Link Aggregation for the z/VM Virtual Switch

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Agenda

- An Overview of the z/VM Virtual Switch

  - Guest LANs vs. the VSWITCH

  - Virtual NICs

- Link Aggregation

  - Benefits

  - Requirements (general)

  - LACP Active vs. Inactive

  - Global VSWITCH and Inter-VSWITCH Links

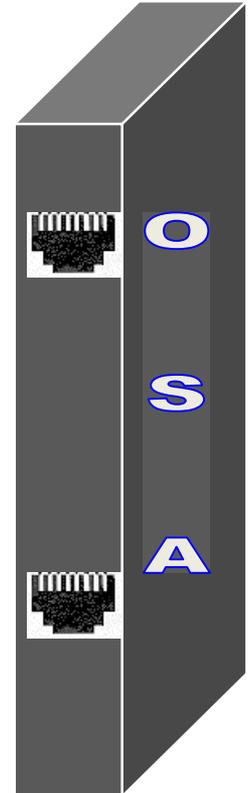**z/VM V6.3**

- Tips and Tricks

Overview of the z/VM Virtual Switch

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Switch – a box that creates a LAN

- Enable and disable a port

- Set port type: trunk or access

- Assign port to one or more VLANs

- Set port speed: 10 / 100 / 1000 / Auto

- Set port duplex mode: Simplex / Duplex / Auto

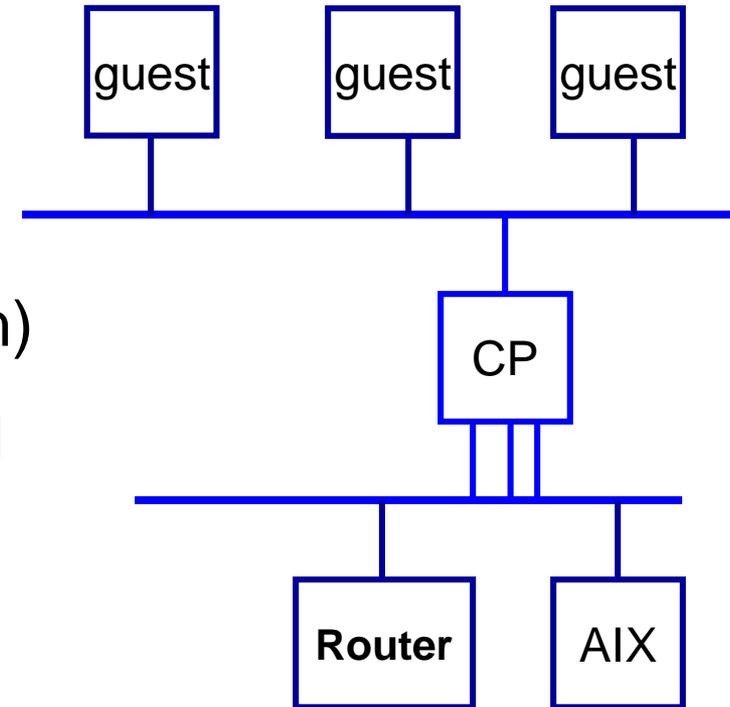- Define an internal router
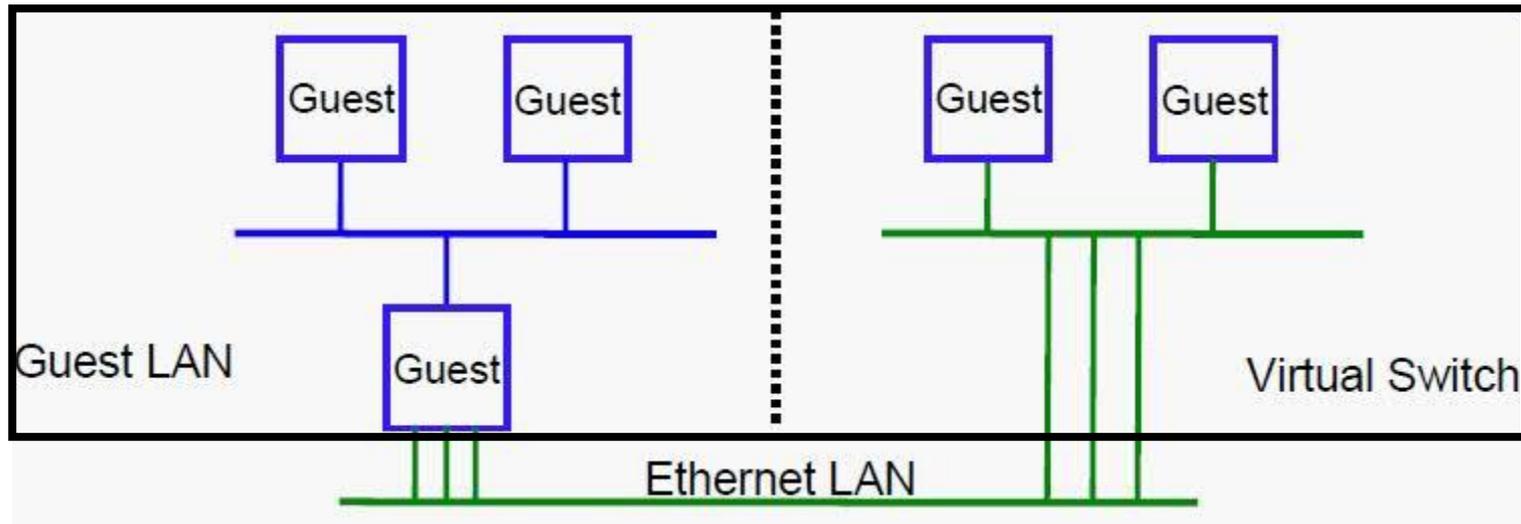
- Define SNAP (sniffer) ports

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Corp

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z/VM Virtual Switch

- Each Virtual Switch has up to 8 separate OSA-Express connections associated with it

- `SYSTEM CONFIG` **(static definition)**

- `CP DEFINE VSWITCH` **command**

- A special-purpose Guest LAN
  - Ethernet
  - Built-in IEEE 802.1q bridge to an outside network
  - IEEE VLAN capable

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Guest LAN vs. Virtual Switch

- Virtual router is required
- Different subnet
- External router awareness
- Guest-managed failover

- No virtual router
- Same subnet
- Transparent bridge
- CP-managed failover

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Virtual Switch Attributes

- Name
- Associated OSAs
- Access List
- One or more controlling virtual machines (minimal VM TCP/IP stack servers)
  - User pre-configured DTCVSW1 and DTCVSW2
  - Controller not involved in data transfer
  - Starts, stops, and monitors OSAs
  - Do not ATTACH or DEDICATE

- Similar to Guest LAN
  - Owner SYSTEM
  - Type QDIO
  - Persistent
  - Restricted

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Creating a Virtual Switch

- Static definitions in the System Configuration file
  Dynamically defined via the CP command
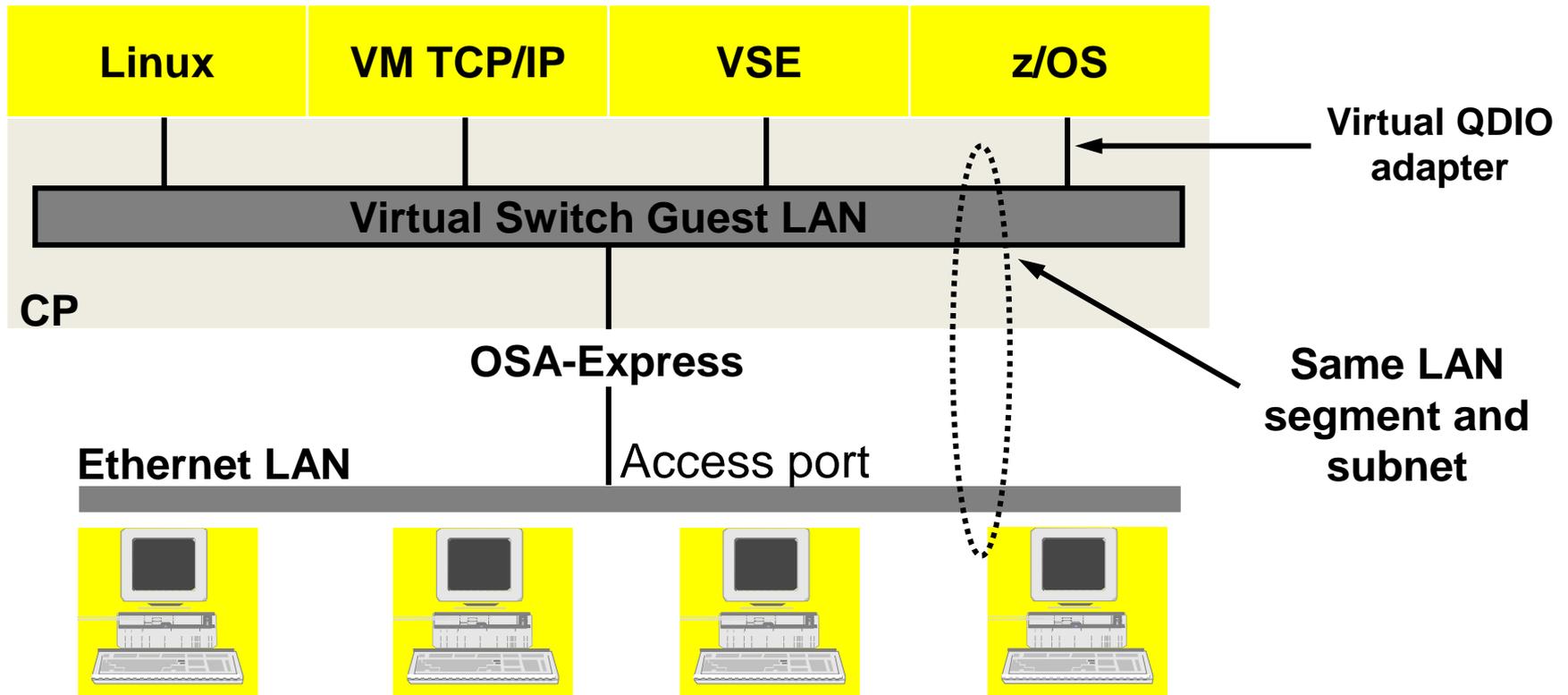
```
DEFINE VSWITCH name
      [RDEV NONE | cuu.Pnn [cuu.Pnn [cuu.Pnn]] ]
      [CONNECT | DISCONNECT]
      [CONTROLLER * | userid]
      [IP IPTIMEOUT 5 NONROUTER | ETHERNET]
      [NOGroup | GROup groupname]

      [VLAN UNAWARE | VLAN def_vid NATIVE native_vid]
      [PORTTYPE ACCESS | PORTTYPE TRUNK]

Example:

DEFINE VSWITCH SWITCH12 RDEV 1E00 1F04 CONNECT
```
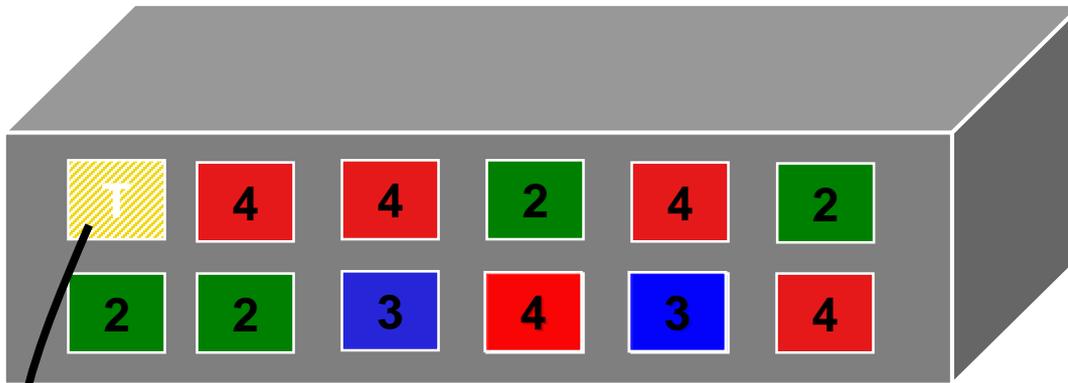
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z/VM Virtual Switch – VLAN unaware

