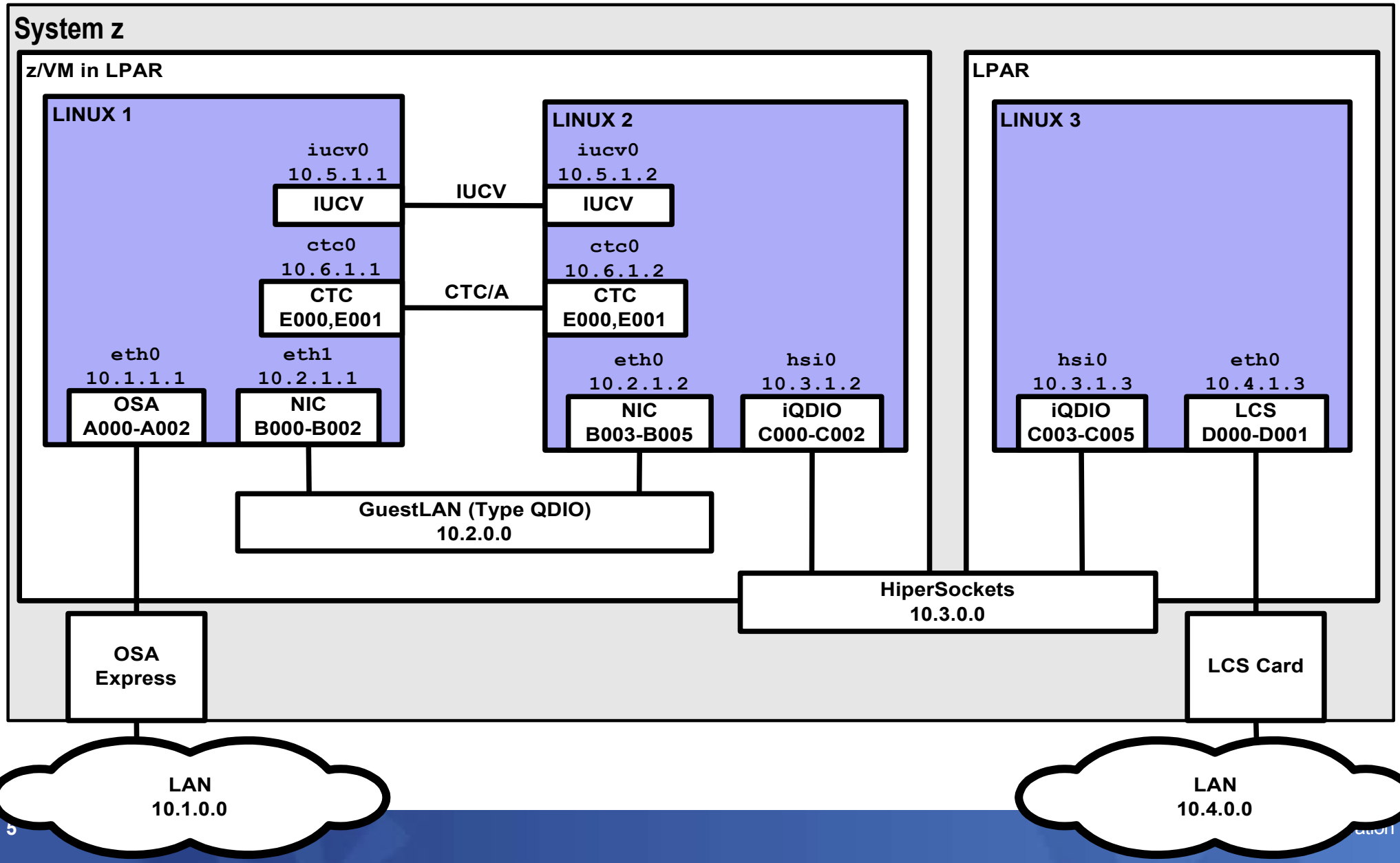
Agenda

- Linux on System z network device drivers
- Configuration of network devices
  - SUSE SLES10
  - RedHat RHEL5
  - Generic (manual)
- Further networking driver aspects
- Advanced aspects
  - Channel Bonding
  - VLAN
  - Virtual IP Addresses

Linux for System z Network Device Drivers

- QETH
- LCS
- CTC (stabilized)
- NETIUCV (stabilized)

Networking Example



Linux 2.6 Device Model – System z Examples

```
/sys
|--block
|   |--dasda
|   |...
|--bus
|    |--ccw
|    |--ccwgroup
|    |    |--devices
|    |         |--0.0.a000
|    |    |--drivers
|    |         |--lcs
|    |         |--qeth
|    |              |--0.0.a000
|    |--css
|--class
|    |--net
|         |--eth0
|              |--device
|--devices
     |--qeth
          |--0.0.a000
```

Block Devices:
DASD, RAM-Disk, Minidisk
SCSI, Loopback

CCW Group Devices:
QETH, LCS

Example: a QETH device

Many ways to find a device

LCS Device Driver

- LCS – LAN Channel Station
- Supports:
  - OSA Express(2) (in non-QDIO mode)
    - Fast Ethernet
    - 1000Base-T Ethernet
    - HighSpeed TokenRing (<= z990)
    - ATM (running Ethernet LAN Emulation) (<= z990)
- May be preferred instead of QETH for security reasons
  - Administrator defines OSA Address Table, whereas with QETH each Linux registers its own IP address --> restricted access

But: performance is inferior to QETH's performance!

Message to CTC and IUCV users

- CTC = Channel-to-Channel connection
- IUCV = Inter User Communication Vehicle
- CTC and NETIUCV device drivers are deprecated (LINUX 2.6+)
- Device drivers still available for backward compatibility
- Migrate
  - Virtual CTC and IUCV (under z/VM) to guest LAN HiperSockets or guest LAN type QDIO
  - CTC inside a CEC to Hipersockets
  - CTC to OSA-Express (QDIO)

QETH Device Driver

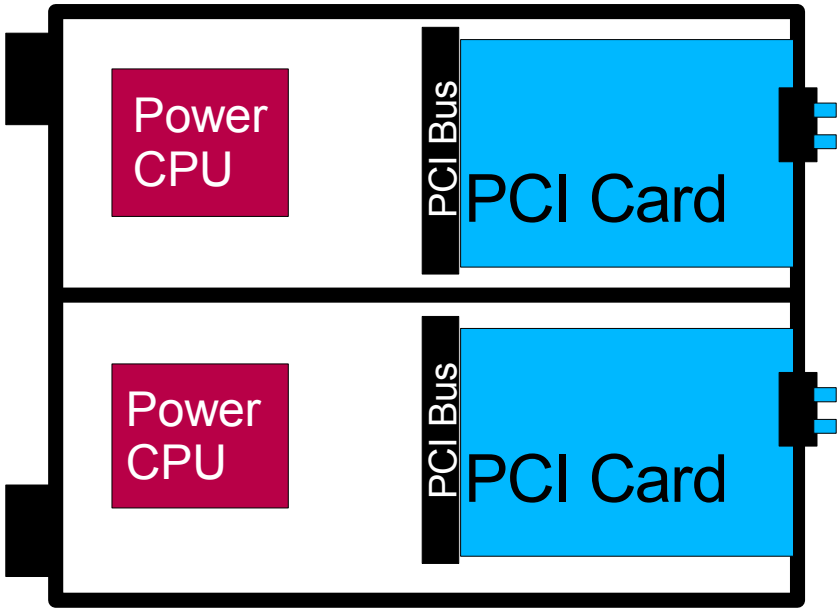
- Supports:
  - OSA Express(2)
    - Fast/Giga/10GBit Ethernet
    - 1000Base-T Ethernet
    - HighSpeed TokenRing (<= z990)
    - ATM (running Ethernet LAN Emulation) (<= z990)
  - System Z HiperSockets
  - z/VM
    - GuestLAN Type QDIO (layer2 / layer3), Type Hiper
    - z/VM VSWITCH (layer2 / layer3)
- IPv4, IPv6, VLAN, VIPA, Proxy ARP, IP Address Takeover, Channel Bonding

