

# z/VM Virtual Switch

21<sup>st</sup> Edition

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## Notes

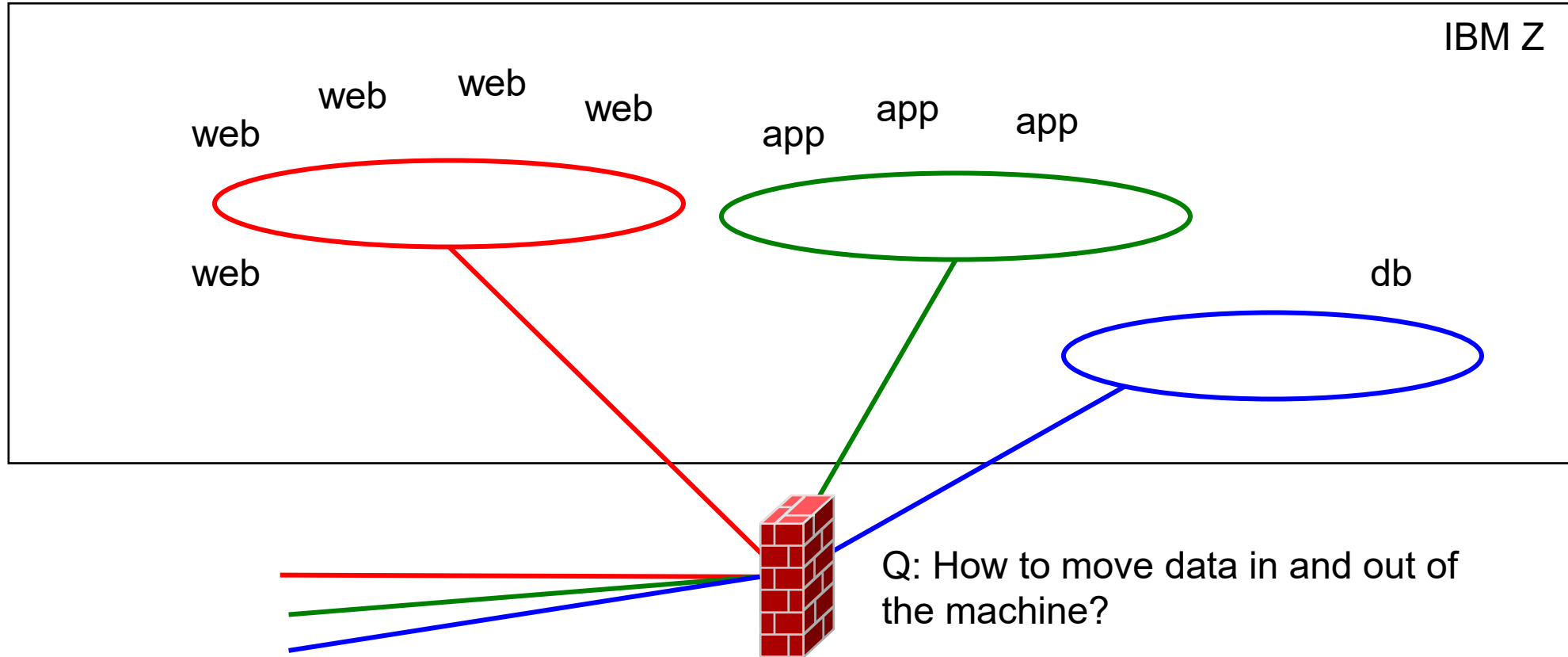
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# Topics

- Overview
- The Uplink
- The virtual NIC
- The VSWITCH controller
- Link Aggregation
- Port sharing
  - Global VSWITCH and shared port groups
- HiperSocket VSWITCH Bridge
- Diagnostics

# Multi-zone Network on IBM zSystems With outboard firewall / router

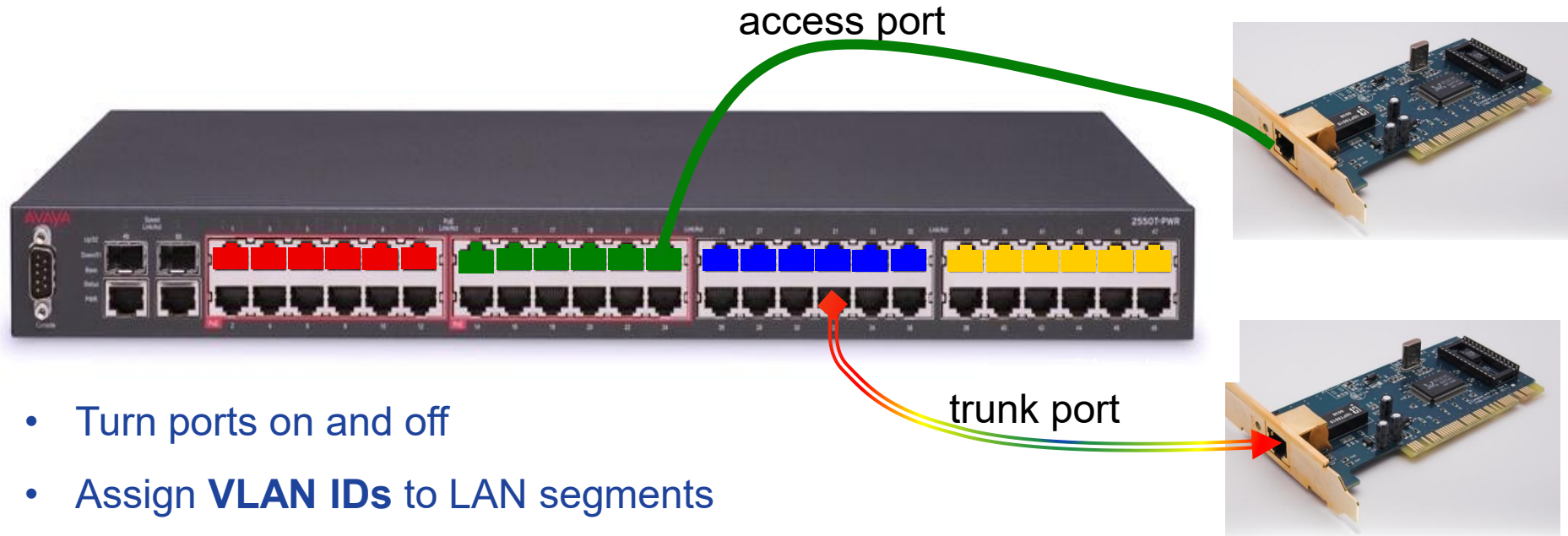


Q: How to move data in and out of the machine?

A: z/VM<sup>®</sup> Virtual Switch

## Q: What's a switch?

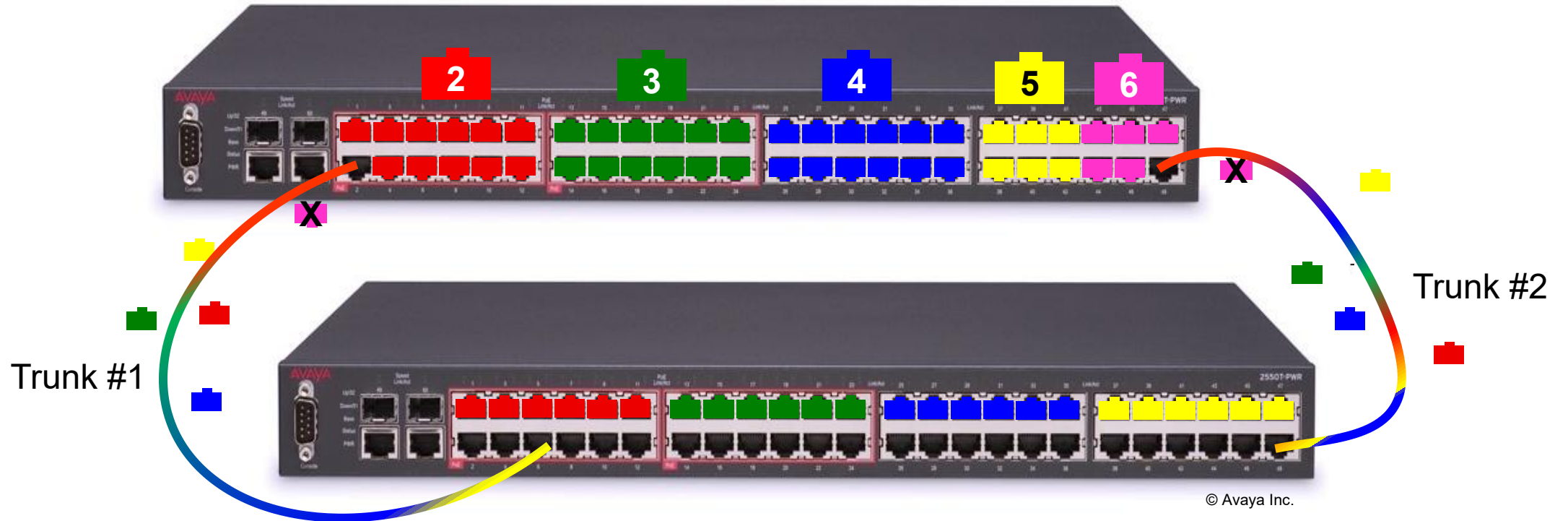
A: A network device management endpoint



- Turn ports on and off
- Assign **VLAN IDs** to LAN segments
- Associate **access** ports with a single VLAN ID
- Associate **trunk** ports with multiple VLAN IDs
- Provide fast switching of data between ports
- Provide sniffer functions