Linux | **VM TCP/IP** | **VSE** | **z/OS**

Virtual Switch Guest LAN

Virtual QDIO adapter

CP

OSA-Express

Same LAN segment and subnet
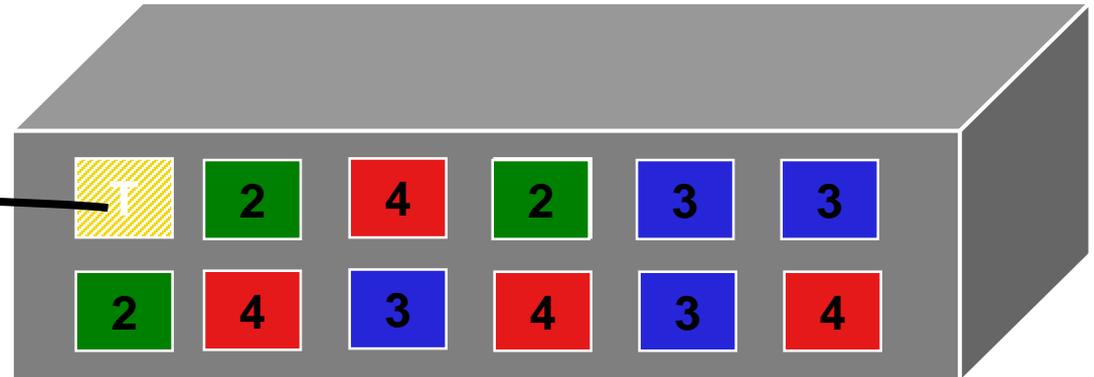
Ethernet LAN

Access port

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Trunk Port vs. Access Port
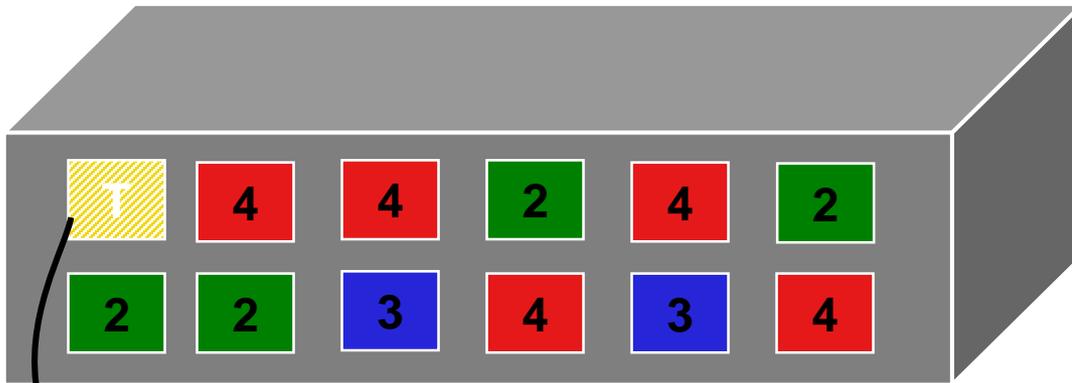

▸ Access port carries traffic for a single VLAN

▸ Host not aware of VLANs

▸ Trunk port carries traffic from all VLANs
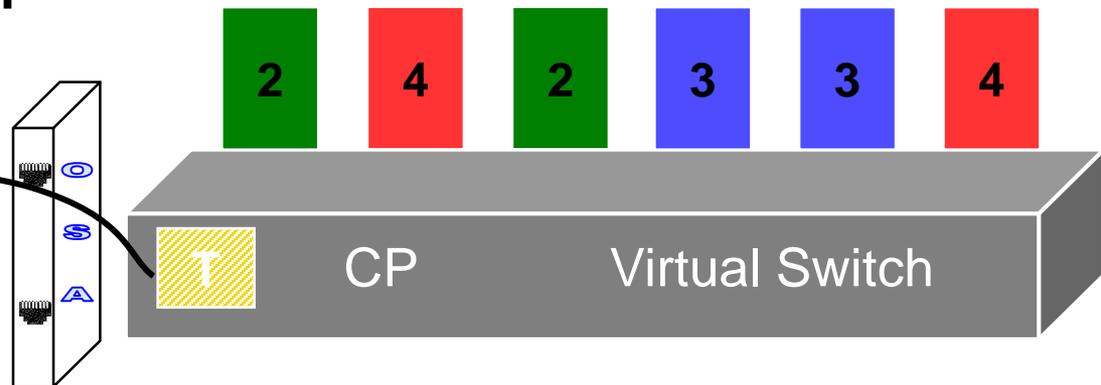
▸ Every frame is tagged with the VLAN id

Physical Switch to Virtual Switch

▶ **Trunk port carries traffic between CP and switch**

▶ **Each guest can be in a different VLAN**

CP   Virtual Switch

z/VM Virtual Switch – VLAN aware

Linux	z/VM TCP/IP	VSE	z/OS

Virtual Switch Guest LAN

CP

Virtual QDIO adapter

OSA-Express

Ethernet LAN

Trunk port

IEEE 802.1q transparent bridge

Multiple LANs

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Network with VSWITCH

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Network with VSWITCH

LPAR 1

LPAR 2

z/VM

web web web

web web

app app

web app

z/OS
DB2

VSWITCH

To internet
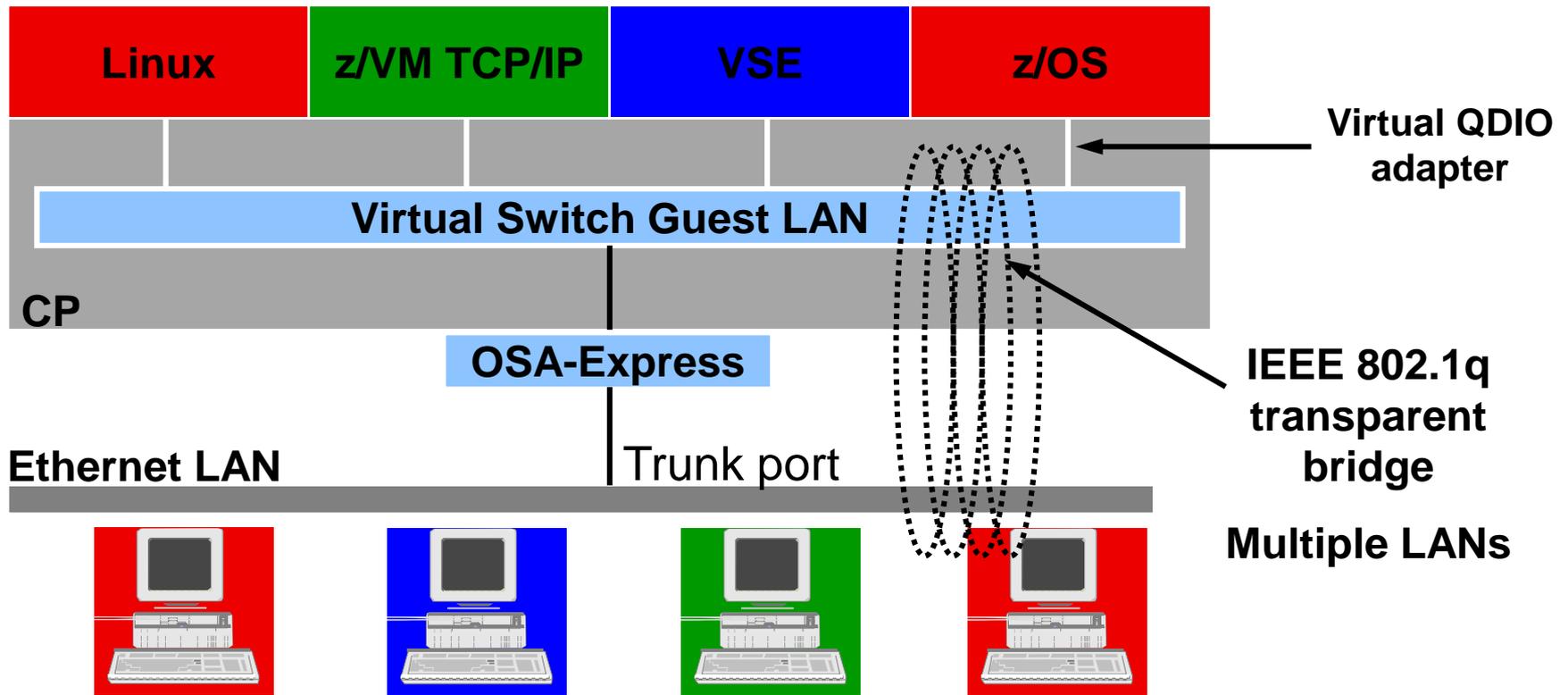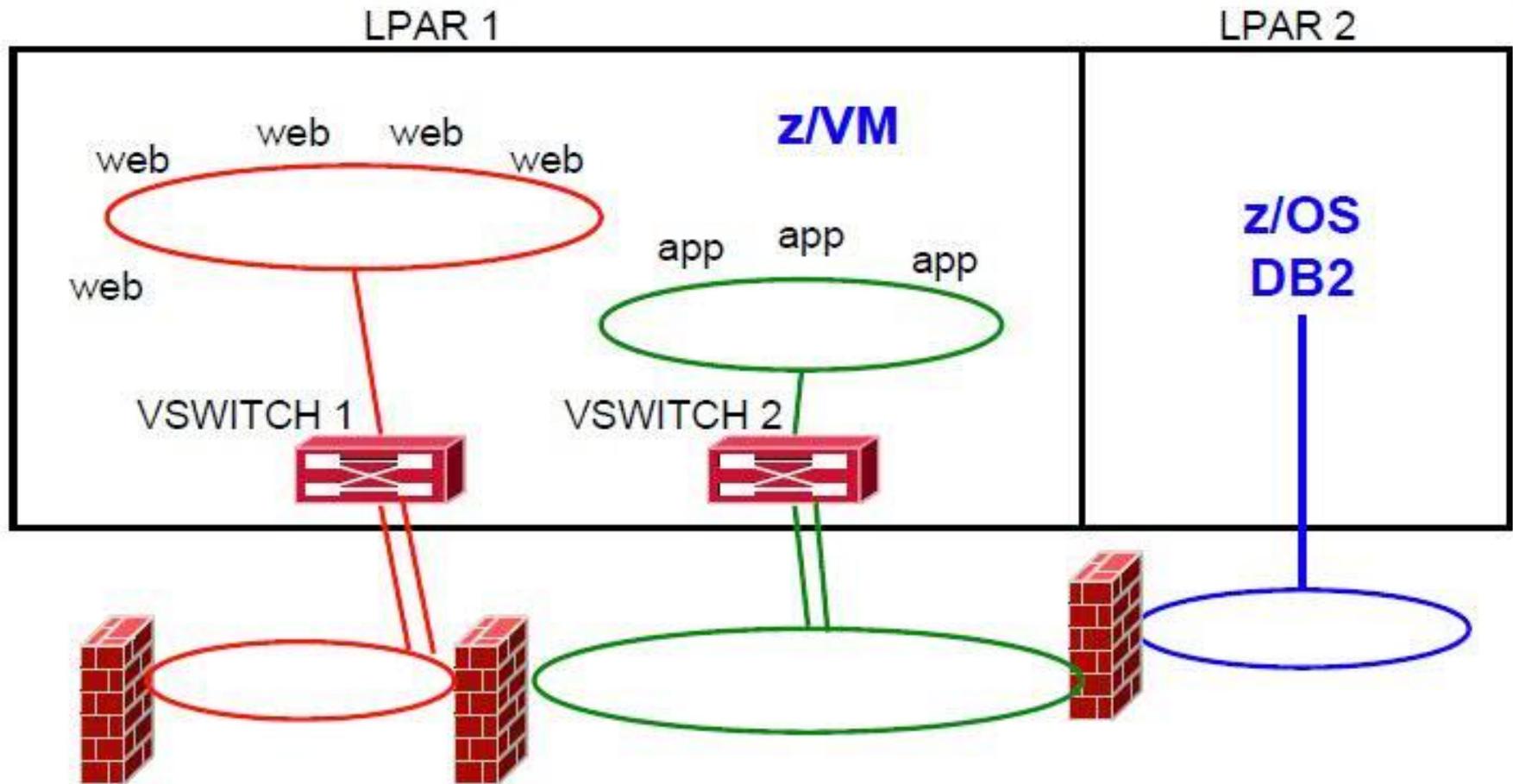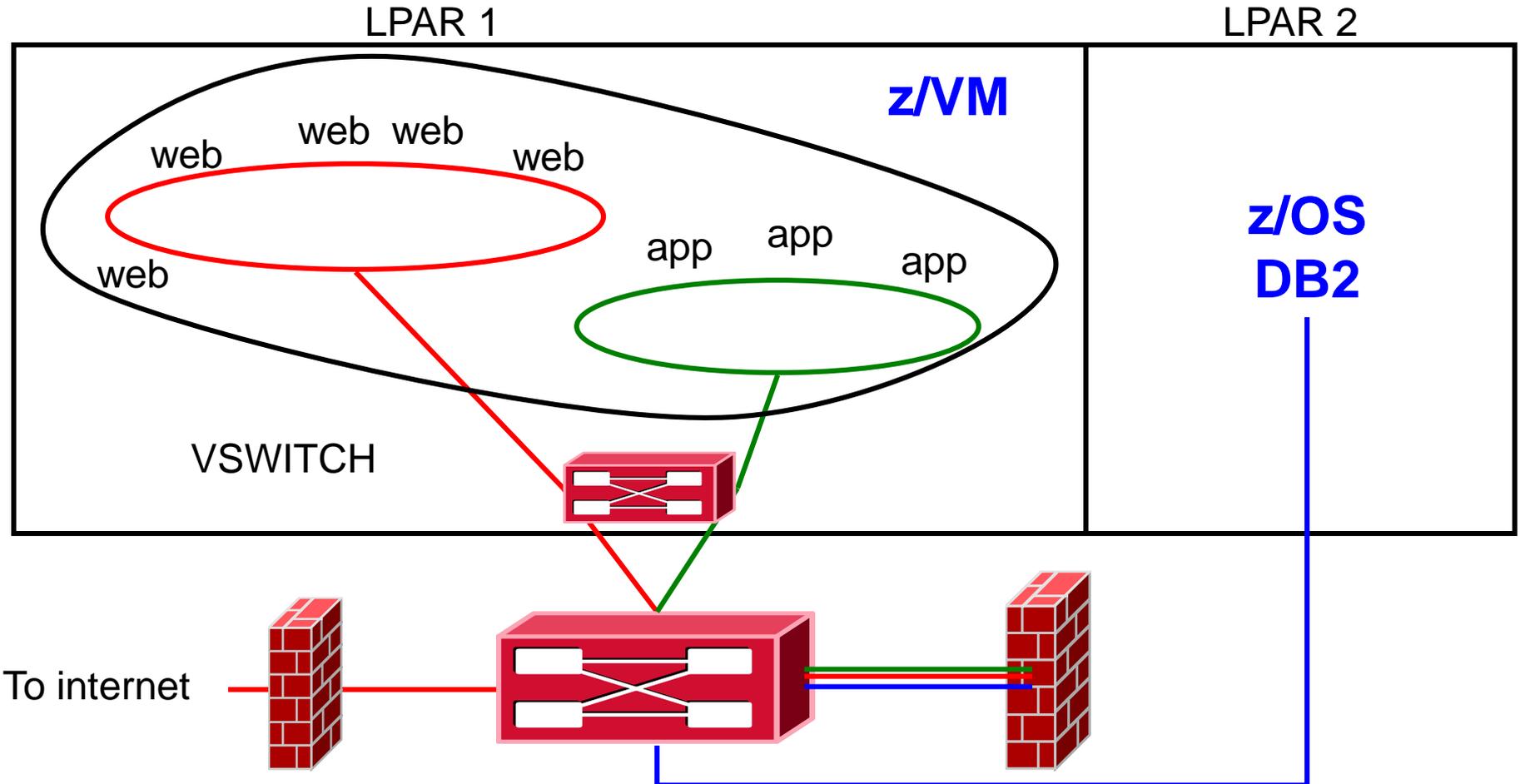
With 1 VSWITCH, 3 VLANs, and a multi-domain firewall