Primary network driver for Linux on System z

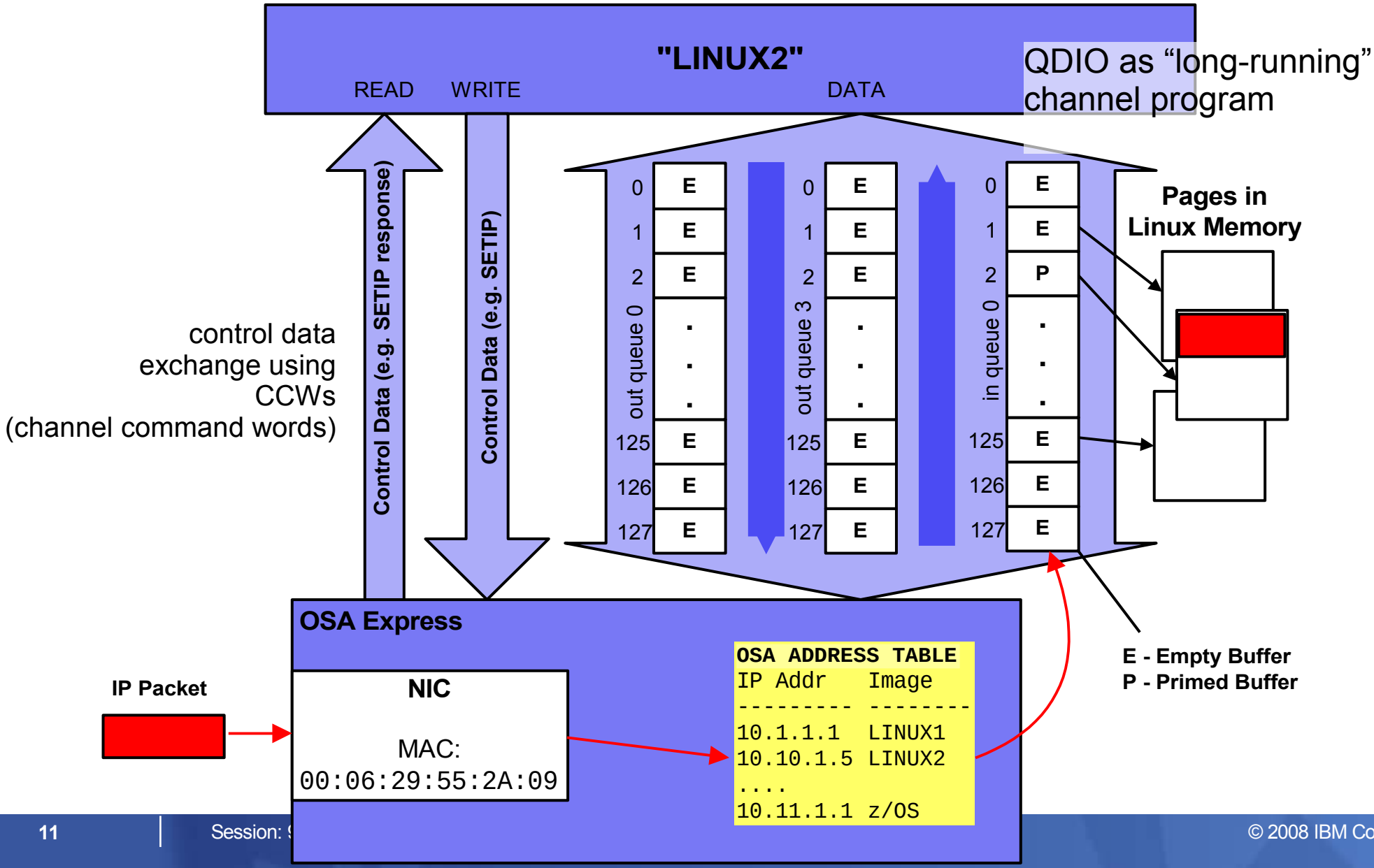
Main focus in current and future development

Primary Network Device: OSA Express

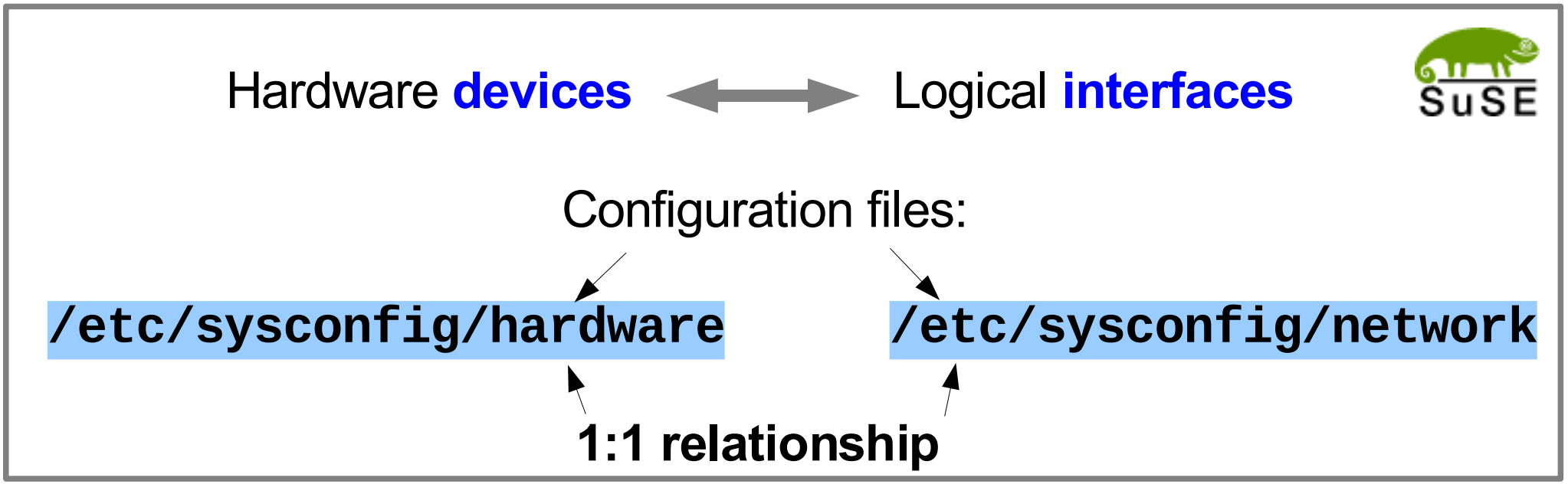
- 'Integrated Power computer' with network daughter card
- Shared between up to 640 / 1920 TCP/IP stacks
- OSA Address Table: which OS image has which IP address
- Three devices (I/O subchannels) per stack:
  - Read device (control data <-- OSA)
  - Write device (control data --> OSA)
  - Data device (network traffic)
- Network traffic Linux <--> OSA
  at IP (layer3) or ethernet (layer2) level
- One MAC address for all stacks (layer 3)
- OSA handles ARP (layer 3)
  (Address Resolution Protocol)



