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13196: HiperSockets on System zEC12 – Overview

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IBM System z Firmware Development

(Presented by Linda Harrison)

16 August 2013

SHARE in Boston

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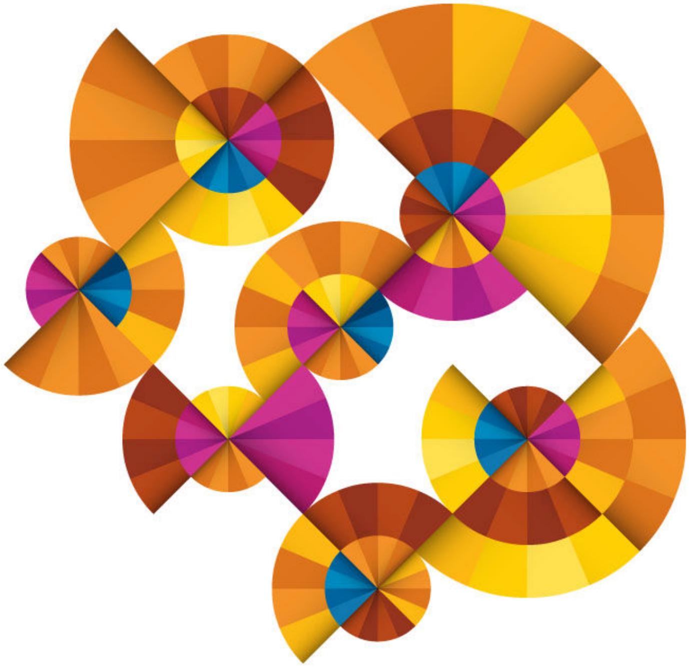
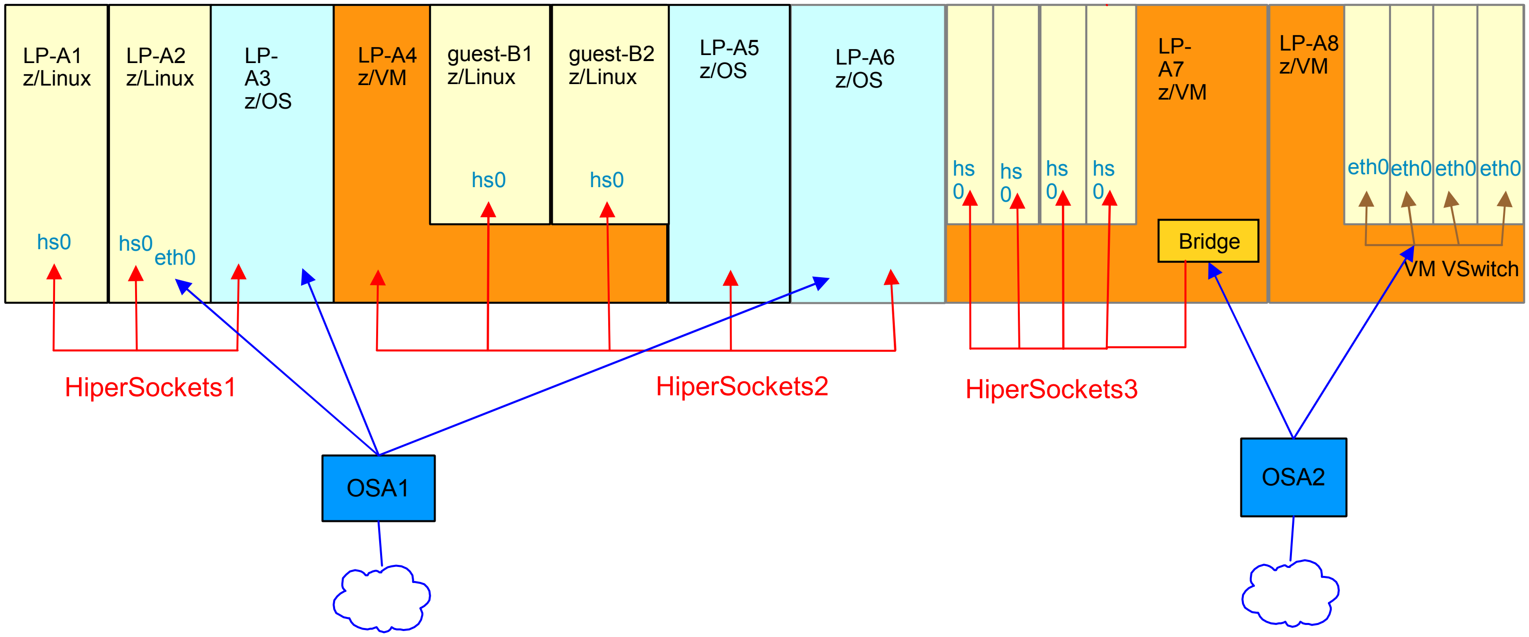
Agenda