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Layer Mode: IP vs. Ethernet

- ETHERNET = "Layer 2"
  - Each guest has a unique MAC address
  - Guest sends ethernet frame to NIC
  - OSA and CP have MAC address awareness

- IP = "Layer 3"
  - All guests have the same MAC address
  - Guest sends IP packets to NIC
  - OSA adds frame
  - OSA and CP have IP address awareness

Security controls on the VSWITCH

- Virtual Sniffers
  - Guest must be authorized via SET VSWITCH or security server
  - Guest enables promiscuous mode using CP SET NIC or via device driver controls
    - E.g. tcpdump -P
  - Guest receives copies of all frames sent or received for authorized VLANs

- Port Isolation
  - Stop guests from talking to each other, even when in same VLAN
  - Shut off OSA "short circuit" to other sharers

- Access lists
  - Not all guests can access a VSWITCH by default ….

Change the Virtual Switch access list

- Specify after DEFINE VSWITCH statement in SYSTEM CONFIG to add users to access list

```
MODIFY VSWITCH name GRANT      userid
SET                            [VLAN vid1 vid2 vid3 vid4]
                               [PORTTYPE ACCESS | TRUNK]
                               [PROmiscuous | NOPROmiscuous]

SET     VSWITCH name REVOKE userid

Examples:
  MODIFY VSWITCH SWITCH12 GRANT LNX01 VLAN 3 7 105
  CP SET VSWITCH SWITCH12 GRANT LNX02 PORTTYPE TRUNK
                                   VLAN 4-20 22-29
  CP SET VSWITCH SWITCH12 GRANT LNX03 PRO
```

- CP QUERY LAN or VSWITCH to display current access list (see DETAILS option)

Virtual Network Interface Card (NICs)

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Virtual Network Interface Cards (NICs)

- A simulated network adapter
  - OSA-Express QDIO
  - HiperSockets
  - Must match LAN type

- 3 or more devices per NIC
  - More than 3 to simulate
    port sharing on 2nd-level system
    or for multiple data channels

- Provides access to Guest LAN or Virtual Switch

- Created by directory or CP DEFINE NIC command

Virtual Machine

Guest LAN or
virtual switch

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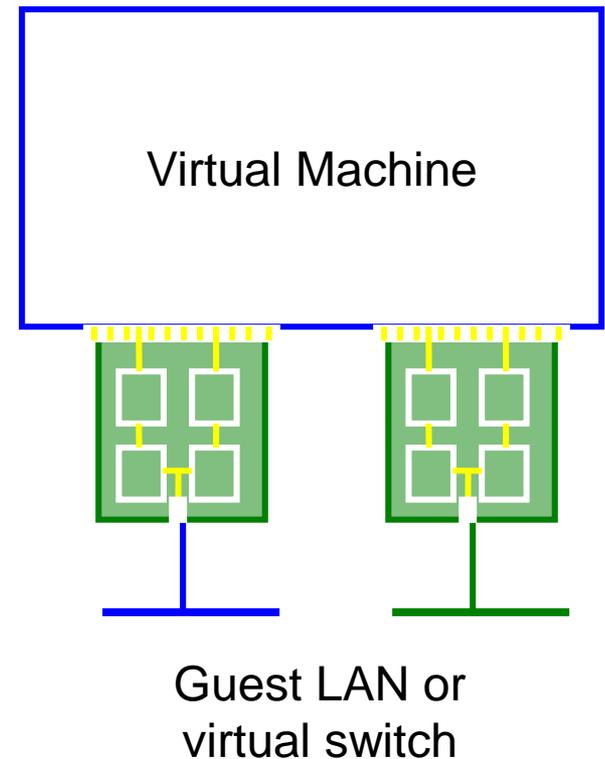
Virtual NIC - User Directory

▪ May be automated with USER DIRECT file:

```
NICDEF vdev [TYPE HIPERS | QDIO]
            [DEVices devs]
            [LAN owner name]
            [CHPID xx]
            [MACID xxyyzz]

Example:

NICDEF 1100 LAN SYSTEM SWITCH1 CHPID B1 MACID B10006
```

Combined with VMLAN
MACPREFIX to create
virtual MAC

Virtual NIC - CP Command

- May be interactive with CP DEFINE NIC and COUPLE commands:

```
CP DEFINE NIC vdev
        [[TYPE] HIPERsockets|QDIO]
        [DEVices devs]
        [CHPID xx]

CP COUPLE vdev [TO] owner name

Example:

CP DEFINE NIC 1200 TYPE QDIO
CP COUPLE 1200 TO SYSTEM CSC201
```
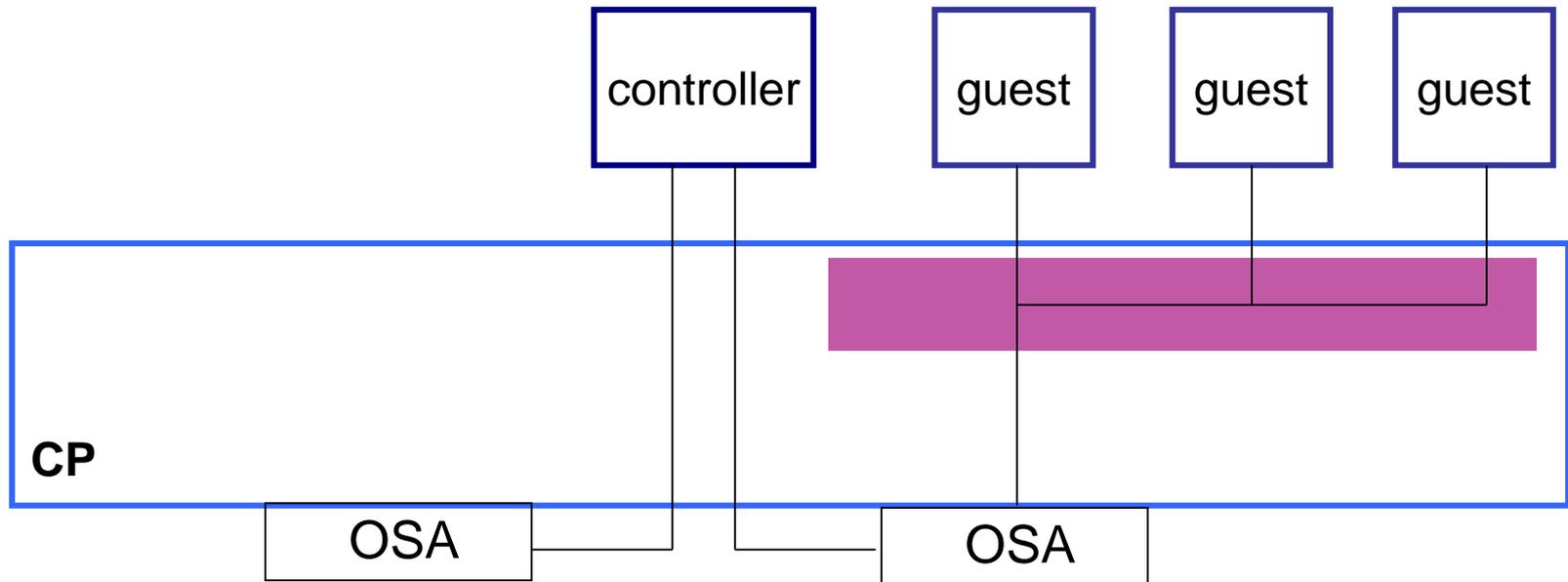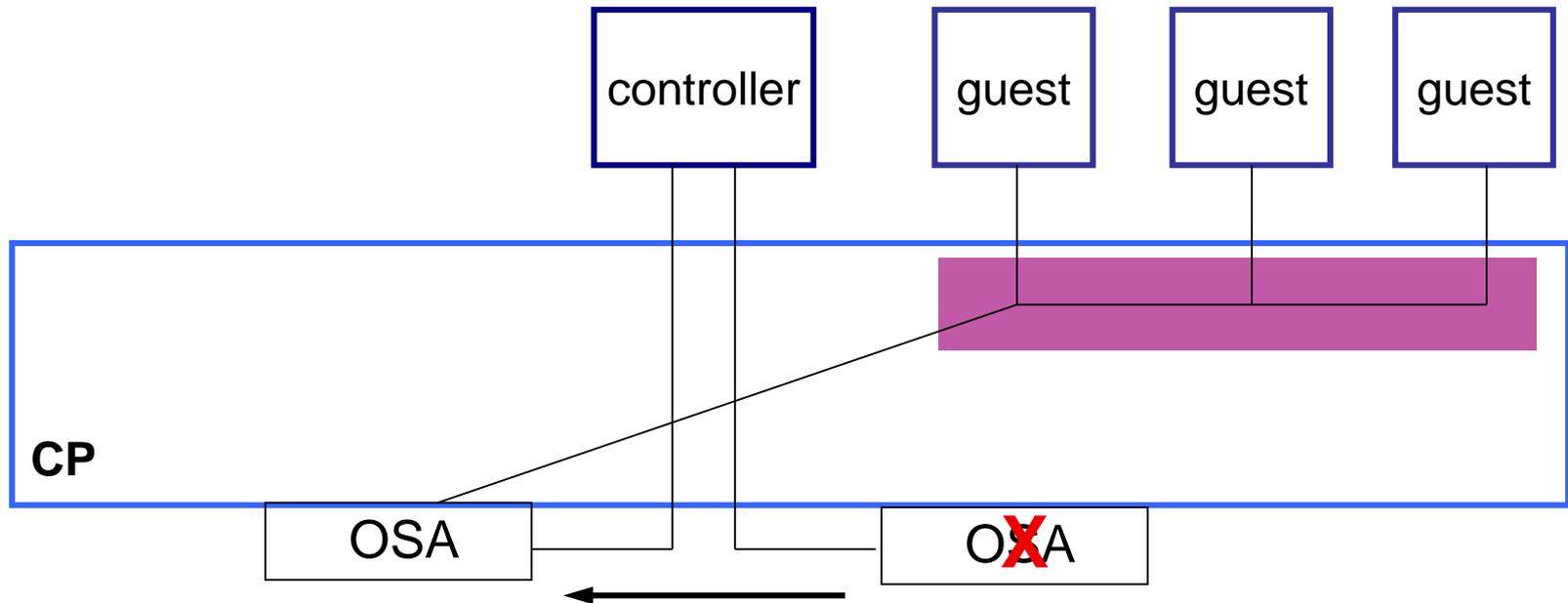
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What is Link Aggregation?