The Queued Direct I/O (QDIO) Architecture



SUSE SLES 10 Network Configuration



Naming convention:

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

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

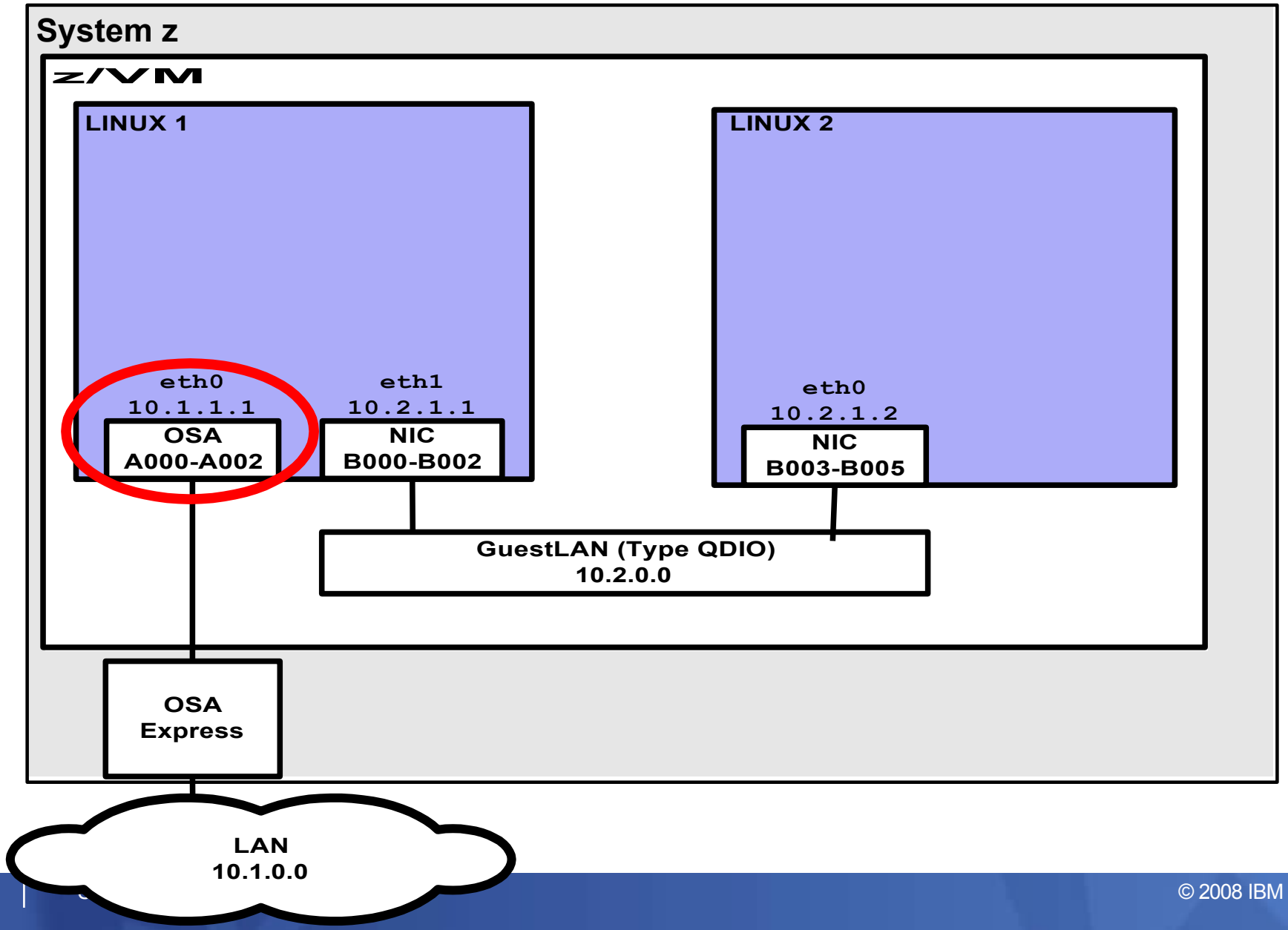
ifcfg-qeth-bus-ccw-0.0.a000

Scripts: **hwup / hwdown** and **ifup / ifdown**

see **/etc/sysconfig/hardware/skel/hwcfg-<device type>**

/usr/share/doc/packages/sysconfig/README and README.s390

Networking Example

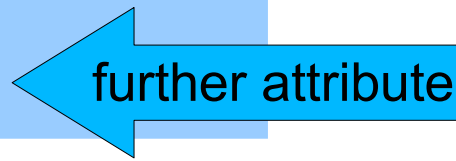


Static QETH Device Setup (SUSE SLES10)

For LINUX 1 eth0

1. Create a hardware device configuration file:

```
/etc/sysconfig/hardware/hwcfg-qeth-bus-ccw-0.0.a000:
  CCW_CHAN_IDS='0.0.a000 0.0.a001 0.0.a002'
  CCW_CHAN_MODE='OSAPORT'
  CCW_CHAN_NUM='3'
  MODULE='qeth'
  MODULE_OPTIONS=''
  MODULE_UNLOAD='yes'
  SCRIPTDOWN='hwdown-ccw'
  SCRIPTUP='hwup-ccw'
  SCRIPTUP_ccw='hwup-ccw'
  SCRIPTUP_ccwgroup='hwup-qeth'
  STARTMODE='auto'
  QETH_LAYER2_SUPPORT='0'
  QETH_OPTIONS='checksumming=hw_checksumming'
```



Static QETH Device Setup (SUSE SLES10) (cont.)

- **CCW_CHAN_IDS** are Read, Write, Data subchannels
  - Hexadecimal characters must be lowercase
- **STARTMODE** 'auto' --> started by hotplug agents
  'manual' --> manual startup
- **QETH_OPTIONS** allows to set optional attributes

  e.g.
  `QETH_OPTIONS='checksumming=hw_checksumming'`

- A sample hwcfg-file for QETH can be found at `/etc/sysconfig/hardware/skel/hwcfg-qeth`

Static QETH Device Setup (SUSE SLES10) (cont.)

2. Create an interface configuration file:

```
/etc/sysconfig/network/ifcfg-qeth-bus-ccw-0.0.a000
  BOOTPROTO='static'
  BROADCAST='10.1.255.255'
  IPADDR='10.1.1.1'
  NETMASK='255.255.0.0'
  NETWORK='10.1.0.0'
  STARTMODE='onboot'
```

Explanations are found in

```
/etc/sysconfig/network/ifcfg.template
```

3. Before reboot: test your config files:

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

RedHat RHEL5 Network Configuration

- Configuration files:

  /etc/modprobe.conf

```
alias eth0 qeth
alias eth1 qeth
alias hsi0 qeth
alias eth2 lcs
```

/etc/sysconfig/network-scripts/ifcfg-<ifname>

```
NETTYPE      qeth | lcs | ctc | iucv
TYPE         Ethernet | CTC | IUCV
SUBCHANNELS  0.0.b003,0.0.b004,0.0.b005
PORTNAME
OPTIONS
MACADDR
```

- **ifup/ifdown** scripts contain mainframe-specifics

Static QETH Device Setup (RedHat RHEL5)

For LINUX 1 eth0

1. Create the configuration file:

```
/etc/sysconfig/network-scripts/ifcfg-eth0:
  DEVICE=eth0
  SUBCHANNELS='0.0.a000,0.0.a001,0.0.a002'
  PORTNAME=OSAPORT
  NETTYPE=qeth
  TYPE=Ethernet
  BOOTPROTO=static
  ONBOOT=yes
  BROADCAST=10.1.255.255
  IPADDR=10.1.1.1
  NETMASK=255.255.0.0
  OPTIONS='checksumming=hw_checksumming'
```

Static QETH Device Setup (RedHat RHEL5) (cont.)