- System z Networking

- HiperSockets Insights
  - Configuration
  - **How does it work?**
  - What are the implications?
  - **Performance considerations**



System z Networking



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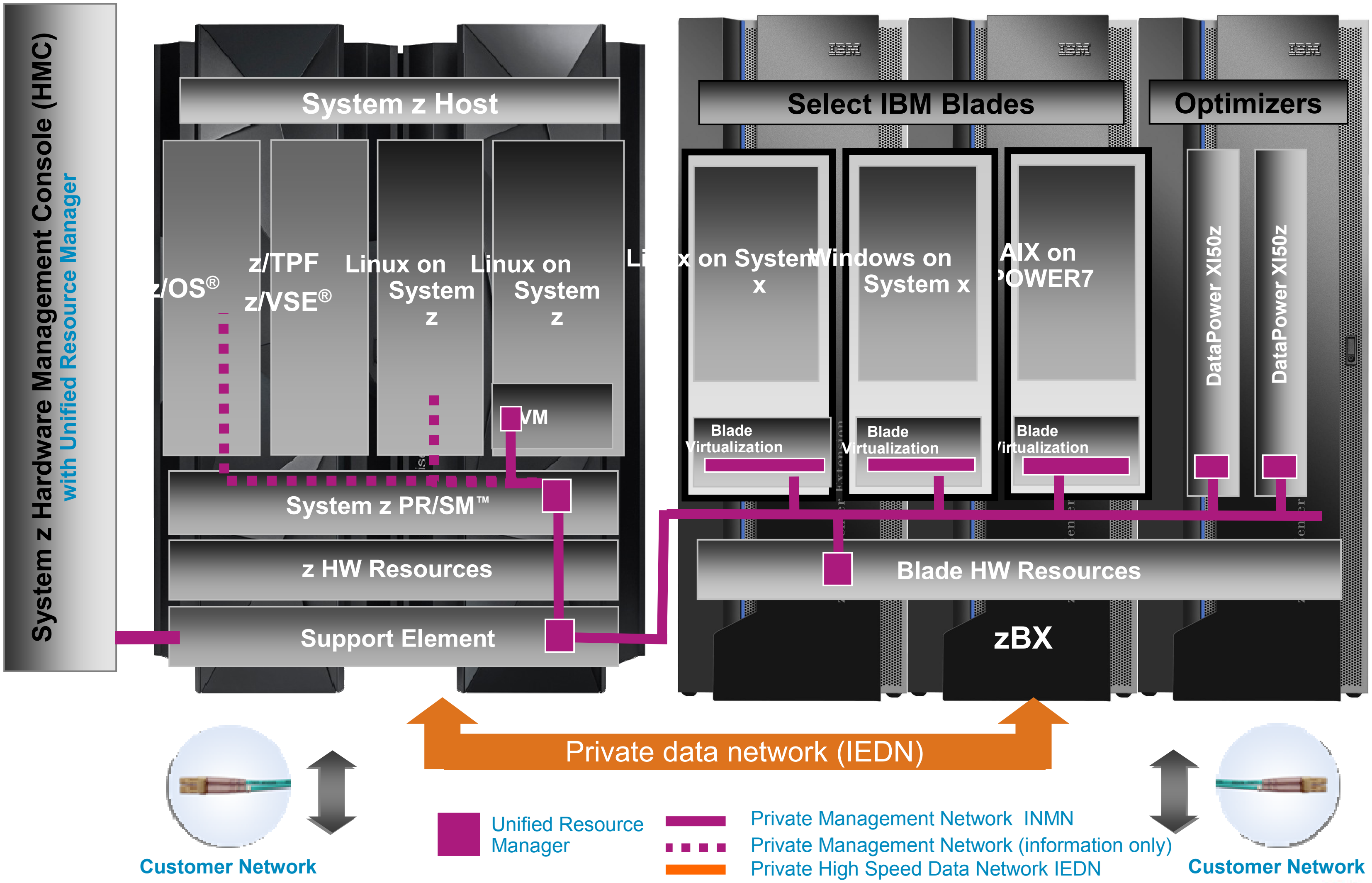
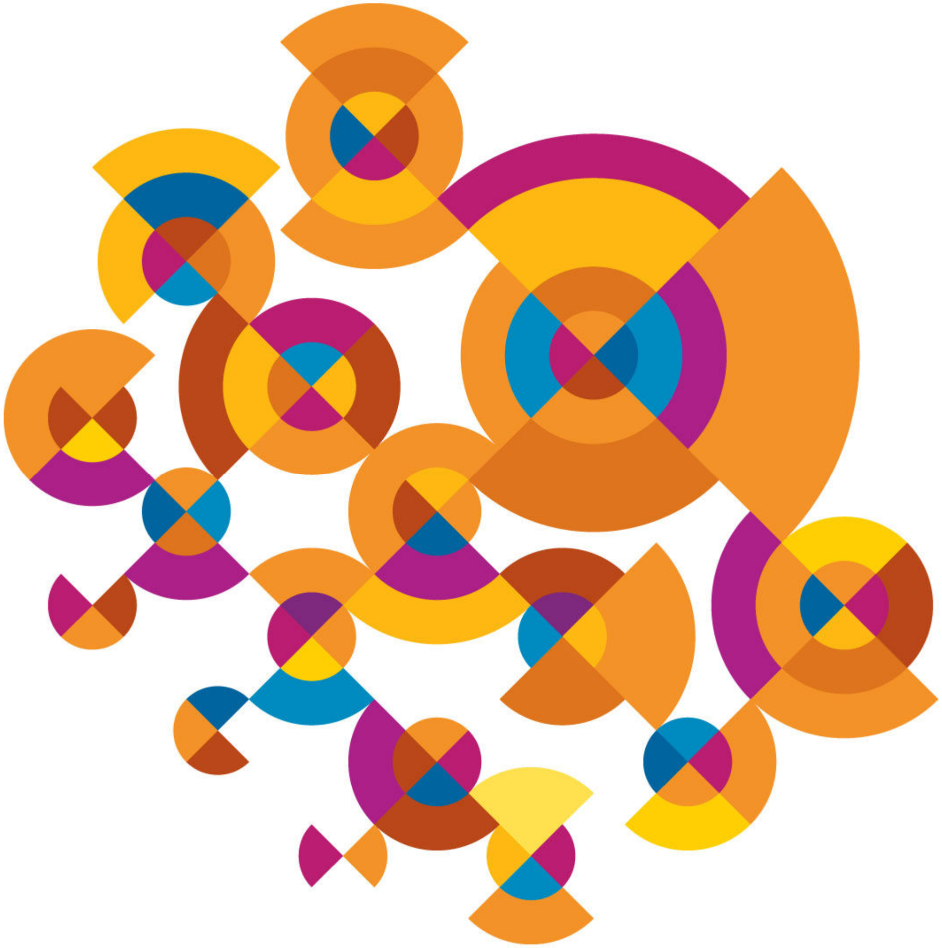
zBX zEnterprise BladeCenter Extension



HiperSockets Insights

- How does it work?
- Why does it matter?