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Traditional VSWITCH Setup

- Up to 8 OSAs per VSWITCH

- Define a VSWITCH with 3 RDEVs

  - Use one for data transfer, keep two as back-up devices

  - Automatic failover

Traditional VSWITCH Setup

```
┌──────────┐   ┌───────┐ ┌───────┐ ┌───────┐
│controller│   │ guest │ │ guest │ │ guest │
└──────────┘   └───────┘ └───────┘ └───────┘
```

CP

OSA   O**X**A

If OSA dies or stalls, controller will detect it and switch to backup OSA

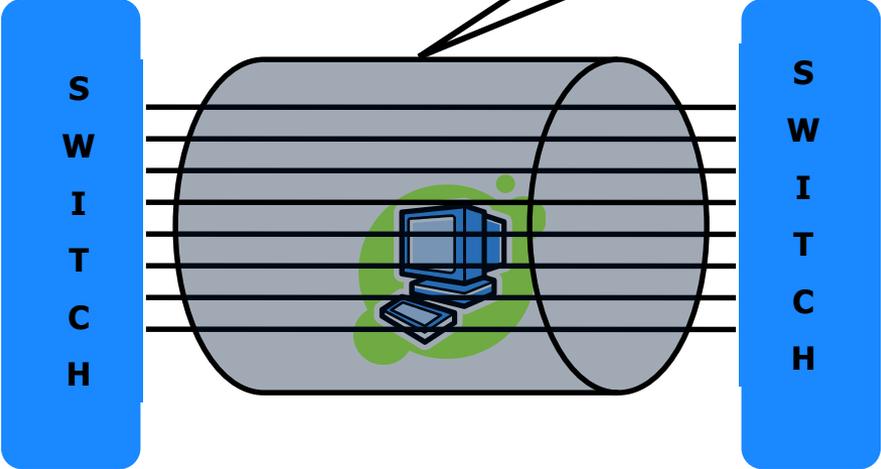- Failover to a back up OSA causes a brief network outage

  - Improved from release to release, but a brief outage is still technically an outage

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But, wait a minute.

"Why aren't you using my back-up OSA card?"

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Link Aggregation

Group two or more ports together to form a logical fat pipe between two switches

IEEE 802.3ad

Cascading Switches

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VSWITCH Link Aggregation Specifications

- Group multiple active QDIO VSWITCH real OSA connections as a single logical group
    - Up to 8 OSA ports (within a group or as backup devices)
    - Synchronized conversations over the same OSA link
    - Only one aggregate group per VSWITCH
    - No support for aggregation of virtual NICs

- 802.3ad compliance for **Layer 2 ETHERNET VSWITCH** only

- MAC level implementation – transparent to all connected NICs or protocols

VSWITCH Link Aggregation Specifications

- Port group management
  - Dynamic (LACP ACTIVE)
  - Static (LACP INACTIVE)

- Near seamless failover
  - Port failover to another port within the group
  - Group failover to a single backup port (existing failover support)

- Minimal link selection overhead

- Distribute single guest port's traffic across multiple OSA connections.

- External controls using SET PORT and other commands

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Hardware Requirements

- Dedicated* OSA Express2 or Express3 Ports

  - ▶ Same type of NIC card (10, 100,1000 and 10000 mbps)
  - ▶ Point to point connection to the same switch
  - ▶ Support of IEEE 802.3ad by both switches
  - ▶ Full duplex mode (send and receive paths)
  - ▶ VLAN considerations
    - – All member OSA ports within the group must be trunk links to provide the virtual LAN connectivity in which to flow tagged traffic
    - – Aggregated link should be viewed as one logical trunk link containing all the VLANs required by the LAN segment

  *Except with a Shared Port Group

Simple Virtual Switch LAN Segment

- Create a simulated Layer 2 or Layer 3 switch device
- Virtual machine access control and VLAN authorization
- Create ports and connect NIC to virtual switch (LAN Segment)
- Provides full MAC address management (generation and assignment)
- Forwards traffic between Guest Ports by either IP or MAC address
- 1-n VSWITCHs per z/VM image

Create VSWITCH (Class B Userid)

```
DEF VSWITCH VSWITCH1 ETHERNET

SET VSWITCH VSWITCH1 GRANT user
```

From Linux Virtual Machines

```
DEF NIC 100 TYPE QDIO

COUPLE 100 SYSTEM VSWITCH1
```
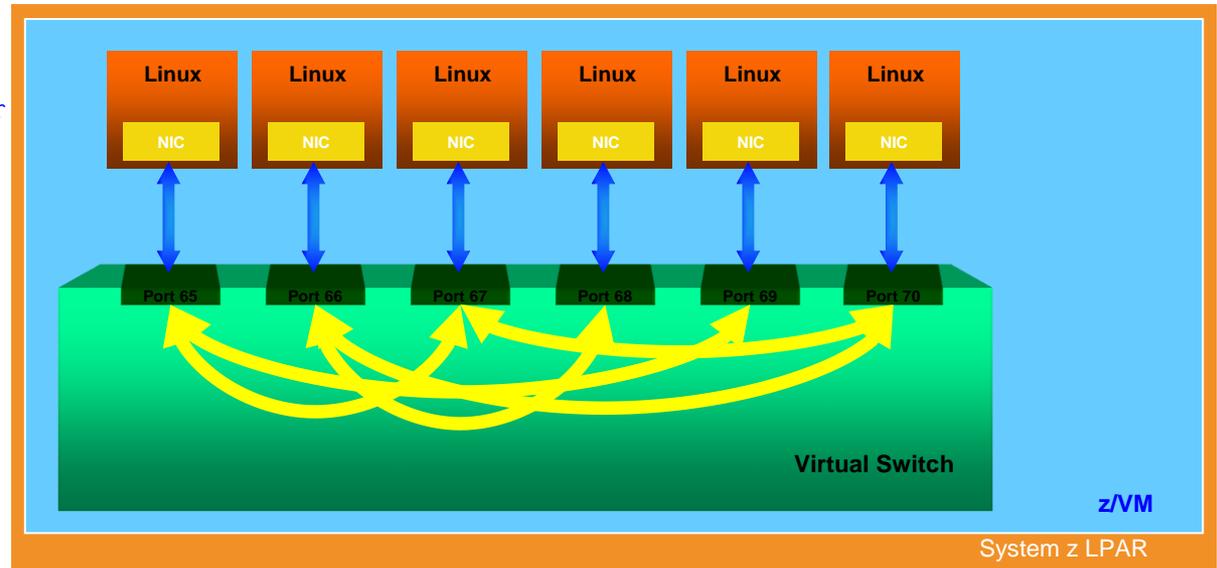
Cascading a Virtual to a Physical Switch

Start VM TCPIP Controllers

XAUTOLOG DTCVSW1
XAUTOLOG DTCVSW2

Connect the Real Switch

SET VSWITCH VSWITCH1 RDEV 100

Linux — NIC — Port 65
Linux — NIC — Port 66
Linux — NIC — Port 67
Linux — NIC — Port 68
Linux — NIC — Port 69
Linux — NIC — Port 70

VM TCPIP Controller

Virtual Switch
Port 1

z/VM

System z LPAR

OSA
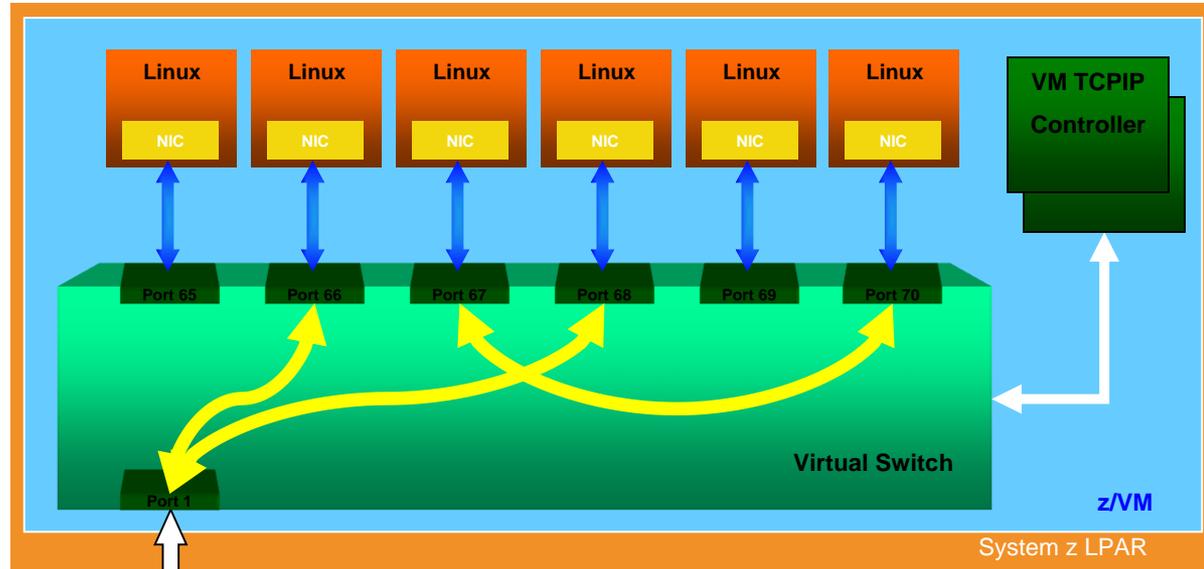
QDIO Connection (3 Devices)