## Q. What's a Bridge?

A: A way to connect two switches

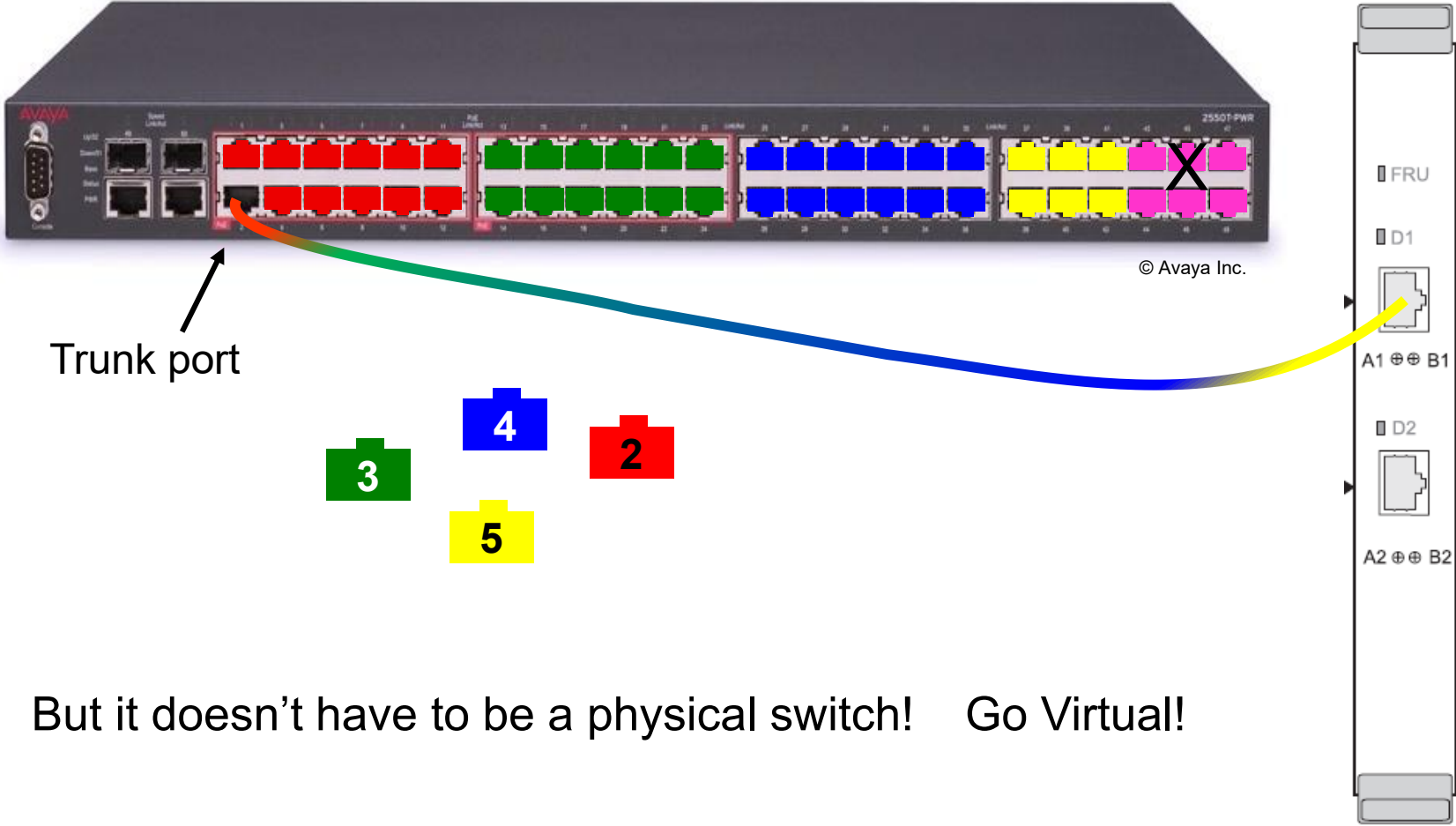


- If you run out of ports, you don't throw it away, you **bridge** it to an adjacent switch
- A **trunk** port carries ethernet frames for **multiple** LAN segments (subnets)
- **VLAN tags** in each frame identify the LAN segment it belongs to
- Redundant connections for high availability

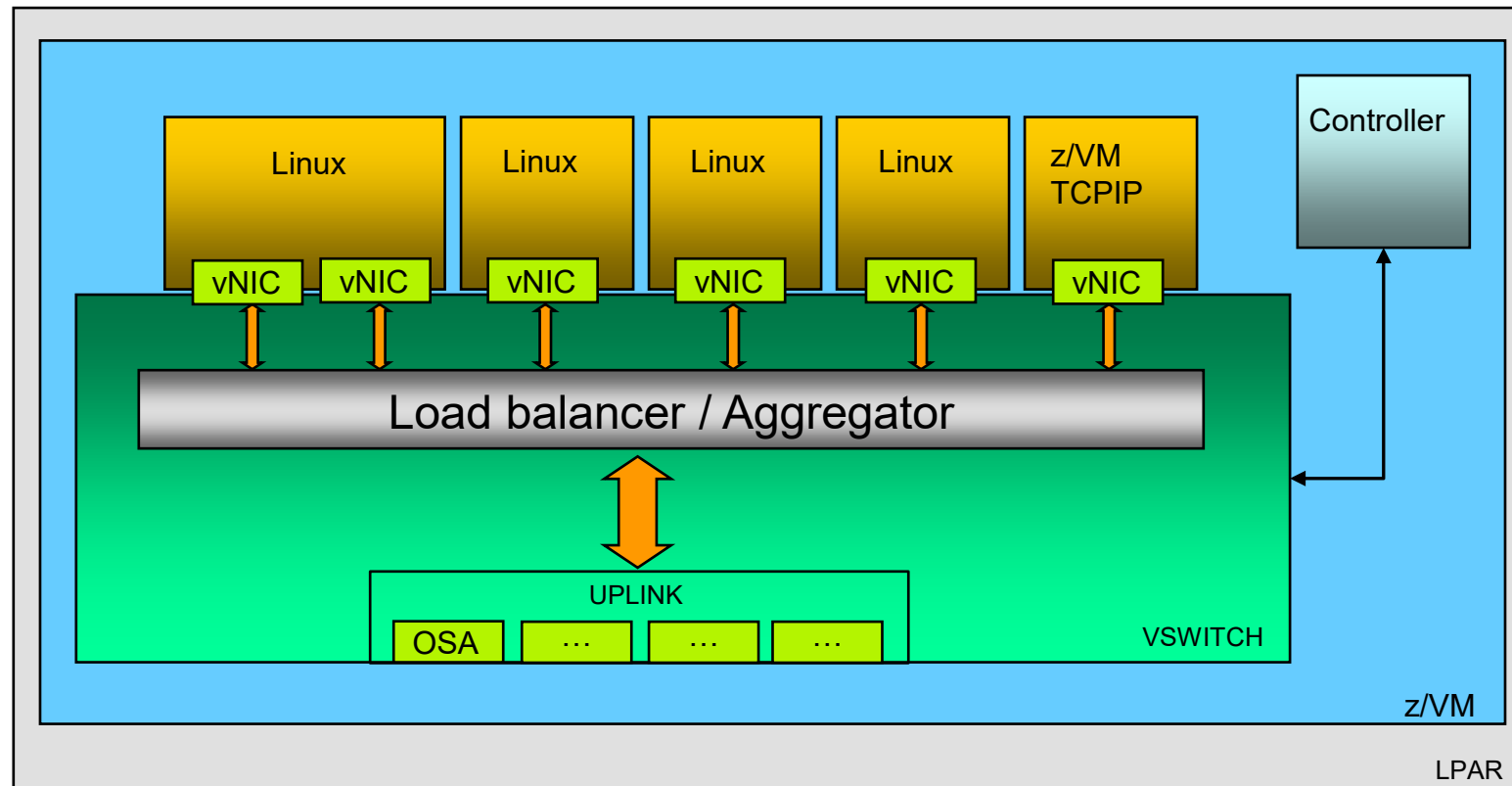
# Bridge versus Router

- A bridge connects two LAN segments that are in the same subnet
  - aka "Layer 2 switch"
  - Behaves as a single LAN segment
  - Do not confuse this with deprecated term "Layer 2 VSWITCH"
- A router connects two LAN segments that are in different subnets
  - aka "Layer 3 switch"
  - Do not confuse this with deprecated term "Layer 3 VSWITCH"
- A VSWITCH configurations are **bridges**, not routers.