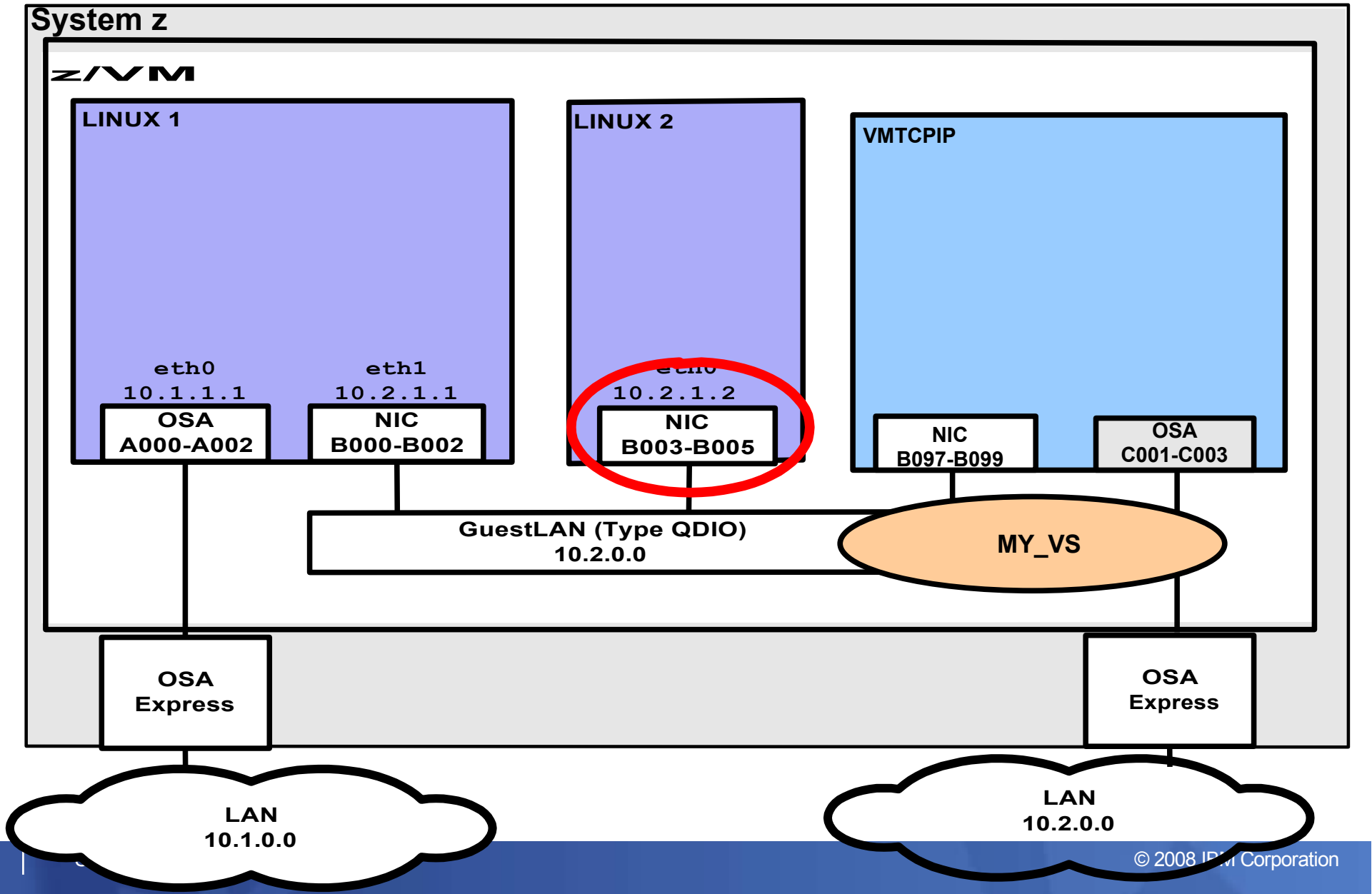
2. Add / verify alias in /etc/modprobe.conf:

```
/etc/modprobe.conf:
   ...
   alias eth0 qeth
   ...
```

3. For details see:

http://www.redhat.com/docs/manuals/enterprise/

Networking Example



Dynamic QETH Device Setup

For LINUX 2 eth0

1. In your z/VM console (if not already defined in user directory) do

    1.1. Create a GuestLAN or VSWITCH

```
[ #CP DEFINE LAN MY_LAN TYPE QDIO ]

#CP DEFINE VSWITCH MY_VS RDEV C001 CONTROLLER * IP

#CP SET VSWITCH MY_VS GRANT LINUX2
```

    1.2. Create a virtual NIC

```
#CP DEFINE NIC B003 TYPE QDIO
```

    1.3. Couple virtual NIC to GuestLAN/VSWITCH

```
#CP COUPLE B003 TO * MY_VS
```

Dynamic QETH Device Setup (cont.)

2. Load the QETH device driver module:

```
#> modprobe qeth
```

3. Create a new QETH device by grouping its CCW devices:

```
#> echo 0.0.b003,0.0.b004,0.0.b005 > /sys/bus/ccwgroup/
   drivers/qeth/group
```

4. Set optional attributes:

```
#> echo 64 > /sys/bus/ccwgroup/drivers/qeth/0.0.b003/
   buffer_count

#> echo 1 > /sys/devices/qeth/0.0.b003/fake_ll
```

Note the alternative ways to your device

Dynamic QETH Device Setup (cont.)