Read Control Device

Write Control Device

Data Device

Port 1

Physical Switch

Adding a Failover Device

Issue the SET VSWITCH command and include the new RDEV
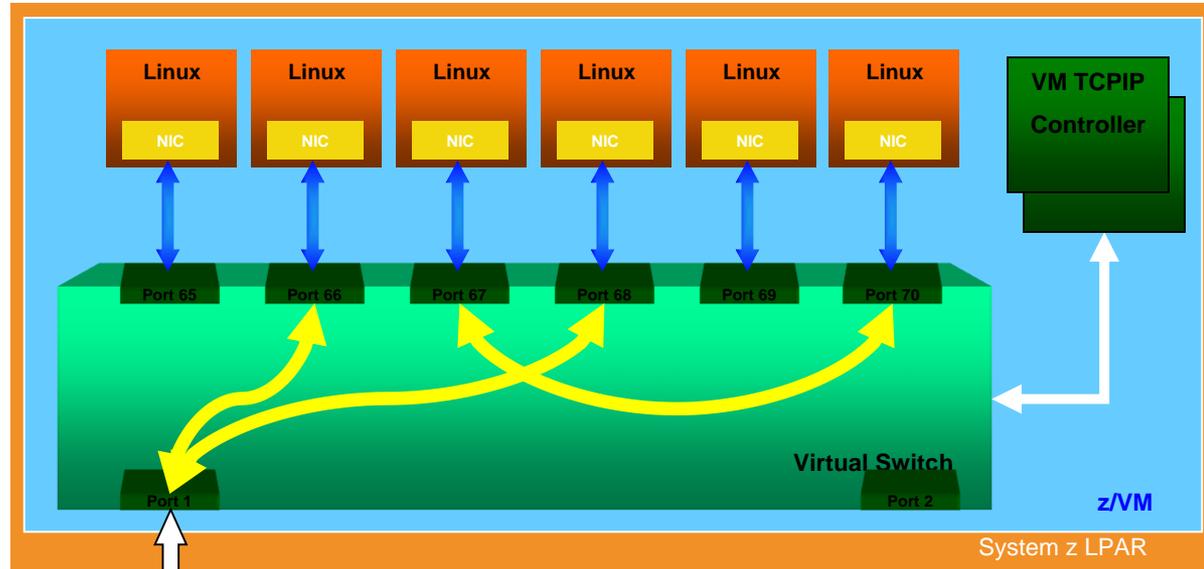
Example

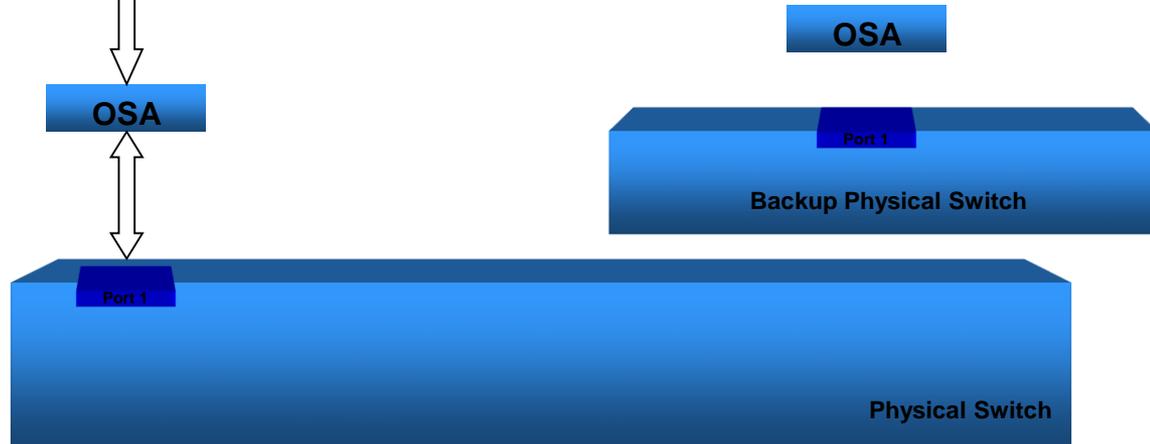SET VSWITCH VSWITCH1 RDEV 100 500
SET VSWITCH VSWITCH1 CONNECT

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Port Failover

Port
Error

QDIO connection terminated
on the primary OSA device
and is established and
activated on the BACKUP
device

Only one QDIO Connection is
active at any point in time

Linux	Linux	Linux	Linux	Linux	Linux
NIC	NIC	NIC	NIC	NIC	NIC

VM TCPIP
Controller

Port 65   Port 66   Port 67   Port 68   Port 69   Port 70

Virtual Switch

Port 1   Port 2

z/VM

System z LPAR

OSA

OSA

Port 1

Backup Physical Switch

Port 1

Physical Switch

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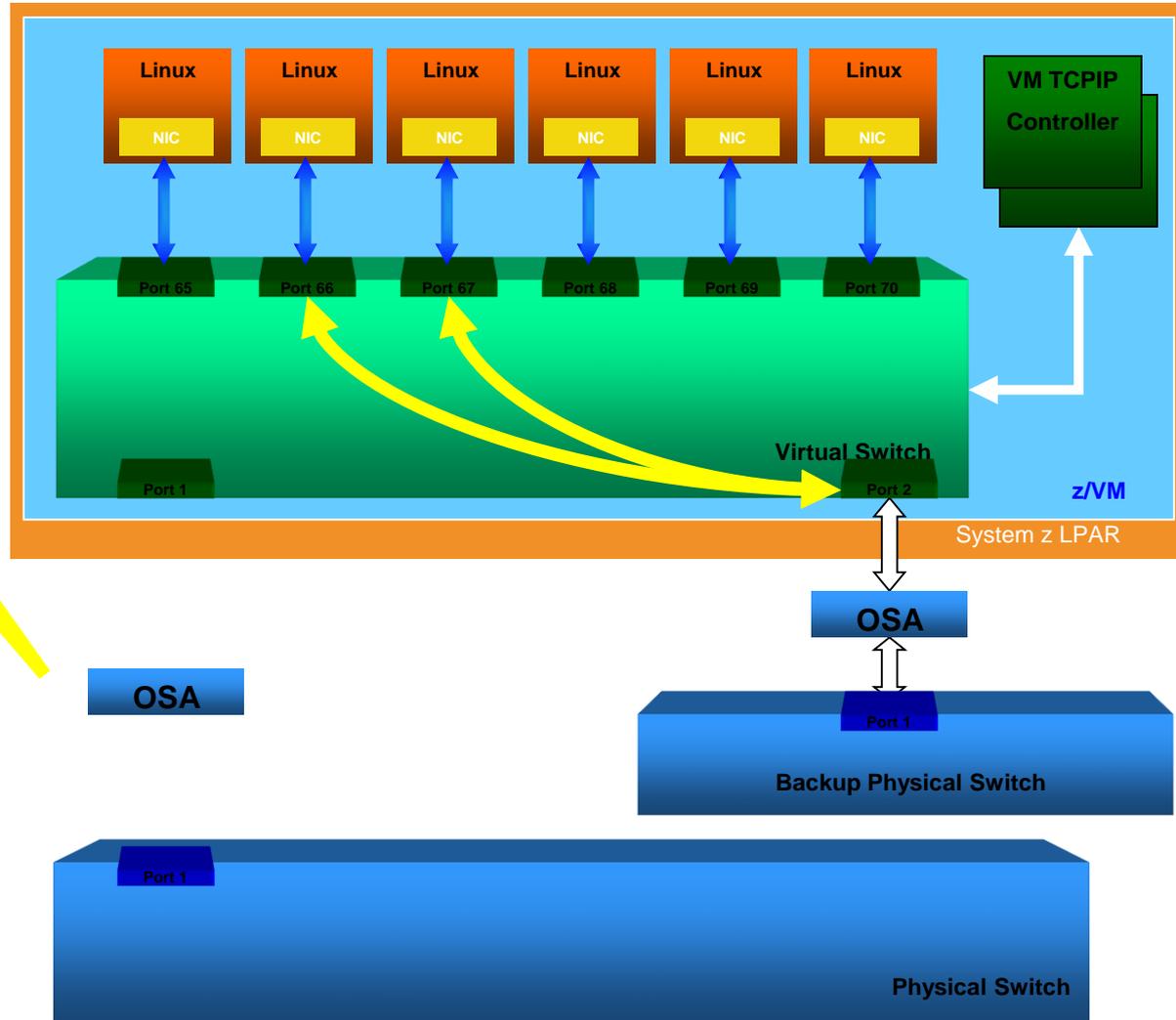
Defining Port Groups

Two step process to create a LinkAG port configuration
1. Create a port group using new SET PORT CP Command
2. Associate a port group with an ETHERNET type VSWITCH

Create a Port Group

SET PORT GROUP ETHGRP JOIN 500 600 700 800

SET PORT GROUP ETHGRP LACP INACTIVE

Display INACTIVE Port Groups
Q PORT GROUP INACTIVE

```
Group: ETHGRP      Inactive      LACP Mode: Inactive
 VSWITCH <none>                   Interval: 300
 RDEV: 0500
 RDEV: 0600
 RDEV: 0700
 RDEV: 0800
```

Display ACTIVE Port Groups
Q PORT GROUP

```
HCPSWP2837E No active groups found.
```

SET or MODIFY PORT GROUP

- Use the SET or MODIFY PORT command to define or change the OSA Express devices that make up a link aggregation group and to set the attributes of a link aggregation group

```
Privilege Class: B                           +------+
                                             |      |(1)
                                             v      |
>>---SET-PORT-GROup groupname -+- JOIn --+---rdev --------+--->< 
                               +- LEAve -+                |
                               +- DELete ----------------+
                               +- LACP -+- ACTive -----+--+
                               |        +- INActive ---+  |
                               +- INTerval--+- nnnn -+----+
                                            +- OFF --+
                                               (2)
```

Note: (1) You can specify a maximum of 8 real device numbers
(2) Operands that may be specified while the group is ACTIVE