# VLAN-aware Virtual Switch

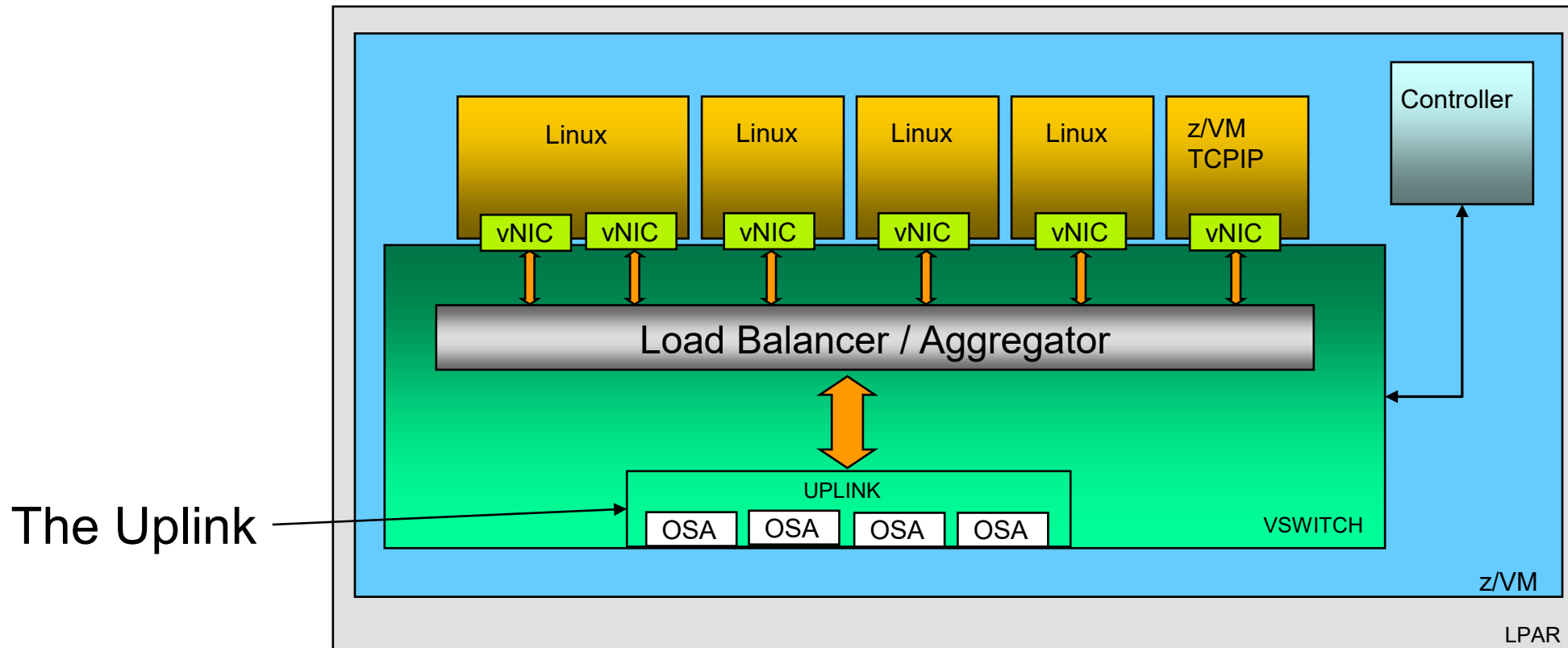


# The Virtual Switch



# The Virtual Switch

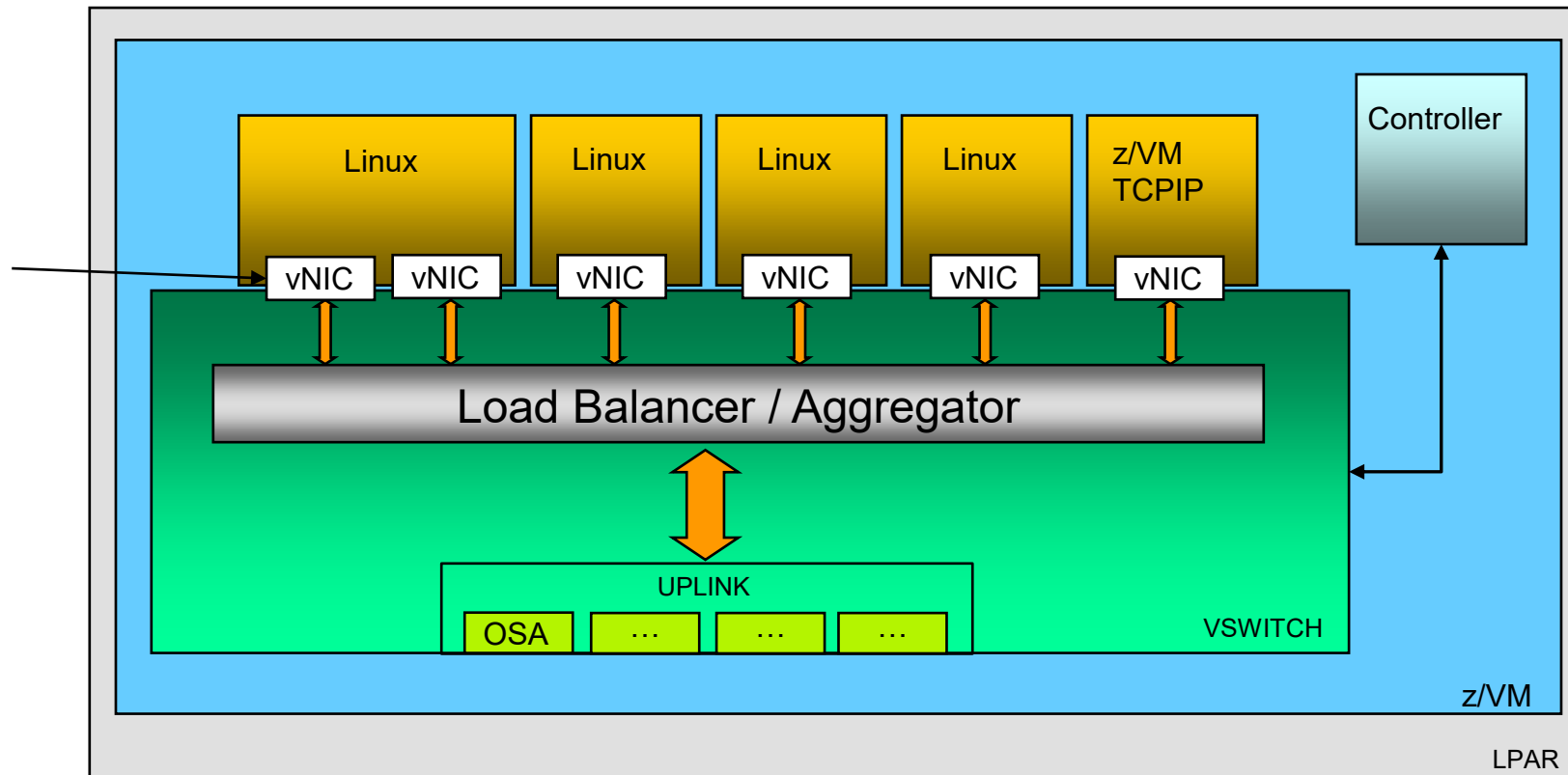
## Configurable Elements



# The Virtual Switch

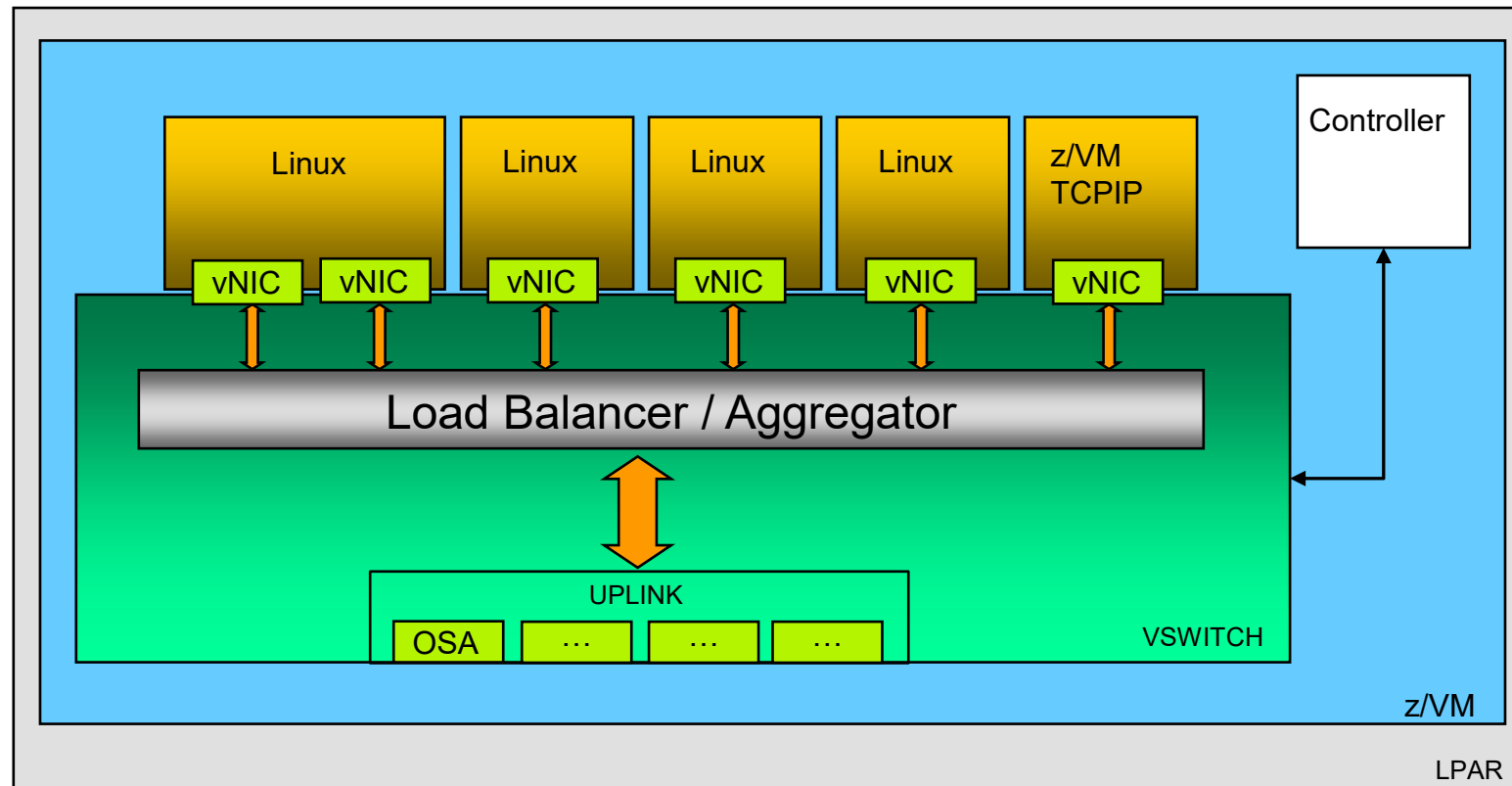
## Configurable Elements

The virtual network interfaces



# The Virtual Switch

## Configurable Elements



The  
Controller

# Virtual Switch general principles

— Bring controllers up first

- Used only for OSD chpids, not OSH

— `DEFINE VSWITCH name {ETHERNET | IP} PORTBASED`

```
    {uplink attributes}  
    {virtual NIC defaults}  
    {accounting settings}
```

— Unless otherwise configured, traffic remains as close to the virtual machines as possible

- Within the VSWITCH
- Within the OSA
- Out to the physical switch

## Suggested Practice:

- Use PORTBASED option for consistency of QUERY VSWITCH output and future directions
- Bring up in AUTOLOG1 / 2 after the controllers are up

# The Uplink

# Uplink Port

— Connects VSWITCH to network

- Without an uplink, data can move only among coupled guests
  - Better than a Guest LAN!

— OSA (OSD) or Network Express (OSH) CHPID

- OSA operates in ETHERNET or IP mode
- Network Express is ETHERNET only

— VLAN aware or unaware

— For high availability, you need more than one physical connection

- Single-port failover (serial)
- Link Aggregation port group (parallel)

## Uplink: IP mode

— DEFINE VSWITCH *name* IP PORTBASED  
[NONROUTER | PRIROUTER]

- Guest and host device driver sends and receives IP packets
- All virtual NICs have the same physical MAC address
  - Packet delivery based on guest-registered IP address
- Good for z/OS guests without support for IBM z17
  - No IPv6
  - No link aggregation



**Deprecated**

## Uplink: **ETHERNET** mode

— `DEFINE VSWITCH name ETHERNET PORTBASED`

— Guest and host device driver sends and receives fully-formed ethernet frames

— Virtual MAC address used as physical MAC address

- More about that later

# Uplink: port options

## — No ports

- Similar to Guest LAN, but with better security
- Excellent for 2nd level systems

## — One active port with one or two failover ports

- Round-robin failover
- If all dead, wait for signs of life
- SET VSWITCH SWITCHOVER to manually change
- Maximum bandwidth = 25 Gb/s

## — Up to 8 active ports operating concurrently

- IEEE 802.1AX link aggregation (a form of channel bonding)
- Maximum bandwidth = 200 Gb/s (8 x 25 Gb/s)
- SET PORT GROUP to add or remove ports
- ETHERNET mode only