5. Set the new device online:

```
#> echo 1 > /sys/devices/qeth/0.0.b003/online
```

6. Check your QETH devices:

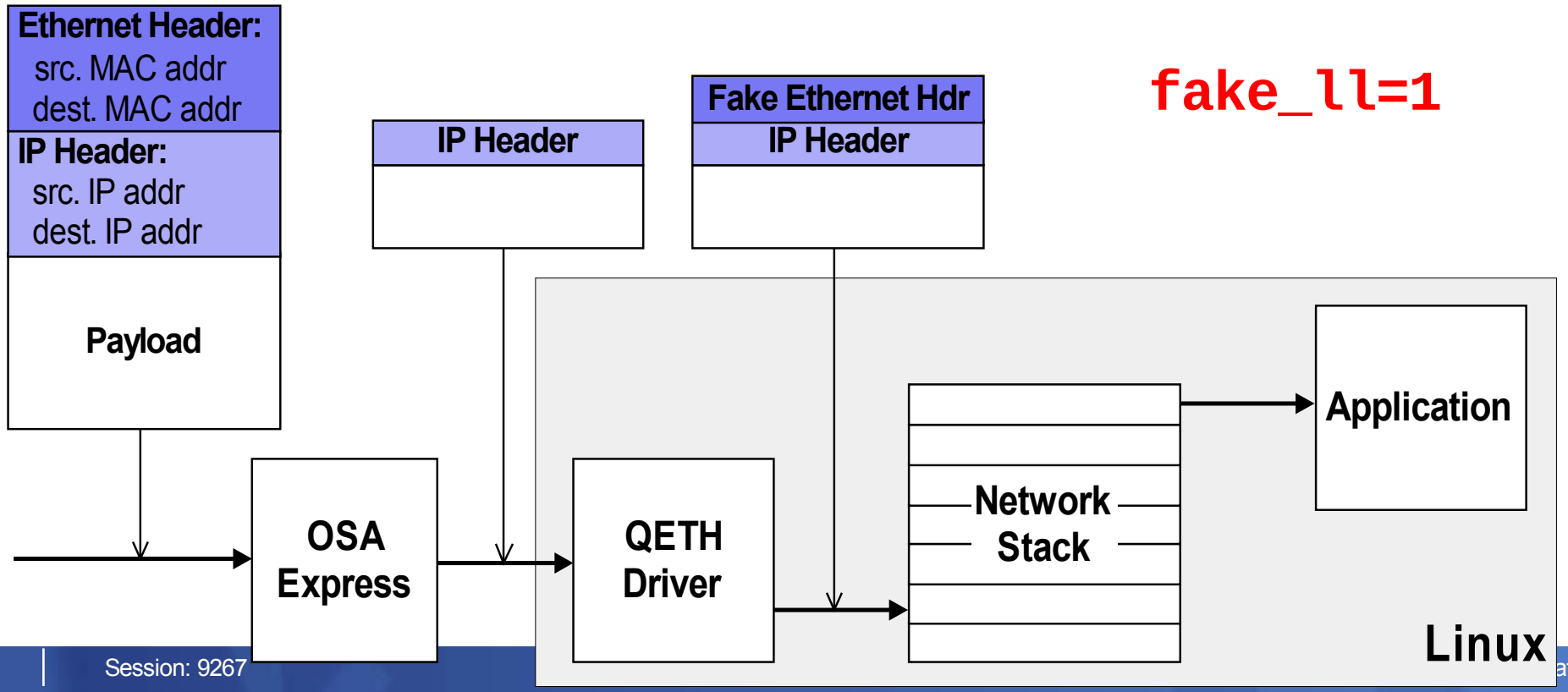
```
#> lsqeth -p
devices                         CHPID interface  cardtype
------------------------------- ----- ---------- -------------- ...
0.0.c000/0.0.c001/0.0.c002 xC0   hsi0       HiperSockets
0.0.b003/0.0.b004/0.0.b005 x01   eth0       GuestLAN QDIO
```

7. Configure your new eth0 interface:

```
#> ifconfig eth0 10.2.1.2 netmask 255.255.0.0
```

QETH Device sysfs Attribute fake_ll

- Build fake ethernet headers before handing packets to the network stack.
- Required by some network applications, e.g. **DHCP** or TCPDUMP (for layer3 devices only)



QETH Device sysfs Attribute large_send

- Offload TCP segmentation from Linux network stack to OSA-card

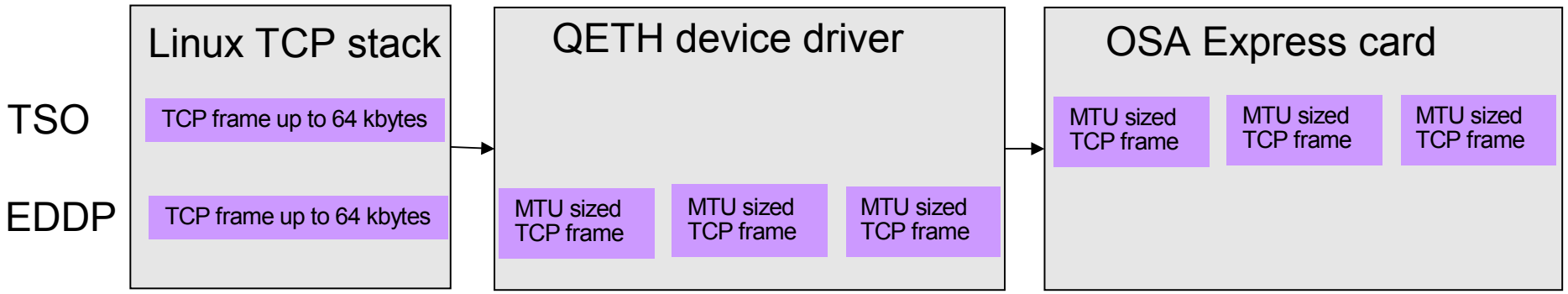
```
QETH_OPTIONS='large_send=TSO'                    or
```

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

- Offload TCP segmentation from Linux network stack to device driver

```
QETH_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

- additional redundancy check to protect data integrity
- Offload checksumming for incoming IP packages from Linux network stack to OSA-card