LACP INACTIVE LinkAG Group

- **Associate a port group with an ETHERNET type VSWITCH**

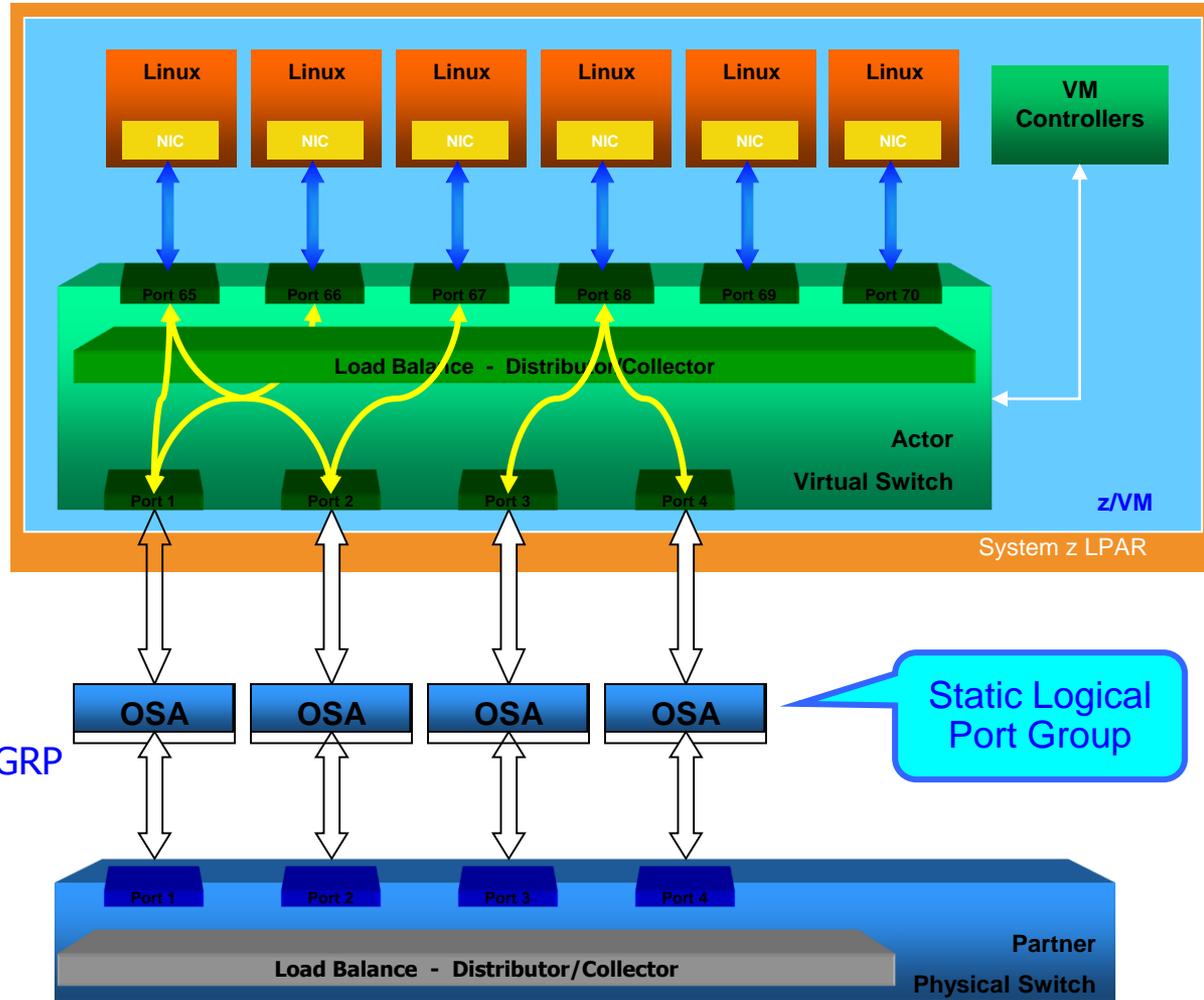**Disconnect the Physical Switch**

SET VSWITCH VSWITCH1 DISCON

Setup Partner Switch for a LACP INACTIVE port

Associate the Port Group

SET VSWITCH VSWITCH1 GROUP ETHGRP

Connect the Port Group

SET VSWITCH VSWITCH1 CONNECT

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LACP ACTIVE LinkAG Group

Create a Dynamically Managed LinkAG Port Group

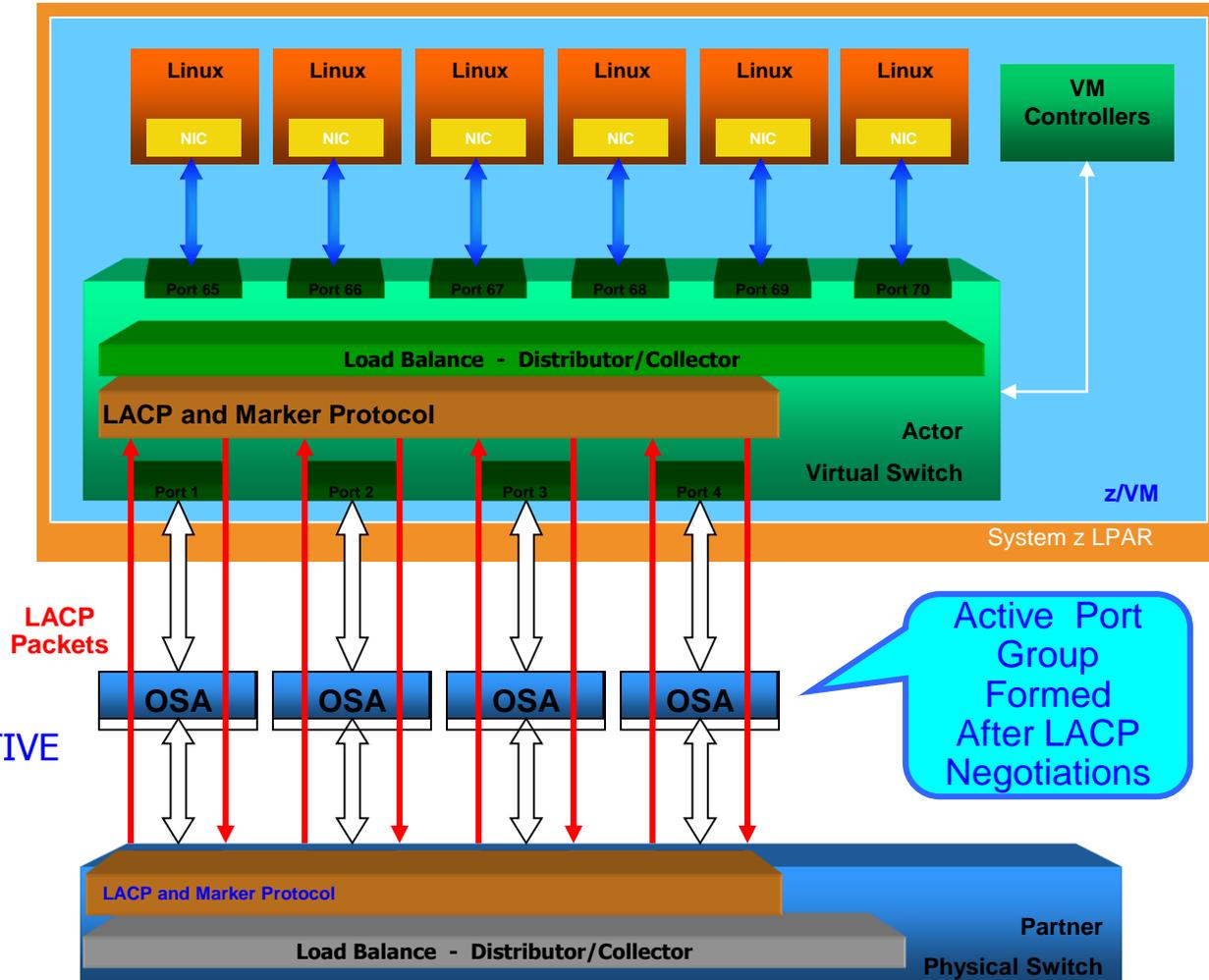**Disconnect the Physical Switch**

SET VSWITCH VSWITCH1 DISCON

Setup Partner Switch for a LACP ACTIVE port

Make Port Group LACP ACTIVE

SET PORT GROUP ETHGRP LACP ACTIVE

Connect the Port Group

SET VSWITCH VSWITCH1 CONNECT

Linux | Linux | Linux | Linux | Linux | Linux

NIC | NIC | NIC | NIC | NIC | NIC

VM Controllers

Port 65 | Port 66 | Port 67 | Port 68 | Port 69 | Port 70

Load Balance - Distributor/Collector

LACP and Marker Protocol

Actor

Port 1 | Port 2 | Port 3 | Port 4

Virtual Switch

z/VM

System z LPAR

LACP Packets

OSA | OSA | OSA | OSA

Active Port Group Formed After LACP Negotiations

LACP and Marker Protocol

Load Balance - Distributor/Collector

Partner
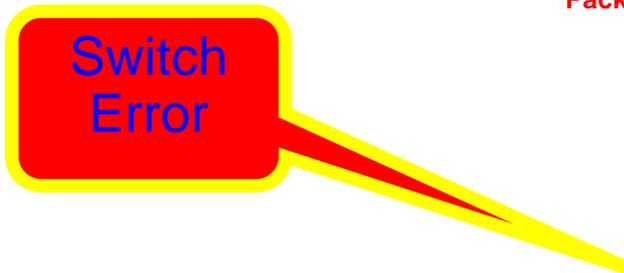
Physical Switch

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Switch Failover to Traditional Backup Device

LinkAG group can be setup to failover to a single port on another switch

Select another physical switch on the same LAN segment

Add the BACKUP device

SET VSWITCH VSWITCH1 RDEV 100

Switch Error

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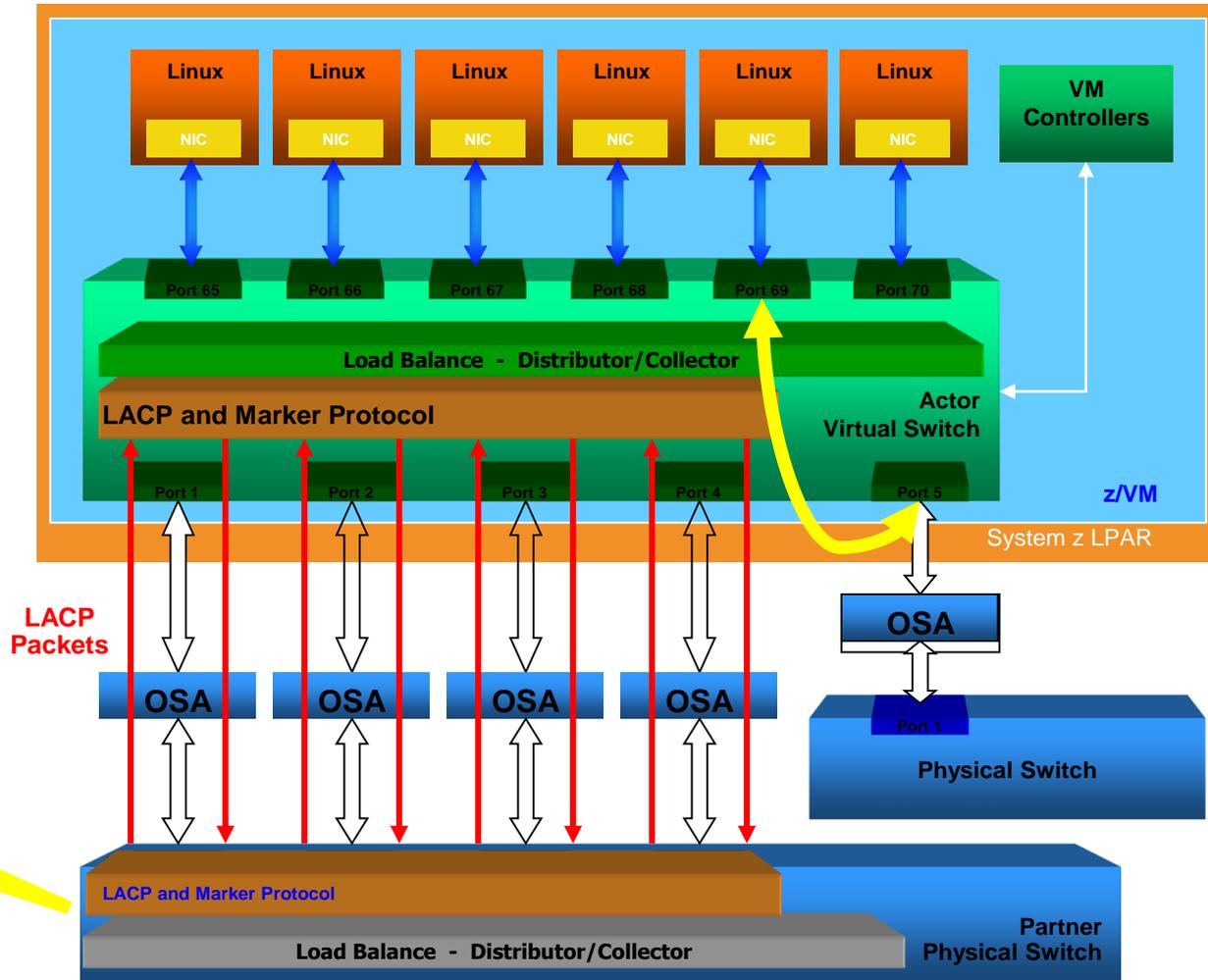
# Advantages of a LACP ACTIVE Port Group   (Recommended)