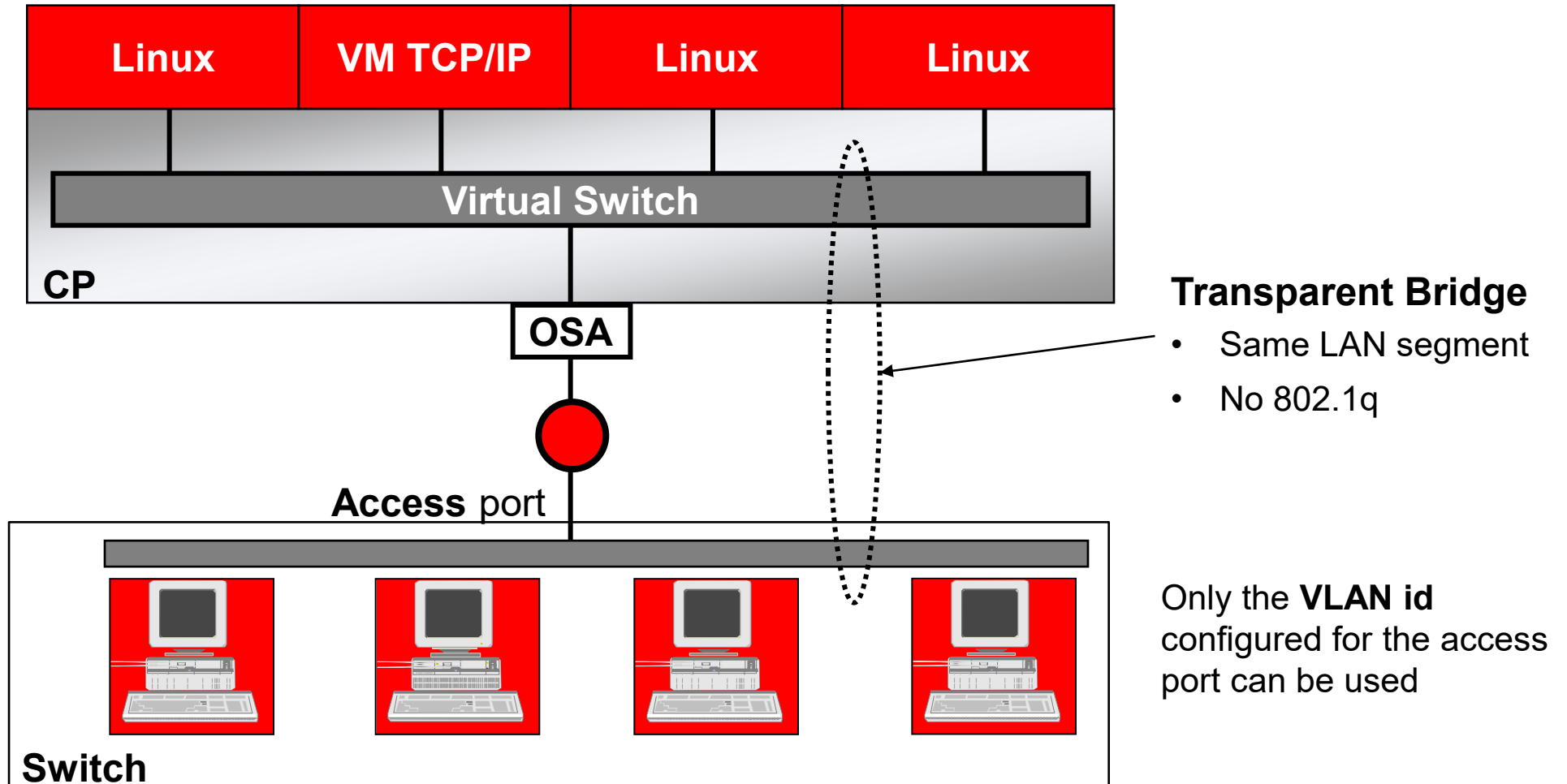
## Uplink: Port selection

```
DEFINE VSWITCH ...  
  
    RDEV NONE  
or  
    RDEV port1 [port2 [port3] ]  
or  
    GROUP group_name
```

- RDEV NONE is a ***disconnected*** VSWITCH
- **Port** is identified by device number associated with an OSA or Network Express CHPID, plus and an optional physical port specification (P0 or P1)
  - 1EC0 (default is P0)
  - 1EC0.P0
  - 1EC0.P1
- Group name comes from **SET PORT GROUP**

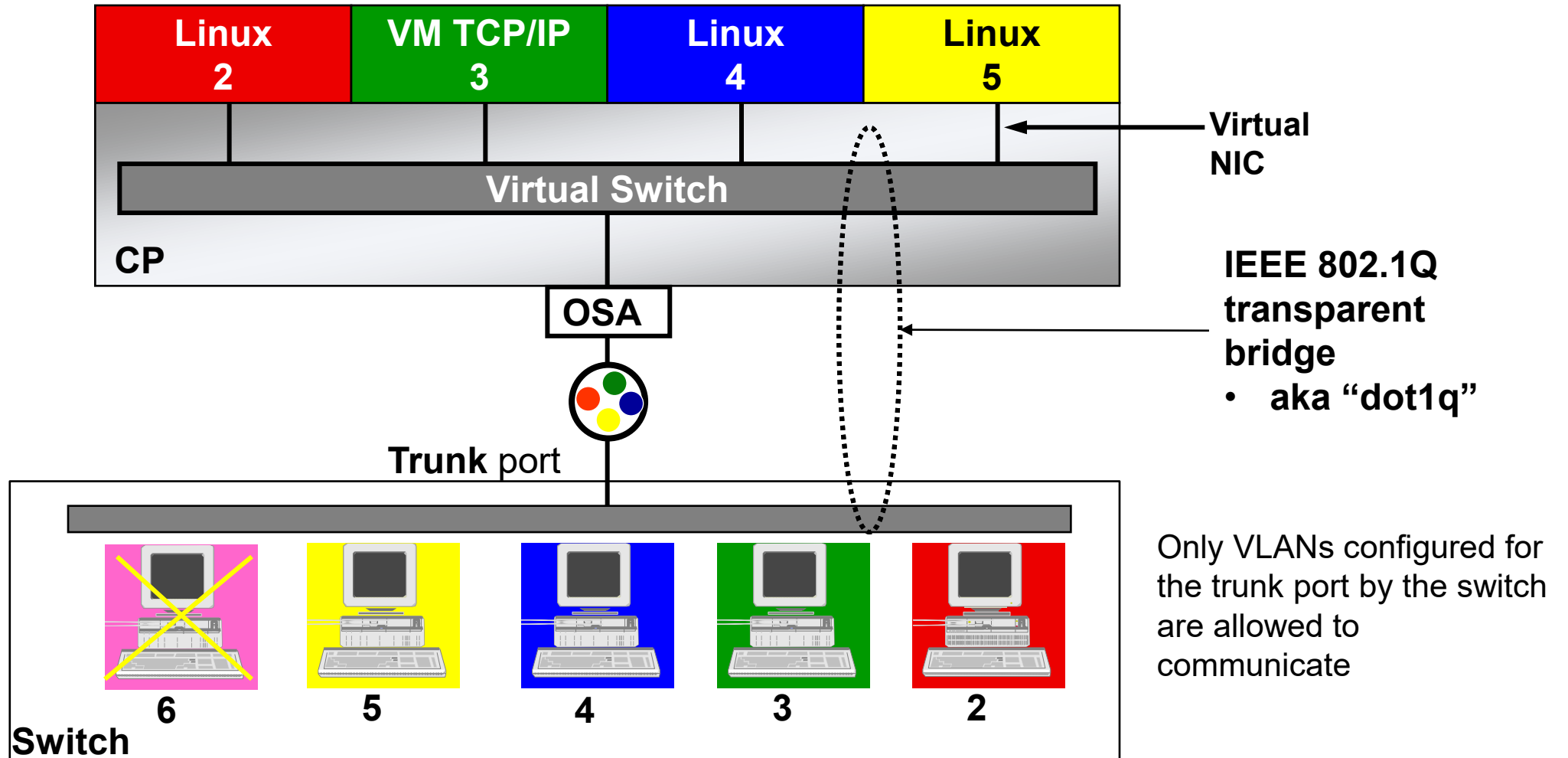
# Uplink: Access port, VLAN unaware

VSWITCH carries traffic for a single LAN segment (subnet)



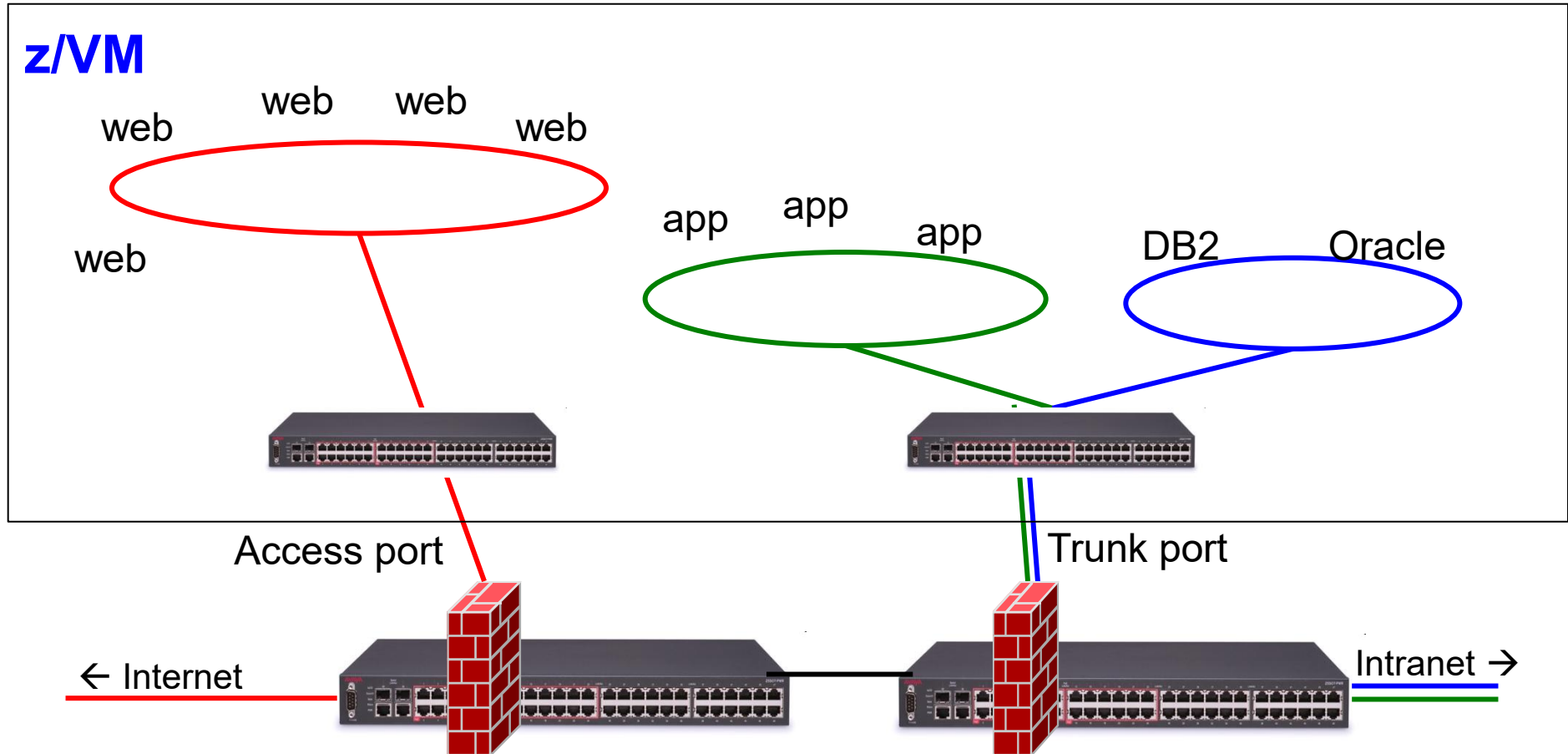
# Uplink: Trunk port, VLAN aware

VSWITCH carries traffic for multiple LAN segments (subnets)



# VLAN-aware Virtual Switch

## Multiple LAN segments per VSWITCH



Shared infrastructure is cheaper than dedicated, but be aware of any rules that prohibit comingling of **Internet** and **Intranet** traffic on the same infrastructure

# Uplink: Trunk or Access port?

## — Access port

```
DEFINE VSWITCH ...  
    VLAN UNAWARE
```

- This is the default configuration

## — Trunk port

```
DEFINE VSWITCH ...  
    VLAN AWARE | vid  
    NATIVE 1 | NATIVE vid | NATIVE NONE
```

### Suggested Practices

- Use a trunk port defined using “VLAN AWARE NATIVE NONE”
- Don't specify PORTTYPE TRUNK (it doesn't do what you think it does)



## Sidebar: A word of advice about the native VLAN

- When an untagged frame is received on a trunk port the switch will associate the frame with the local default or native VLAN ID (VID), typically VLAN 1
- Used for switch management traffic
  - **Do not allow guests to interfere with the physical switch!**
- Identified by the NATIVE keyword on the DEFINE VSWITCH command
  - CP removes tags for frames associated with the native VLAN ID
- **VLAN nn NATIVE nn** is **wrong!**
  - Same number on both operands
  - You're really plugged into an **access port**
  - Change to VLAN UNAWARE
  - If any NICDEF has an assigned VLAN id that matches NATIVE nn, it's wrong, too!