```
QETH_OPTIONS='checksumming=hw_checksumming'     or
```

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

- ===> move workload from Linux to OSA-Express adapter
- Available for OSA-devices in layer3 mode only

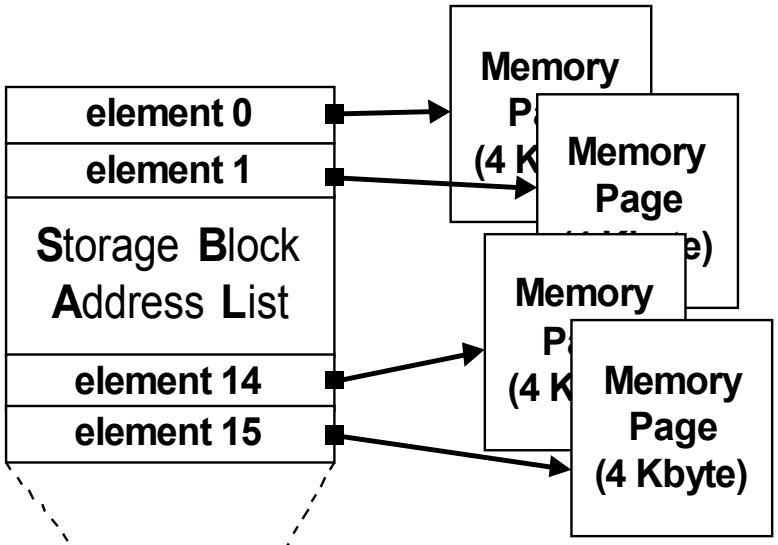
QETH Device sysfs Attribute recover

- enforce recovery of a qeth device

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

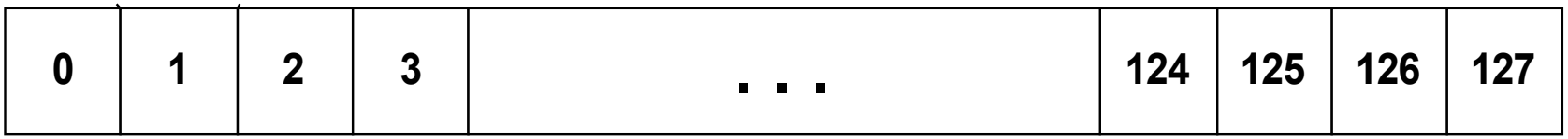
QETH Device sysfs Attribute buffer_count

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



Per QETH card memory usage:

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



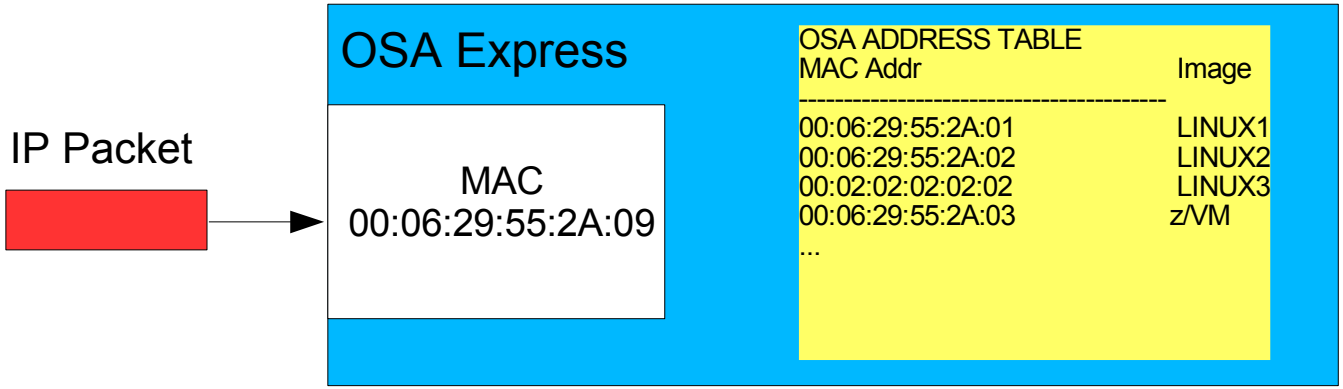
8 buffers — 16 buffers (default, recommended) — 128 buffers

Boost performance

Save memory

QETH Layer 2 mode

- OSA works with MAC addresses ==>no longer stripped from packets.



- **hwcfg-qeth... file (SLES10)** : `QETH_LAYER2_SUPPORT=1`
- **ifcfg-qeth... file (SLES10):** `LLADDR='<MAC Address>'`
- **ifcfg-... file (RHEL5) :** `MACADDR='<MAC Address>'`
  `OPTIONS='layer2=1'`
- Direct attached OSA:
  MAC address must be defined with ifconfig manually
  `ifconfig eth0 hw ether 00:06:29:55:2A:01`
- HiperSocket: **new** layer2 support starting with z10
  MAC address automatically generated
- VSWITCH or GuestLAN under z/VM: MAC address created by z/VM

QETH Layer 2 mode (cont.)

```
/sys
|--devices
   |--qeth
      |--0.0.<devno>
         |--layer2
```

- activating Layer 2 is done per device via sysfs attributes
- possible layer2 values:
  - 0: use device in Layer 3 mode
  - 1: use device in Layer 2 mode

- setting of layer2 attribute is only permitted when device is offline !

- Advantages:
  - Independent of IP-protocol
  - DHCP, tcpdump working without option fake_ll
  - channel bonding possible
  - No OSA-specific setup necessary for
    - Routing, IP Address Takeover, Proxy ARP

QETH Layer 2 mode (cont.)

- Direct attached OSA
  - Restrictions:
  - Older OSA-generation (<= z990):
    Layer2 and Layer3 traffic can be transmitted over the same OSA CHPID, but not between two hosts sharing the same CHPID !

- HiperSocket (new with z10)
  - Layer2 and Layer3 traffic separated

- GuestLAN type QDIO supported
  GuestLAN definition for layer2:

```
define lan <lanname> ... type QDIO ETHERNET
define nic <vdev> QDIO
couple <vdev> <ownerid> <lanname>
```

- VSWITCH

```
define vswitch <vswname> ... ETHERNET ...
define nic <vdev> QDIO
couple <vdev> <ownerid> <lanname>
```

Commands / tools for qeth-driven devices

- List of known qeth devices: *cat /proc/qeth* or *lsqeth -p*

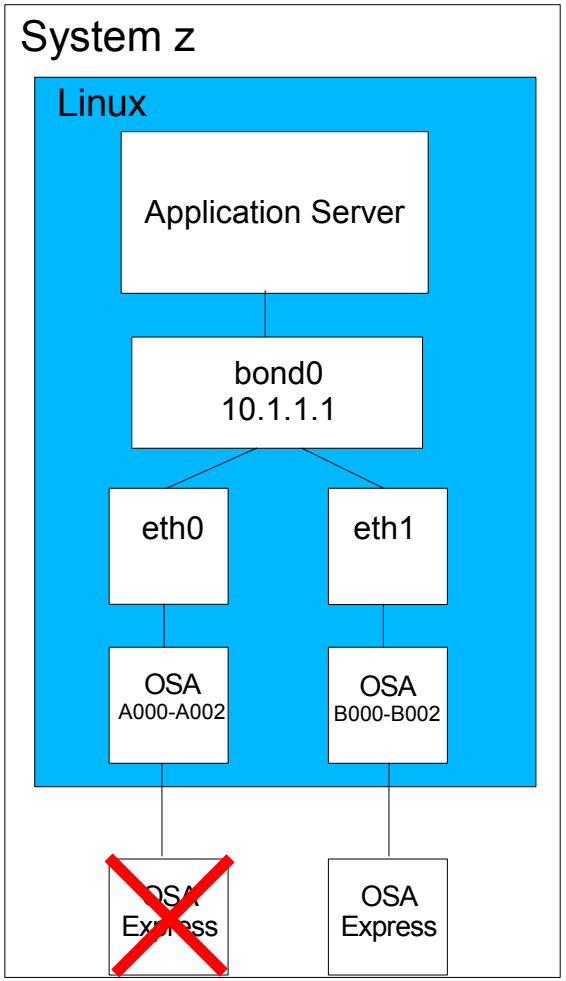
```
#> cat /proc/qeth
devices                   CHPID interface  cardtype     port chksum  ...
------------------------- ----- ---------- ------------ ---- ------  ...
0.0.a000/0.0.a001/0.0.a002 xA0   eth0       OSD_1000     0    sw      ...
0.0.b000/0.0.b001/0.0.b002 xB0   hsi0       HiperSockets 0    sw      ...
```

- Attributes of qeth device: *lsqeth* or *lsqeth <interface>*

```
#> lsqeth eth0
Device name                          : eth0
-------------------------------------------
        card_type                    : OSD_1000
        cdev0                        : 0.0.f5f0
        cdev1                        : 0.0.f5f1
        cdev2                        : 0.0.f5f2
        chpid                        : 76
        online                       : 1
        checksumming                 : sw checksumming
        state                        : UP (LAN ONLINE)
        buffer_count                 : 16
        layer2                       : 0
```

Clip of displayed attributes only

Channel Bonding



- The Linux bonding driver provides a method for aggregating multiple network interfaces into a single logical "bonded" interface
- provides failover and / or load-balancing functionality
- better performance depending on bonding mode
- transparent for LAN infrastructure
- applies to layer2-devices only
- latest setup description:

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

Channel bonding setup

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

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

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

```
#> modprobe bonding miimon=100 mode=balance-rr
```

- Bring up bonding device bond0

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

- connect eth0 & eth1 to bond0

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

Channel bonding setup (SLES10 – config files)

- interface configuration file for a slave