- Ports can be added or removed dynamically within the LinkAG group
  - Changes made on one switch are automatically made on the other switch
  - Immediate packet rerouting

- Fast "nearly seamless" failover to another port within the group

- Adding or removing capacity is not disruptive

- LACP Protocol provides a heartbeat mechanism

- Marker Protocol allows greater flexibility to dynamically move work from one port to another within the group

- Automatic fail-back from the backup device to a port group

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Shared Link Aggregation Groups

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Shared Port Groups – The Big Picture

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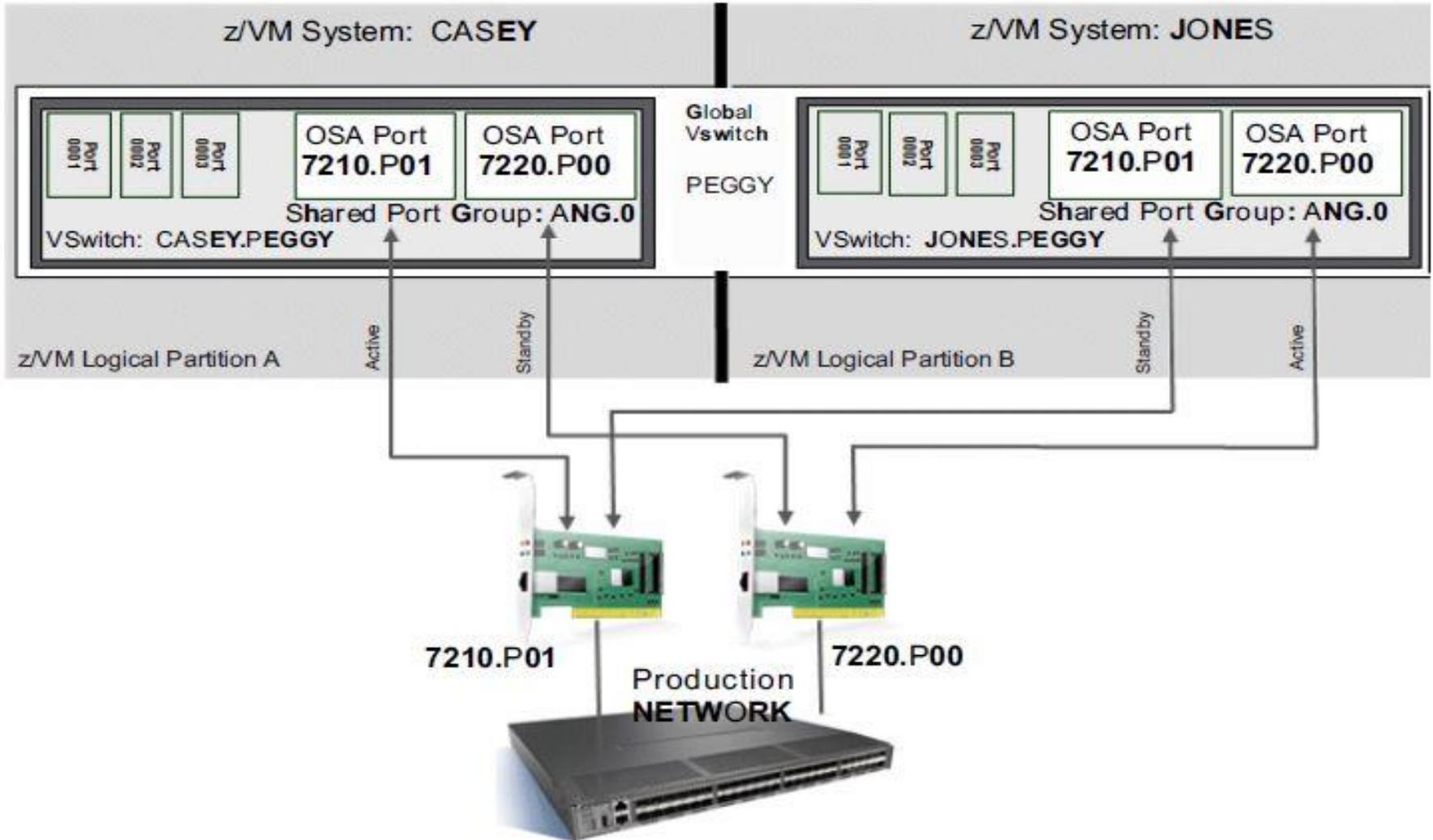
Shared Port Groups – The Bigger Picture
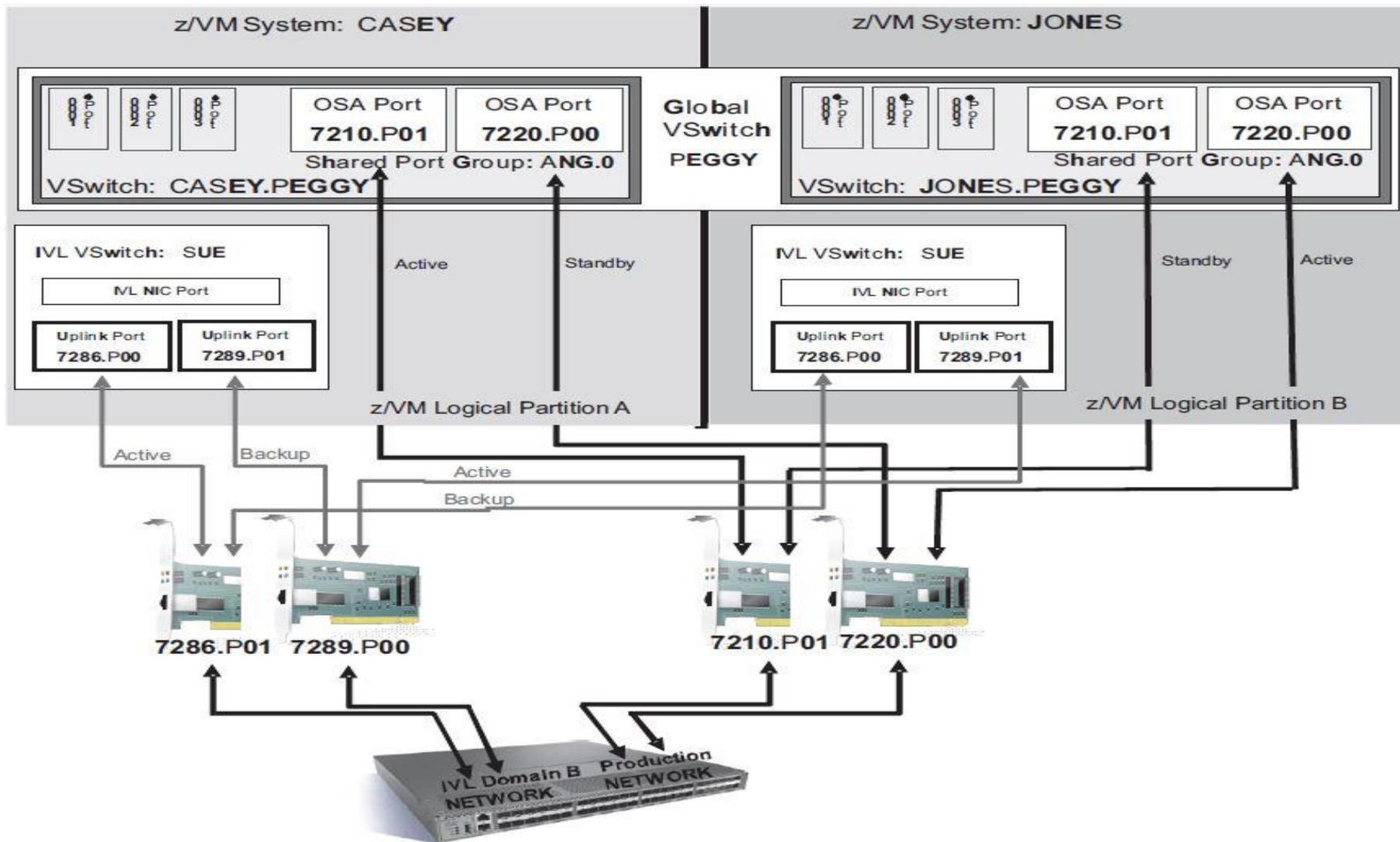
Shared Port Groups: What are they good for?

- Share OSA ports

- Let multiple VSWITCHes use a port group

- Share OSAs across multiple LPARs

- Reduce setup (Configuration changes are propagated to all the z/VM systems sharing the port group.)

- Convenient management (same reason)

- Improved redundancy (Virtual chassis functionality)

- Fewer cavities

Shared Link Aggregation (LAG) Port Groups

- IBM z13 Exclusive!

- Provides a single point of control for OSA Port management across multiple VSWITCHes sharing the same physical port group.

- Requires two new system constructs

  - Global VSWITCH – Provides the mechanism for a Virtual Switch to span multiple z/VM LPARs within a CPC.

  - Inter-VSWITCH Link (IVL) – Provides management and data plane communications between Global VSWITCHes within the same or other z/VM instances.

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Shared Link Aggregation Port Groups

- VSWITCHes are in communication with each other using a registered multicast group

- Port group can be used by multiple VSWITCHes

- Configuration changes are propagated to all z/VM systems sharing the port group

- You can manage the port group from any z/VM system in the IVL domain

- Systems cooperate to balance traffic flow

- Failover mechanism exists utilizing IVL VSWITCHes

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The IVL Domain

- An IVL domain is a group of up to 16 z/VM LPARs on a CPC

- All z/VM Hypervisors sharing the same physical port group must be members of the same IVL domain

- A z/VM LPAR can be a member of exactly one IVL domain

- The IVL domain is established through an IVL VSWITCH
  – One per z/VM LPAR

- Up to 8 IVL Domains can share a single LAN segment

- The bandwidth required by the IVL is minor, consisting of management and LAG data recovery communications

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IVL VSWITCH

- **DEFINE VSWITCH name {options}**
    - TYPE IVL
    - DOMAIN A through H
    - VLAN vid
    - Conventional RDEV list or exclusive port group

- Remember to provide OSA port redundancy for IVL!

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IVL Controls

- SET VSWITCH name IVLPORT {option}

  - VLAN - Change the VLAN ID associated with the IVL

  - RESET – Terminate and recreate the IVL port connection

  - PING – Tests connectivity among z/VM hypervisors in the same IVL domain
    - SET VSWITCH IVL IVLPORT PING ALL

  - HEARTBEAT TIMEOUT – Adjusts how often the local z/VM system confirms connectivity with the other domain members

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Create the Shared Port Group

➢ **SET PORT GROUP name LACP ACTIVE SHARED**

➢ **SET PORT GROUP name JOIN rdev1.port rdev2.port**

➢ z/VM will automatically propagate Shared Port Group information to all active IVL members in the same IVL domain

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Define a Global VSWITCH

➢ DEFINE VSWITCH name GLOBAL ETH GROUP group

➢ A Global VSWITCH is a virtual switch which can span multiple z/VM instances through the IVL Network and which shares the same physical port group.

➢ Must be defined with the same name in all sharing LPARs

➢ A Global ID (systemid.vsw_name) is generated by the control program

➢ Multiple Global VSWITCHes can be defined per z/VM LPAR

➢ An instance of a Shared Port Group is created when it is configured to a virtual switch (group.0).