### Suggested Practice

- Don't do wrong things!

# Disable class G user's ability to create a Guest LAN

— VMLAN statement in SYSTEM CONFIG:

```
VMLAN  
LIMIT TRANSIENT 0
```

## Suggested Practice

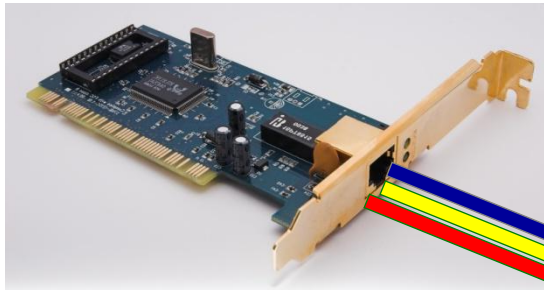
- Don't use Guest LANs – use a disconnected VSWITCH instead

# The Virtual NIC

# Virtual NIC

## Suggested Practice

- Do not use a virtual trunk port

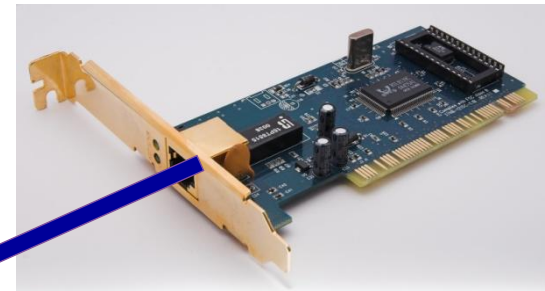
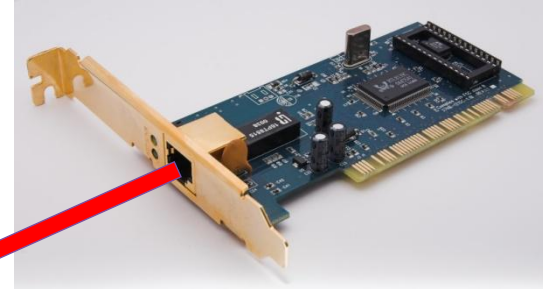


## Virtual trunk port

- More than one VLAN per NIC
- Requires more processing by the guest

## Virtual access port

- One VLAN per NIC



- A guest can have multiple virtual NICs, each on a different VLAN
- Same VSWITCH with different VLANs
- Different VSWITCH

# Virtual NIC: User Directory

Interface is fully configured in the user's directory entry

QDIO = virtual OSD  
EQDIO = virtual OSH



```
NICDEF vdev TYPE QDIO | EQDIO
LAN SYSTEM vswitch-name
[MACID hhhhhh]
[VLAN vlanid]
[PROMISCUOUS]
[PQUPLINKTX LOW | NORMAL | HIGH]

Example:
NICDEF 1100 TYPE QDIO LAN SYSTEM SWITCH1
NICDEF 1100 MACID B10006
NICDEF 1100 VLAN 57 PQUPLINKTX HIGH
```

Combined with VMLAN  
**USERPREFIX** to create virtual MAC

For VLAN-aware VSWITCH, the  
VLAN ID of this interface

Permission to sniff assigned VLANs

Transmission priority on the uplink

Specify NICDEF with same *vdev*  
to continue

Automatically creates *vdev*, *vdev*+1, and *vdev*+2

# Virtual NIC: MAC Addresses

## — 6 bytes

- E.g. 02:00:0A:00:01:23
- Prefix + ID

## — Prefix

- E.g. 02:00:0A
- Comes from **VMLAN** statement in SYSTEM CONFIG
  - Leading '02' is required; indicates that they are administratively-defined addresses, not globally unique

## — ID

- E.g. 00:01:23
- Persistent: From **MACID** operand of NICDEF directory entry
- Ephemeral: If not defined, set by CP

## — MAC will appear on the physical network

- ETHERNET mode VSWITCH only

# Virtual NIC: Controlling the MAC address

— Global attributes in the **VMLAN** statement in SYSTEM CONFIG:

```
VMLAN MACPROTECT ON
```

```
VMLAN MACPREFIX 02pppp
```

```
VMLAN USERPREFIX 02uuuu
```

Each item is prefixed with "VMLAN"

For CP-generated ephemeral MACs

For admin-assigned persistent MACs

## Suggested Practices

- MACPROTECT ON prevents guests from changing their assigned MAC address
- MACPREFIX unique per z/VM instance
  - Do not allow to default to 020000 (that's how you can detect a misconfigured system!)
  - Enforced for SSI
- USERPREFIX same across all members of a shared directory cluster
  - Enforced for SSI

# Virtual NIC: Sniffers

## — **Promiscuous** mode for sniffers

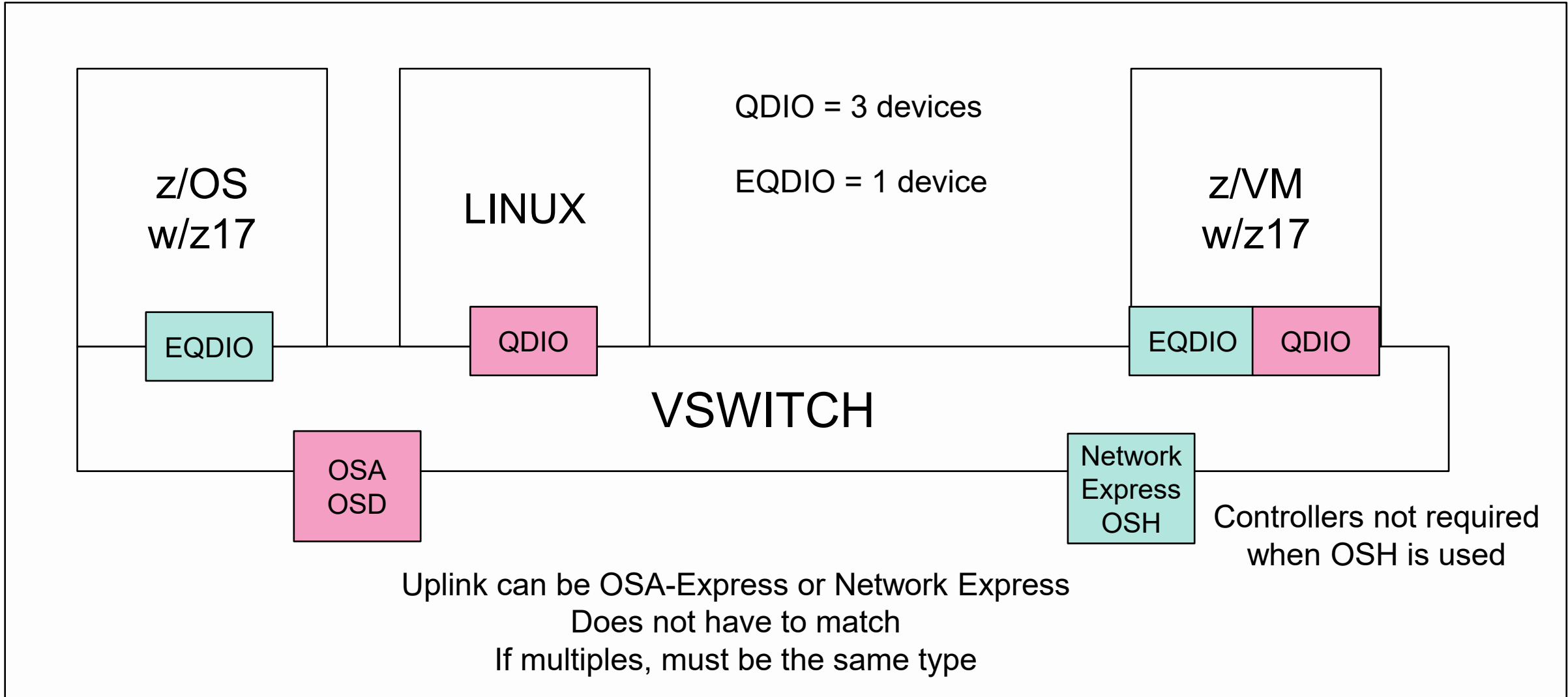
- Guest must be authorized via NICDEF
- Guest enables promiscuous mode using CP SET NIC or via device driver controls
  - E.g. tcpdump -P and download for Wireshark
- Guest receives copies of all frames sent or received for all authorized VLANs

# Virtual NIC: Priority Queuing

- **Priority Queuing** enables the host to provide an ordered set of outbound data queues that the adapter will service in order, but without queue starvation.
- CP creates four queues (in priority order):
  - System
  - High (guest)
  - Normal (guest)
  - Low (guest)
- You assign priority to each virtual NIC
  - Default is “normal”
- Activation required

```
DEFINE VSWITCH ...  
                PRIQUEUING ON
```