```
/etc/sysconfig/network/ifcfg-qeth-bus-ccw-0.0.a000
   BOOTPROTO='static'
   IPADDR=''
   SLAVE='yes'
   STARTMODE='onboot'
```

- interface configuration file for a master

```
/etc/sysconfig/network/ifcfg-bond0
   BOOTPROTO='static'
   BROADCAST='10.1.255.255'
   IPADDR='10.1.1.1'
   NETMASK='255.255.0.0'
   NETWORK='10.1.0.0'
   STARTMODE='onboot'

  BONDING_MASTER='yes'
   BONDING_MODULE_OPTS='mode=1 miimon=1'
   BONDING_SLAVE0='qeth-bus-ccw-0.0.a000'
   BONDING_SLAVE1='qeth-bus-ccw-0.0.b000'
```

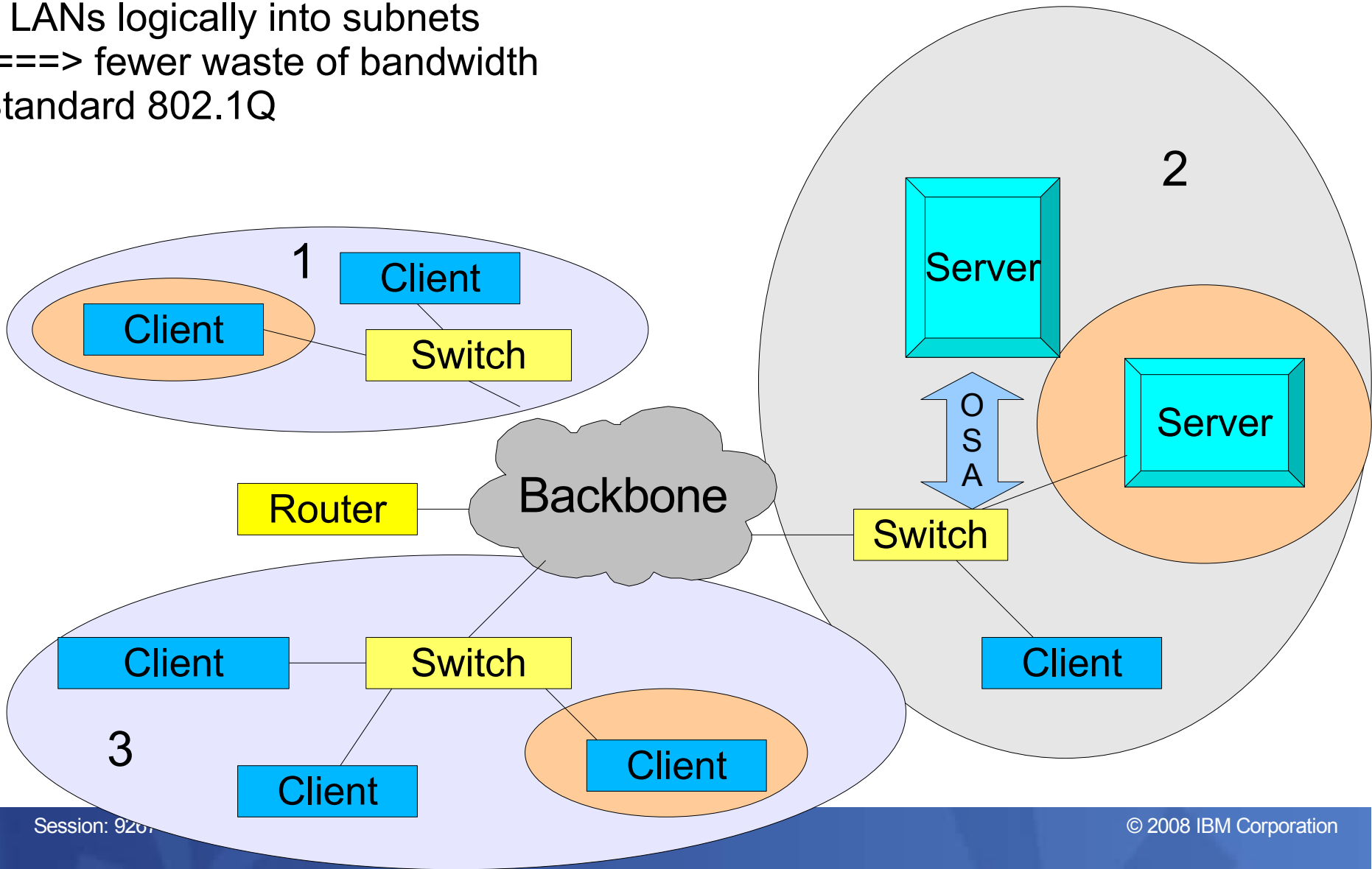
Channel bonding setup (cont.)

```
#> ifconfig
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): 100

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
```

Virtual LAN (VLAN) support

- Risk of big switched LANs: flooded with broadcast traffic
- Devide LANs logically into subnets
  ===> fewer waste of bandwidth
- IEEE Standard 802.1Q



Virtual LAN (VLAN) support (cont.)

- Setup:

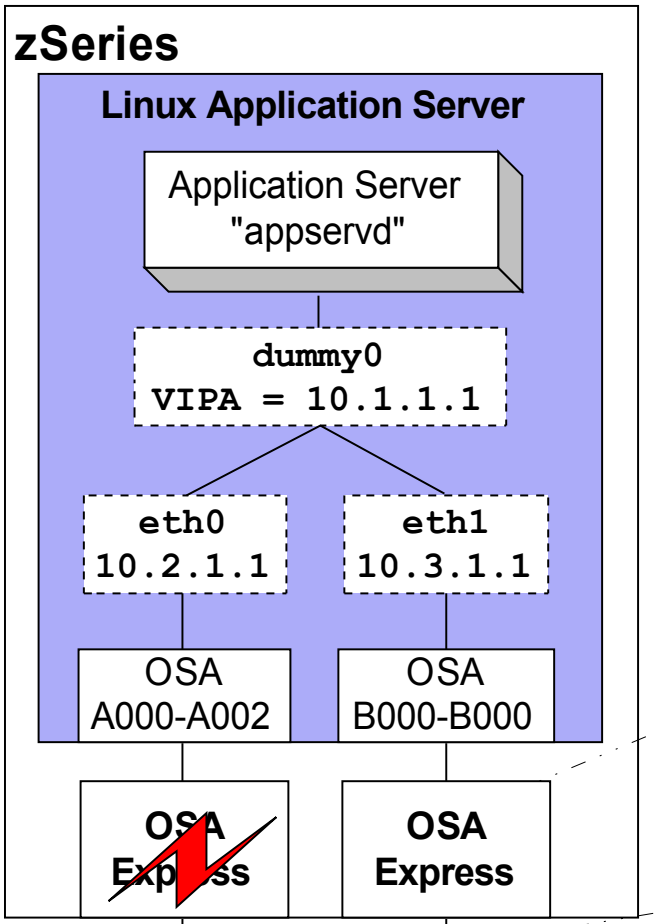
```
ifconfig eth1 9.164.160.23 netmask 255.255.224.0
vconfig add eth1 3
ifconfig eth1.3 1.2.3.4 netmask 255.255.0.0
```

- Displaying info:

```
cat /proc/net/vlan/config
VLAN Dev name    | VLAN_ID
Name-Type: VLAN_NAME_TYPE_RAW_PLUS_VID_NO_PAD
eth1.3           | 3  | eth1
```

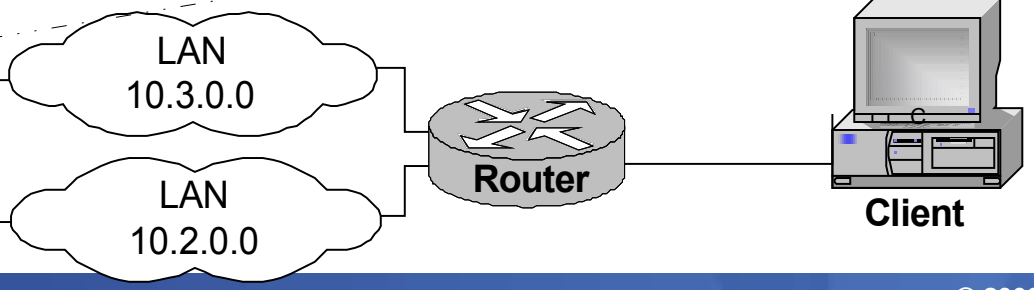
- Implemented:
  VLAN tag, added to packets transmitted
- Supported by:
  real OSA-card, HiperSockets, z/VM Guest LAN, z/VM VSWITCH

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

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



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. 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
```

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. quagga: http://quagga.net).

Interface names

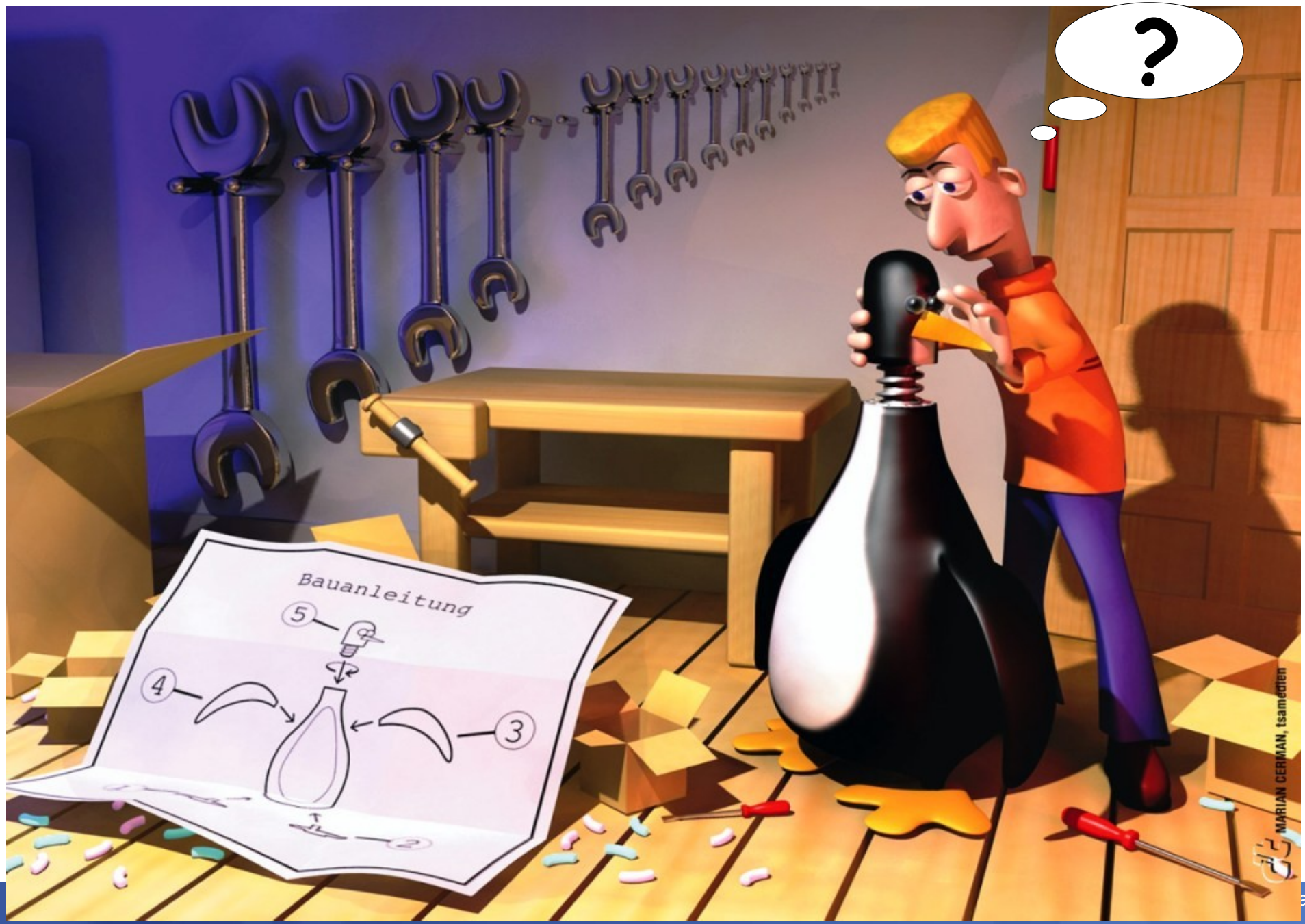
Interface Name	Device Driver	Interface / Link Type	Model / Submodel	Used for
eth<x>	qeth lcs lcs	Ethernet	1731/01 3088/01 3088/60	OSA-card / type OSD P390-LCS-card OSA-card / type OSE
hsi<x>	qeth	Ethernet	1731/05	HiperSockets / type IQD
tr<x>	qeth lcs lcs	Token Ring	1731/01 3088/01 3088/60	OSA-card / type OSD P390-LCS-card OSA-card / type OSE
osn<x>	qeth	SNA<->Ethernet	1731/06	OSA-card / type OSN
ctc<x>	ctc	Point-to-Point	3088/08 3088/1e 3088/1f virtual	Channel-To-Channel adapter FICON adapter ESCON adapter VM-guest communication
iucv<x>	netiucv	Point-to-Point	virtual	VM-guest communication

Summary of Linux Network Device Drivers

	QETH				LCS	CTC	IUCV
	OSA	HiperSockets	GuestLAN QDIO	GuestLAN Hiper			
Adapters	100 Mbps, 1Gbps, 1000 Base-T, HSTR				100 Mbps, 1000 Base-T, HSTR	ESCON, FICON, Virtual CTC/A	
Connection type	LAN	LAN	LAN	LAN	LAN	point-to-point	point-to-point
Layer	Layer2 / 3	Layer2 /3	Layer2 / 3	Layer3	Layer3		
Protocols	IPv4, IPv6	IPv4, Ipv6	IPv4, IPv6	IPv4	IPv4	IPv4	IPv4
Remarks	**Primary network device driver for Linux on System z**				restricted access (admin defines OSA Address Table)	Deprecated	Deprecated

References

- Linux on System z on developerWorks
  http://www-128.ibm.com/developerworks/linux/linux390/index.html
- Linux on System z Documentation
  http://www-128.ibm.com/developerworks/linux/linux390/october2005_documentation.html
- Linux on System z, useful add-ons
  http://www-128.ibm.com/developerworks/linux/linux390/useful_add-ons.html
- Linux on System z – Tuning Hints & Tips
  http://www-128.ibm.com/developerworks/linux/linux390/perf/index.html
- IBM System z Connectivity Handbook
  http://www.redbooks.ibm.com/redpieces/abstracts/sg245444.html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