Shared Port Groups – The Bigger Picture

#IBMz   #z13   #zVM   © 2010, 2015 IBM Corporation
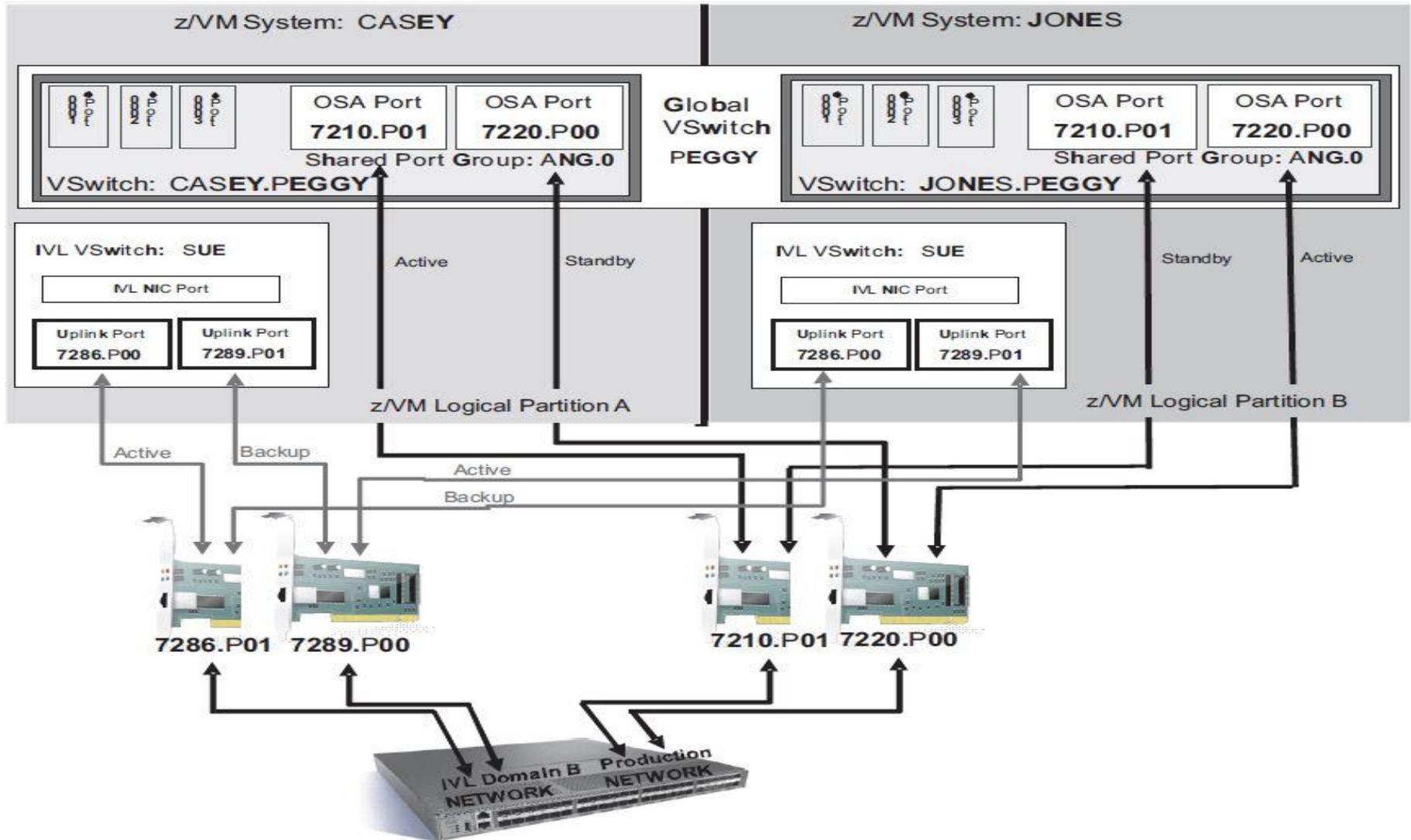
Setting up the Bigger Picture: IVLs

(On CASEY)

DEFINE VSWITCH SUE TYPE IVL DOMAIN B VLAN 8 NATIVE NONE

UPLINK RDEV 7286.P00 7289.P01

(On Jones)

DEFINE VSWITCH SUE TYPE IVL DOMAIN B VLAN 8 NATIVE NONE

UPLINK RDEV 7289.P01 7286.P00

#IBMz   #z13   #zVM

Setting up the Bigger Picture – Shared Port Group

(On either system)

SET PORT GROUP ANG LACP ACTIVE SHARED
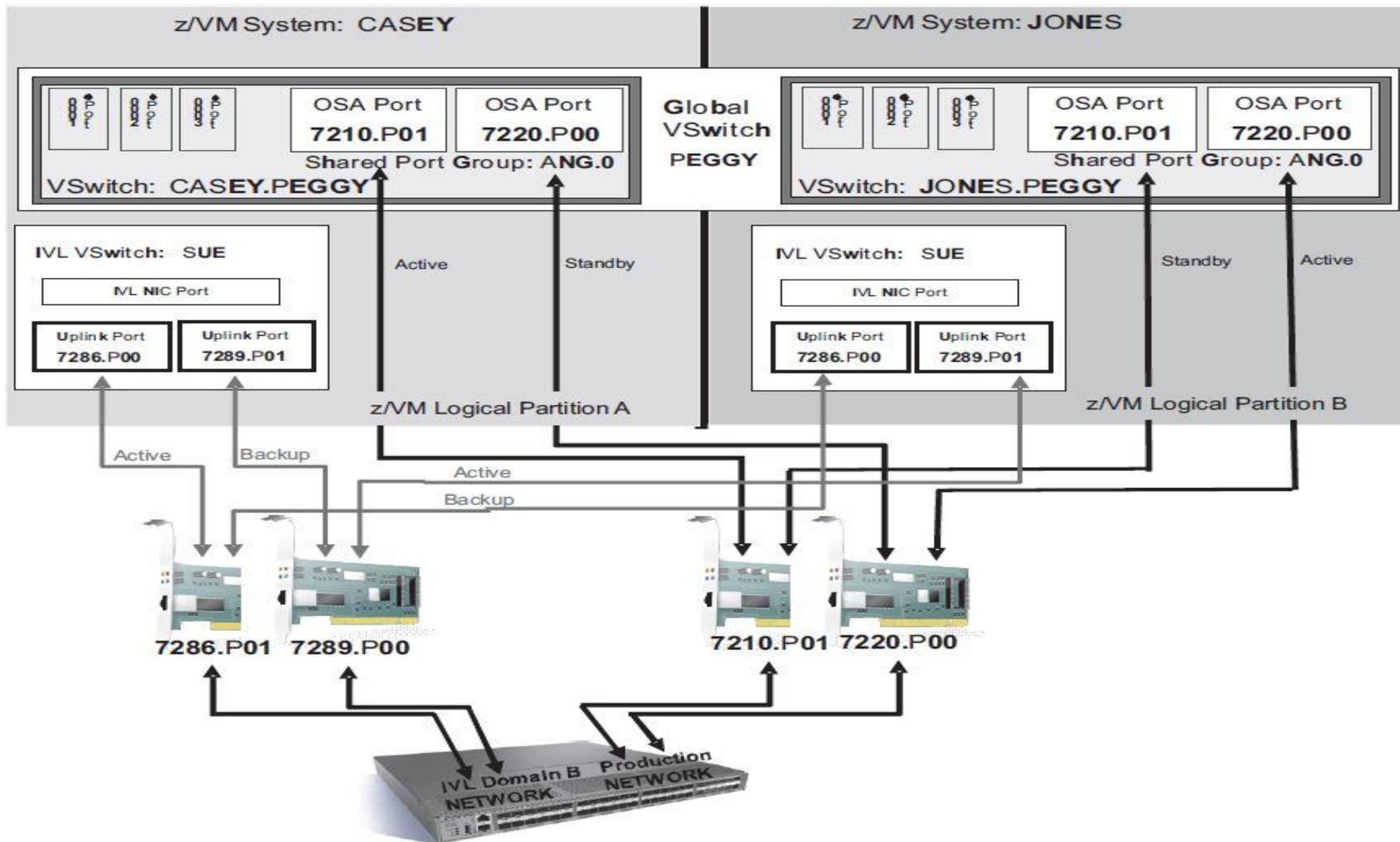
SET PORT GROUP ANG JOIN *7210.P01 7220.P00*

Setting up the Bigger Picture -- VSWITCHes

(On both systems)

DEFINE VSWITCH PEGGY GLOBAL ETHERNET

SET VSWITCH PEGGY UPLINK GROUP ANG

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Shared Port Groups – The Bigger Picture

Tips and Tricks for the z/VM Virtual Switch

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Useful diagnostic commands

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

- **CP QUERY LAN 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

- **CP QUERY PORT GROUP**
  - To determine the members of a particular groupname
  - To determine which groups are active or inactive

Diagnose x'26C'

- "Access Certain System Information" (i.e. QUERY)

- Only some subcodes are relevant to today's discussion
  - x'04' BYUSER ID
  - x'08' virtual LAN system information
  - x'0C' controller list
  - x'10' controller information
  - x'14' guest LAN list
  - x'18' guest LAN information
  - x'1C' virtual switch list
  - x'20' virtual switch information
  - x'24' virtual port, virtual NIC or Hipersockets logical port information
  - x'30' MAC Services

Rough correspondence, diag x'26C' vs. QUERY

- Subcode x'04'   Q BYUSER

- Subcode x'08'   Q VMLAN

- Subcode x'0C', x'10'   Q CONTROLLER

- Subcode x'14', x'18'   Q LAN

- Subcode x'1C', x'20'   Q VSWITCH, Q PORT

- Subcode x'24'   Q NIC

- Subcode x'30'   Q NIC USER *

Using diagnose x'26C'

Design: Include HCPCSIBK COPY in an assembler program

HCPCSIBK is in HCPGPI MACLIB on the 190 disk

Alternative: Convert HCPCSIBK to a .h file and write in C

See D26C tool on the VM Download Page

http://www.vm.ibm.com/download/packages/descript.cgi?D26C

Summing Up Link Aggregation

- IEEE 802.3ad compliant including support of active LACP (Link Aggregation Control Protocol (switch to switch only)
  - No support for aggregation of virtual NICs.

- Deploy up to 8 OSA adapters.

- OSA Adapters that are part of the aggregated group are not sharable with other hosts on z/VM or LPAR.

- Non-disruptive failover
  - Communications will continue if a hardware link in the group experiences a non-recoverable failure.

- Improved bandwidth over link aggregate group

- Workload balanced across aggregated links

Questions?

For More Information …

- http://www.vm.ibm.com/virtualnetwork/
- http://www.vm.ibm.com/virtualnetwork/linkag.html -- z/VM Link Aggregation Development
- http://www.ibm.com/servers/eserver/zseries/os/linux/
- http://www.linuxvm.org/
- http://www.cisco.com/en/US/prod/collateral/switches/ps5718/ps9336/prod_white_paper0900aecd806ee2ed.html

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Dank u
Dutch

Merci
French

Спасибо
Russian

Gracias
Spanish

شكراً
Arabic

Tack så mycket
Swedish

धन्यवाद
Hindi

감사합니다
Korean

תודה רבה
Hebrew

Obrigado
Brazilian
Portuguese

Dankon
Esperanto

Thank You

谢谢
Chinese

ありがとうございます
Japanese

Trugarez
Breton

Danke
German

Tak
Danish

Grazie
Italian

நன்றி
Tamil

děkuji
Czech

ขอบคุณ
Thai

go raibh maith agat
Gaelic

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In case of emergency, break glass:

Backup Slides

Global VSWITCH Common Properties

The following must be the same on each member of a Global VSWITCH Domain

- | – TYPE QDIO

- | – IP or ETHERNET

- | – ISOLATION

- | – VEPA

- | – VLAN AWARE or UNAWARE

- | – NATIVE natvid

- | – USERBASED or PORTBASED

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Link Aggregation and Exclusive Use

HCPSWU2832E An exclusive use error was received for the device.

- Stems from trying to share an OSA-Express2 device between LPARs when a port on the device is a member of a port group

- Be mindful of which devices can / cannot be in exclusive-use mode when defining groups

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Link Aggregation and Flow Control

- As long as they are of the same type and speed, it is possible to combine OSA-Express2 and OSA-Express3 ports into a port group.

- However:
  - the ports must have the same configuration on the physical switch
  - check 'send flow control' defaults on your physical device

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