# z/VM with IBM z17 support



# The Controller

For OSA Express adapters

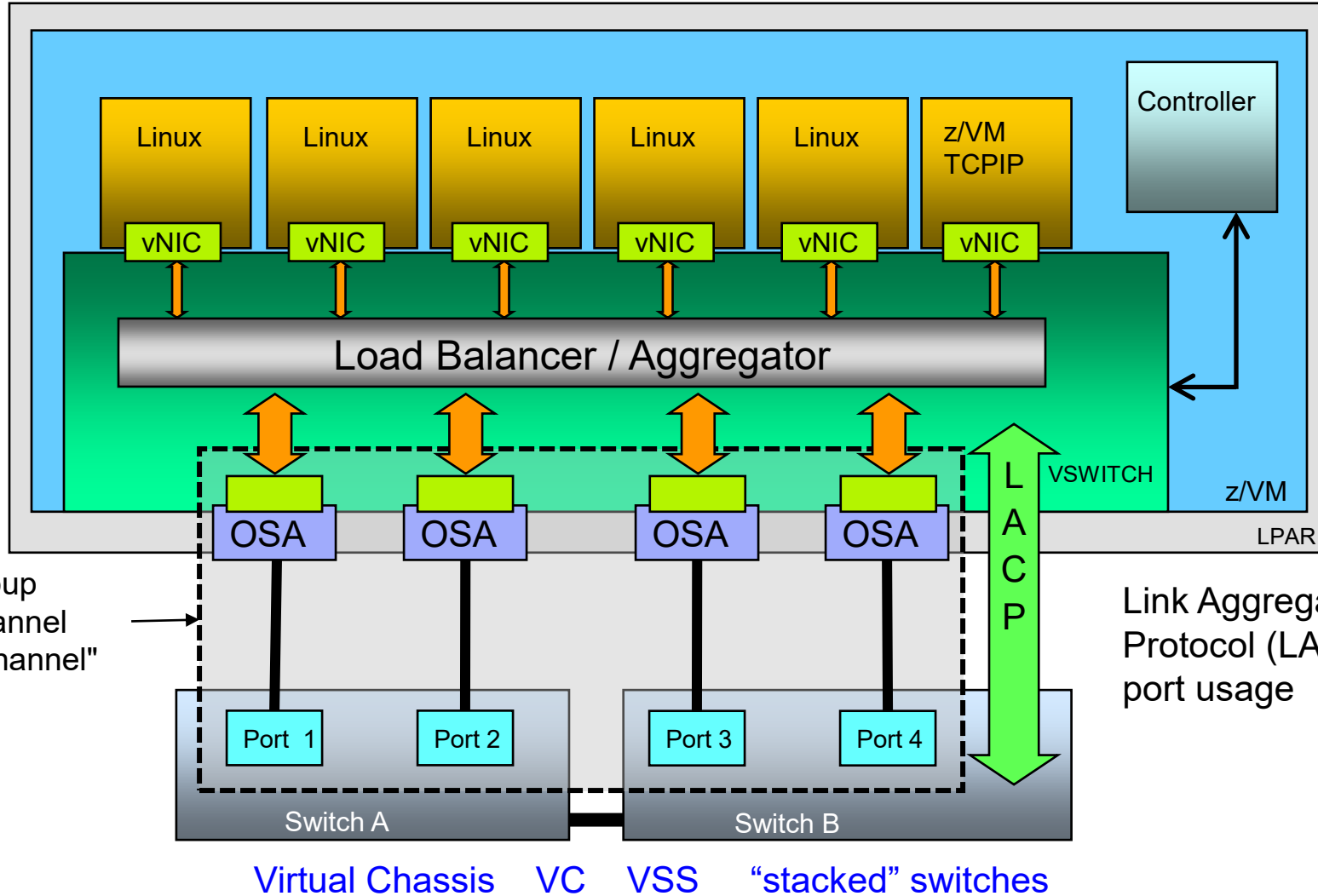
# VSWITCH Controller

- Virtual machine that handles OSA housekeeping duties
  - Specialized VM TCP/IP stack to start, stop, monitor, and query OSA
  - Each controller can service any number of VSWITCHes
  - Not involved in data transfer
  - **Not used for Network Express**
  
- DTCVSW1-DTCVSW4
  - Except for obey list, do not modify their configurations unless directed by Support Center
  - Monitor with system automation and keep them logged on
  - Automatic failover
  - If no controllers are available, uplink will stop!
    - Guest-guest communication ok
  
- Issues messages to virtual console during error recovery
  - NETSTAT CP CLOSE CONS TO *userid* (TCP DTCVSWn

# **IEEE 802.1AX Link Aggregation**

# Link Aggregation

Non-disruptive scalability and failover



Virtual NIC assigned to a real NIC

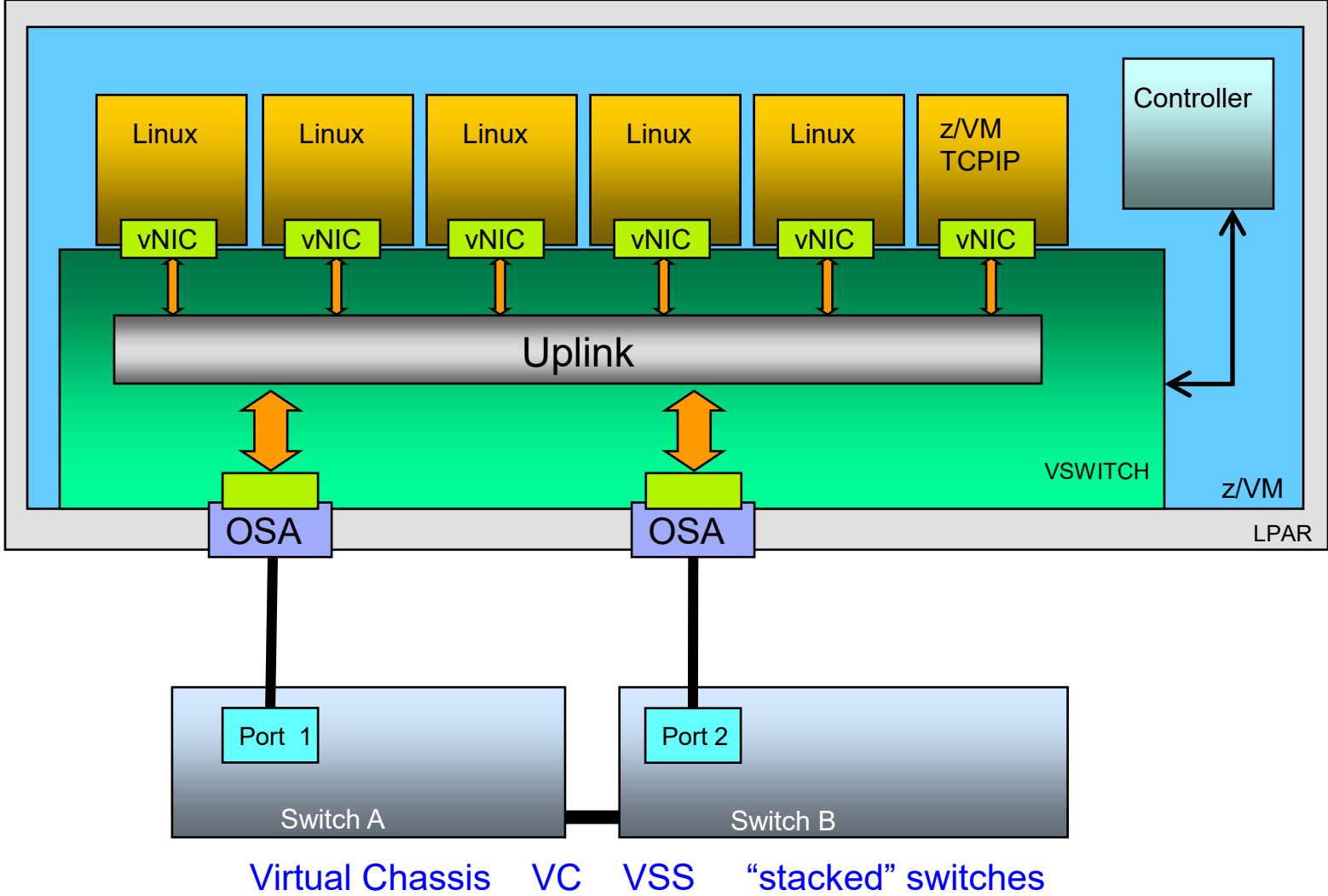
VSWITCH or switch can initiate a change in the assignment via LACP.

- Port group
- Port channel
- "Etherchannel"

Link Aggregation Control Protocol (LACP) controls port usage

Virtual Chassis VC VSS "stacked" switches

# Failover (non-Link Aggregation)



# Link Aggregation

- Binds multiple ports into a single pipe
  - Up to 8 OSA ports per virtual switch
  - Increases Virtual Switch bandwidth
  - Provides seamless failover in the event of a failed adapter, switch port, cable, or switch
  - Only supported for ETHERNET VSWITCHes
  - Virtual NIC is still limited to bandwidth of single physical port
  - Also called a **port channel** or **Etherchannel**
- With **virtual chassis** or **stacked switch** support from switch vendor, can also handle physical switch outage
- Switches talk to each other to provide load balancing and to add/remove adapters from port group

## Link Aggregation: Port group

- Create an OSA port group

```
SET PORT GROUP PCHNL01 JOIN F100 F200.P1
```

- Create a VSWITCH that references to group

```
DEFINE VSWITCH ...  
        ETHERNET  
        GROUP PCHNL01
```

- Done and dusted!

- Ports cannot be shared with other VSWITCHes or LPARs unless using **shared port groups**

### Suggested Practices

- Name your port groups to match the name of the port channel on the switch
- Put VSWITCH definition in AUTOLOG1 or AUTOLOG2

# Sharing Physical Ports

## Port sharing without Link Aggregation

- No special restrictions
- All operating systems
- VSWITCH and/or dedicated

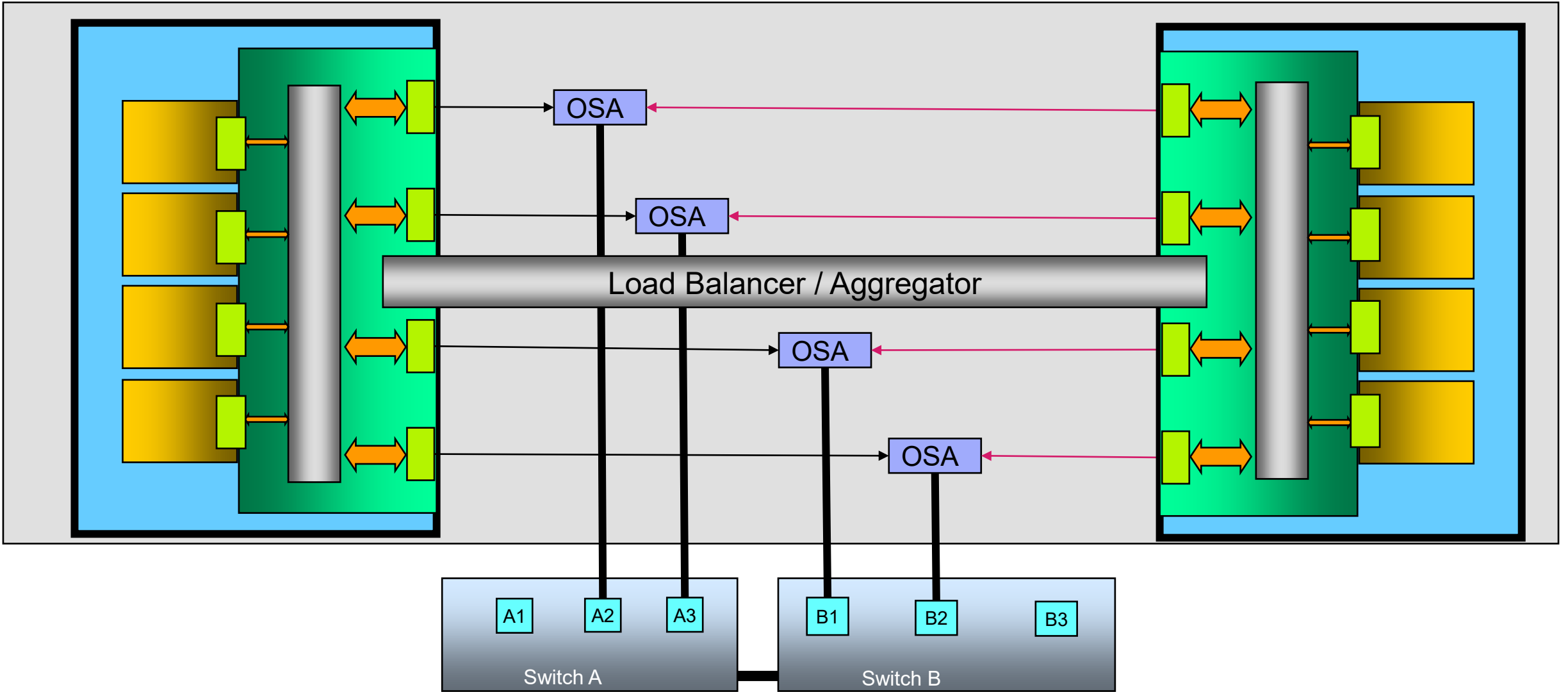
# Port sharing with link aggregation

## Why?

- If suggested practice is 4 ports per VSWITCH
  - ... and you have a 4-member SSI cluster
  - ... and you have one VSWITCH per member
  - ... and you cannot share ports that are in a link-aggregation port group
  - ... then you need 16 ports (i.e. 16 10Gb OSA-Express features)
- That's  $\frac{1}{4}$  of the port capacity of the machine (and expensive)!

# Port sharing with Link Aggregation

## Global VSWITCH with shared port group



# Shared Link Aggregation Port Groups

— Two new system constructs

- **Global VSWITCH**

- Virtual Switch that spans multiple z/VM LPARs within a single CPC, all using the same link aggregation port group

- **Inter-VSWITCH Link (IVL)**

- Provides data channel for management of shared port groups and the Global VSWITCH
- Each z/VM system is assigned to one **IVL domain** (A – H)
- Up to 16 systems in a domain

— All members of the domain can use a SHARED port

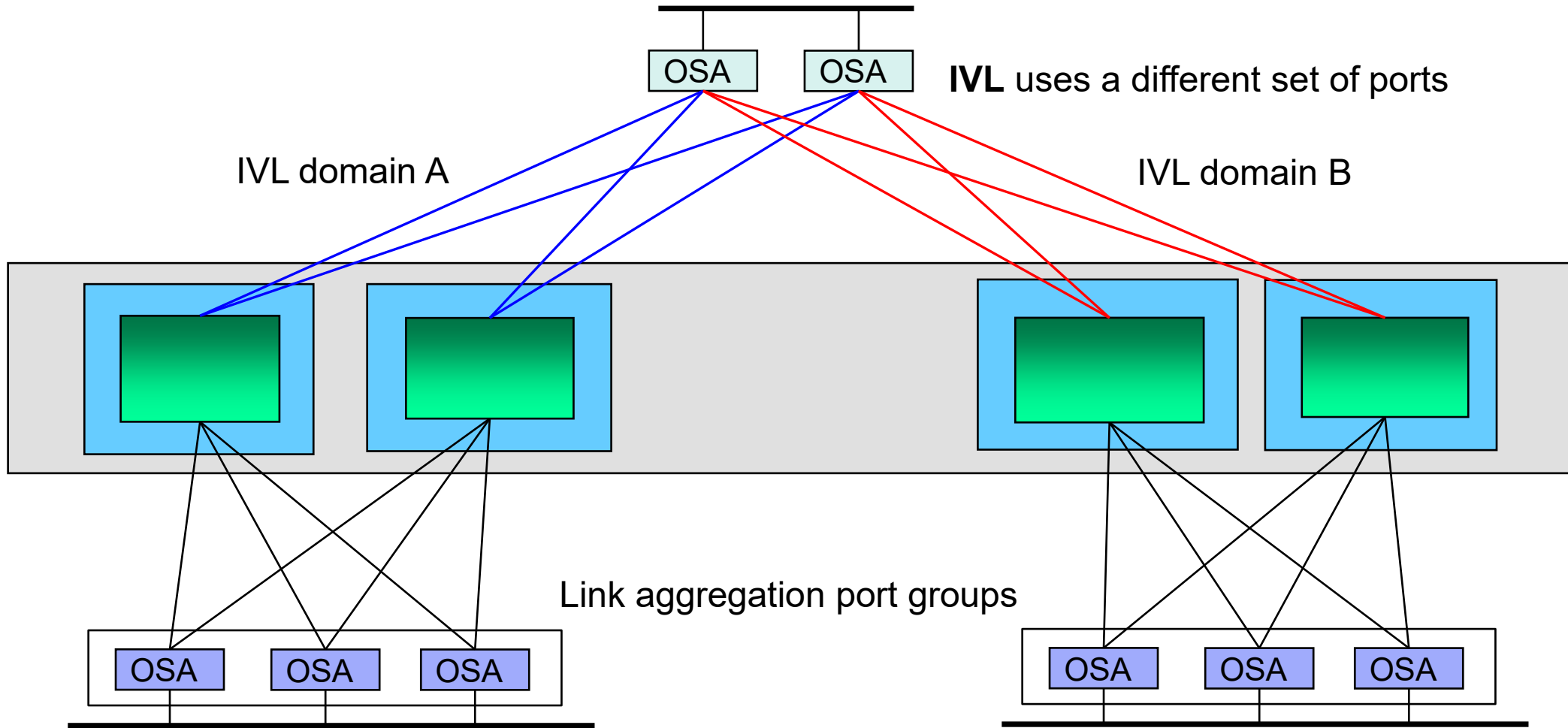
- If not shared, the early bird catches the worm!

— Configuration changes to shared port group or global VSWITCH are propagated to all members of the domain

## Suggested Practice

- One domain for production, another domain for dev/test

# Shared Link Aggregation Port Groups



# IVL: Create the IVL VSWITCH

```
DEFINE VSWITCH name TYPE IVL DOMAIN d [VLAN vid]
```

- Conventional RDEV list or exclusive port GROUP
  - Remember to provide OSA port redundancy!
  - **No, the IVL cannot use the same ports that the global VSWITCHes are using as uplinks!**
- Do this on each z/VM that will share the port group
  - Command must be the same on all instances (name, domain, VLAN id)
  - QUERY VSWITCH will show the name as *systemid.name* instead of “SYSTEM *name*”
    - If you have any programs that interpret the output of QUERY VSWITCH, you may need to fix them
- z/VM automatically joins the domain
- Do this before you create a shared port group or global VSWITCH

## Create a shared Port Group

```
SET PORT GROUP name LACP ACTIVE SHARED  
SET PORT GROUP name JOIN rdev1.port rdev2.port ...
```

- Device numbers can be any device number on the chpid
- CP will select the device numbers to be used on the other z/VM instances
- CP propagates changes to the port group configuration to all active members of the IVL domain
- Do this before you create a global VSWITCH

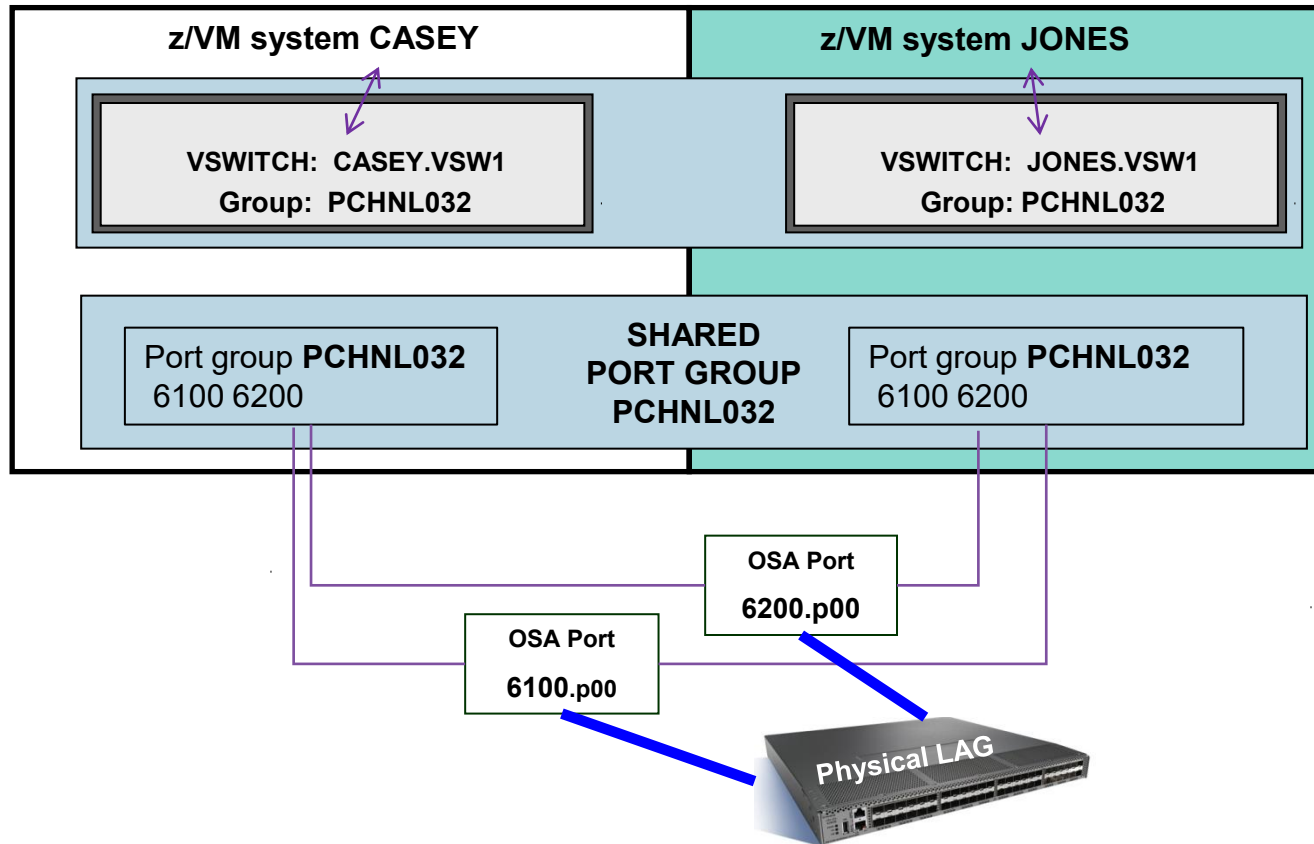
# Create a Global VSWITCH

```
DEFINE VSWITCH name GLOBAL ETHERNET GROUP group
```

- Multiple global VSWITCHes can be defined per z/VM instance
  - All in the same IVL domain
- An *instance* of a Shared Port Group is created when it is configured to a virtual switch

# Create a Global VSWITCH: Example

```
SET PORT GROUP PCHNL032 LACP ACTIVE SHARED
SET PORT GROUP PCHNL032 JOIN 6100 6200
DEFINE VSWITCH VSW1 GLOBAL ETHERNET GROUP PCHNL032
```



- Up to 4 global VSWITCHes in the same **partition** can share a port group
- A 2<sup>nd</sup> level VSWITCH counts!

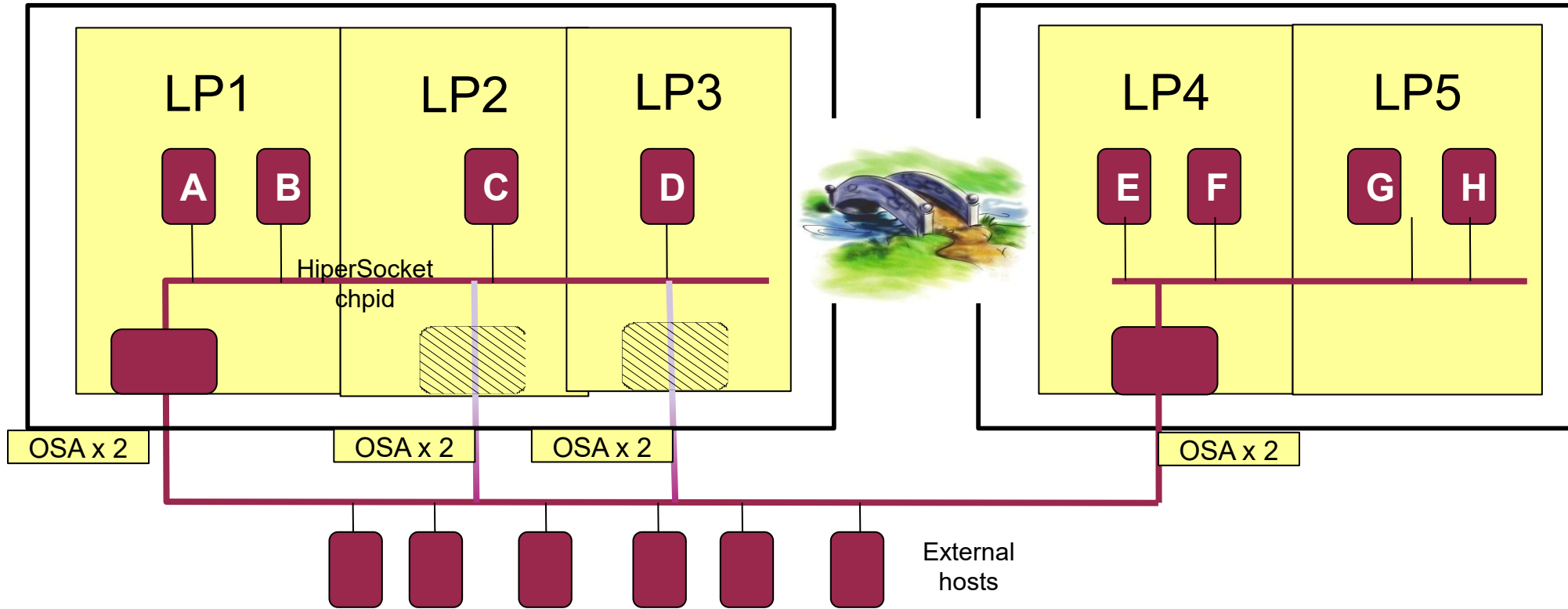
## Link Aggregation: Asynchronous Port Group and VSWITCH Initialization

**!ALERT!**

- Guests cannot connect to a VSWITCH until it is defined (virtual NIC errors)
- A VSWITCH using a shared port group will not be defined until the port group is ready
- Shared port group cannot form until IVL "settles"
- The SET PORT GROUP and DEFINE VSWITCH commands will complete asynchronously
- **Placing SET PORT GROUP and DEFINE VSWITCH in SYSTEM CONFIG is not sufficient!**
- If you bring guests up before your VSWITCH is defined, guests will get NIC errors
- Defer guest startup to automation (e.g. IBM Operations Manager) which waits for VSWITCH activation
  - Watch for messages to OPERATOR
  - QUERY-style polling logic

# HiperSocket VSWITCH Bridge

# HiperSocket VSWITCH Bridge



— One active bridge per partition

— Path MTU discovery support

- Large frames inside
- Smaller frames outside

# HiperSocket VSWITCH Bridge

- Connect HiperSocket LAN to ethernet LAN without a router
  - Same subnet as ethernet LAN
- Full redundancy
  - Up to 5 bridges per CPC (CEC)
  - Automatic failover with optional failback
  - Each bridge can have more than one OSA uplink (typical)
- Enables cross-CPC Live Guest Relocation for guests using HiperSockets
- Does not work with z/OS LPARs
  - Look at z/OS HSCI

# HiperSocket VSWITCH Bridge

```
DEFINE VSWITCH ...  
    ETHERNET  
    BRIDGEPORT RDEV hs-rdev  
    [PRIMARY]
```

- I/O configuration change required
  - HiperSocket CHPID must be defined with CHPARM=x4
- The EXTERNAL\_BRIDGED operand is available on CP DEFINE CHPID command if using native z/VM dynamic I/O

# Suggested Practices

1. Use **ETHERNET** mode VSWITCH with link aggregation
2. Do not specify other options on DEFINE VSWITCH unless you study them carefully
  - E.g. PORTTYPE TRUNK (boo! hiss!)
3. Specify **MACPROTECT ON** and **LIMIT TRANSIENT 0** on VMLAN statement in SYSTEM CONFIG
4. VLAN-aware VSWITCH should be defined with **VLAN AWARE NATIVE NONE**
5. Don't use virtual trunk ports – leave guests VLAN-**unaware**
  - Use multiple NICDEFs, each with its assigned VLAN ID
6. Put VSWITCH definitions in AUTOLOG1 or AUTOLOG2
  - Don't use SYSTEM CONFIG – you may need automation assist

# Diagnostics

## — CP QUERY VMLAN

- to get global VM LAN information (e.g. limits)
- to find out what service has been applied

## — CP QUERY VSWITCH ACTIVE

- to find out which users are coupled
- to find out which IP addresses are active

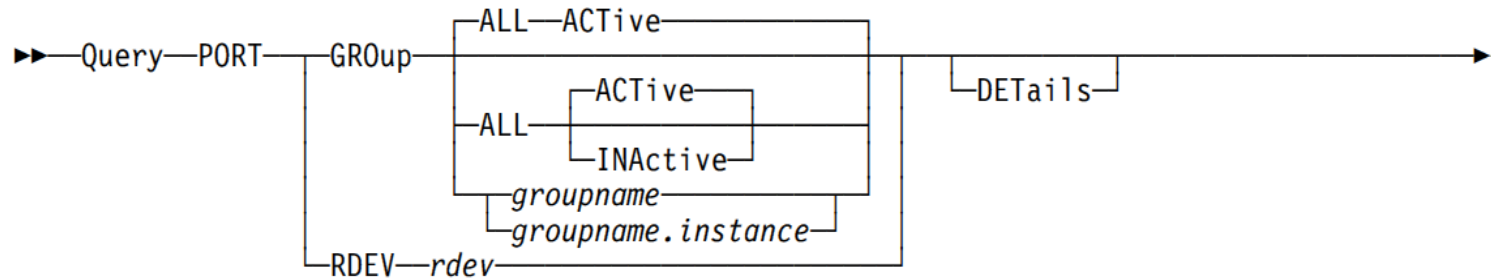
## — CP QUERY NIC DETAILS

- to find out if your adapter is coupled
- to find out if your adapter is initialized
- to find out if your IP addresses have been registered
- to find out how many bytes/packets sent/received

## Diagnostics: Discard Counters

Discard Counter	Uplink: QUERY VSWITCH ACTIVE	Guest NIC: QUERY NIC USER userid vdev
RX > 0 inbound	VSWITCH definition mismatch <ul style="list-style-type: none"><li>• Unused VLAN ID</li><li>• VLAN UNAWARE on trunk</li></ul>	Packets are arriving faster than the guest can consume them
TX > 0 outbound	Overrun on the physical OSA. <ul style="list-style-type: none"><li>• Link is too slow compared to guests</li><li>• Use faster OSA or link aggregation</li></ul>	<ul style="list-style-type: none"><li>• Unauthorized VLAN ID on virtual trunk port</li><li>• Untagged frame on virtual trunk with NATIVE NONE</li><li>• Guest configured as VLAN-aware with virtual access port</li><li>• Overrun target guest</li></ul>
To reset	CP SET VSWITCH COUNTERS CLEAR	Resets when NIC is detached

# Diagnostics: Port Group Verification



- ALL ACTIVE            All port groups that are associated with a virtual switch
- ALL INACTIVE        All port groups that are not associated with a virtual switch
- *groupname* or *groupname.instance*
  - The specified port group, optionally qualified by instance ID
- RDEV                    Information about the specified real device
- DETAILS                Additional information
- See also SET VSWITCH ... IVLPORt PING for a shared port group

# References

## — HELP command

- `help sysconfig definvsw`      **DEFINE VSWITCH statement in SYSTEM CONFIG**
- `help sysconfig vmlan`      **VMLAN statement in SYSTEM CONFIG**
- `help define vswitch`      **CP DEFINE VSWITCH command**
- `help cpset port`      **CP SET PORT GROUP command**
- `help directory nicdef`      **NICDEF statement in user directory entry**

## — Publications:

- z/VM CP Planning and Administration
- z/VM CP Command and Utility Reference
- z/VM Connectivity

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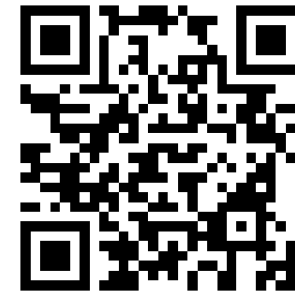
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# Contact Information

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