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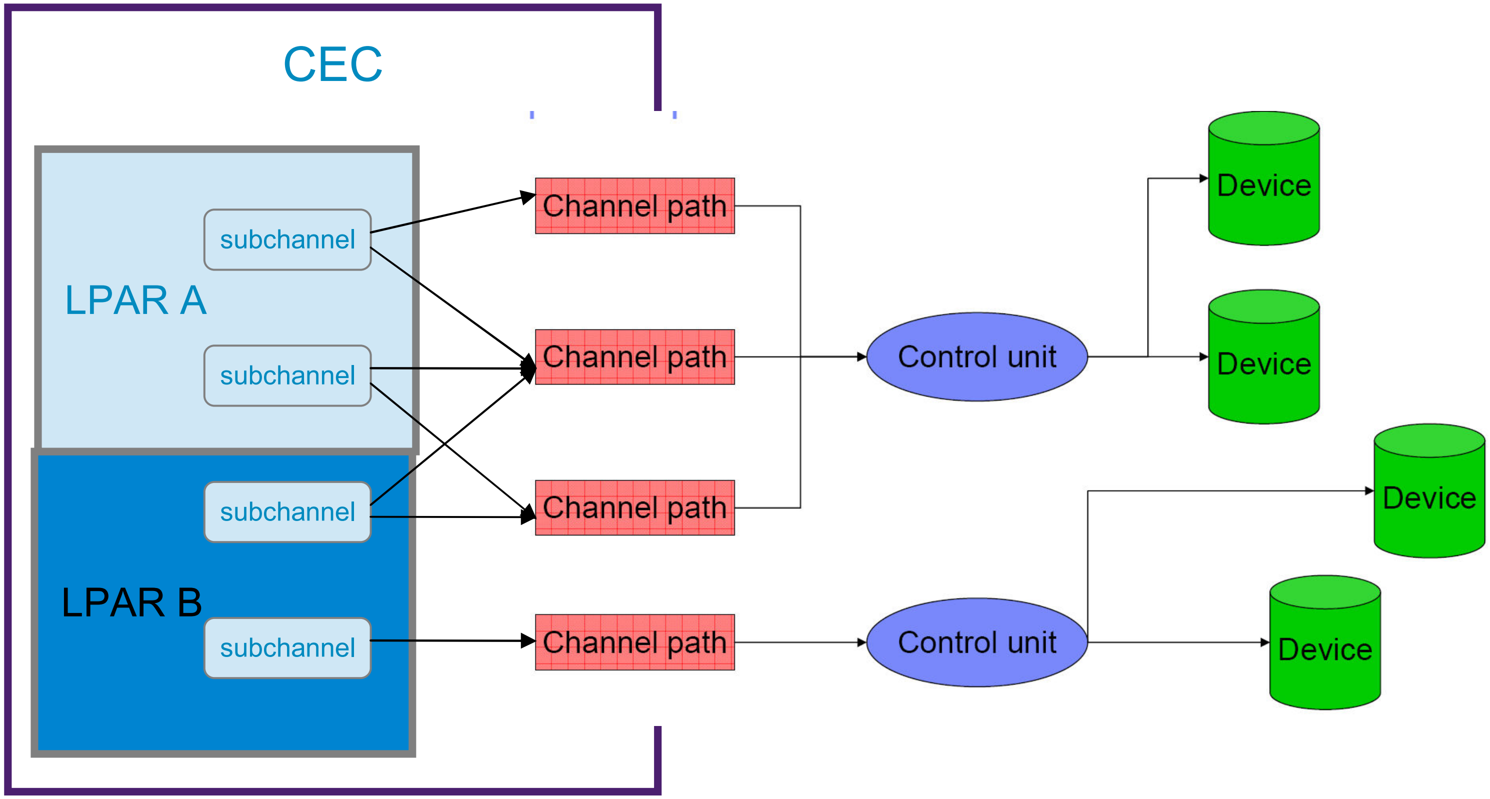
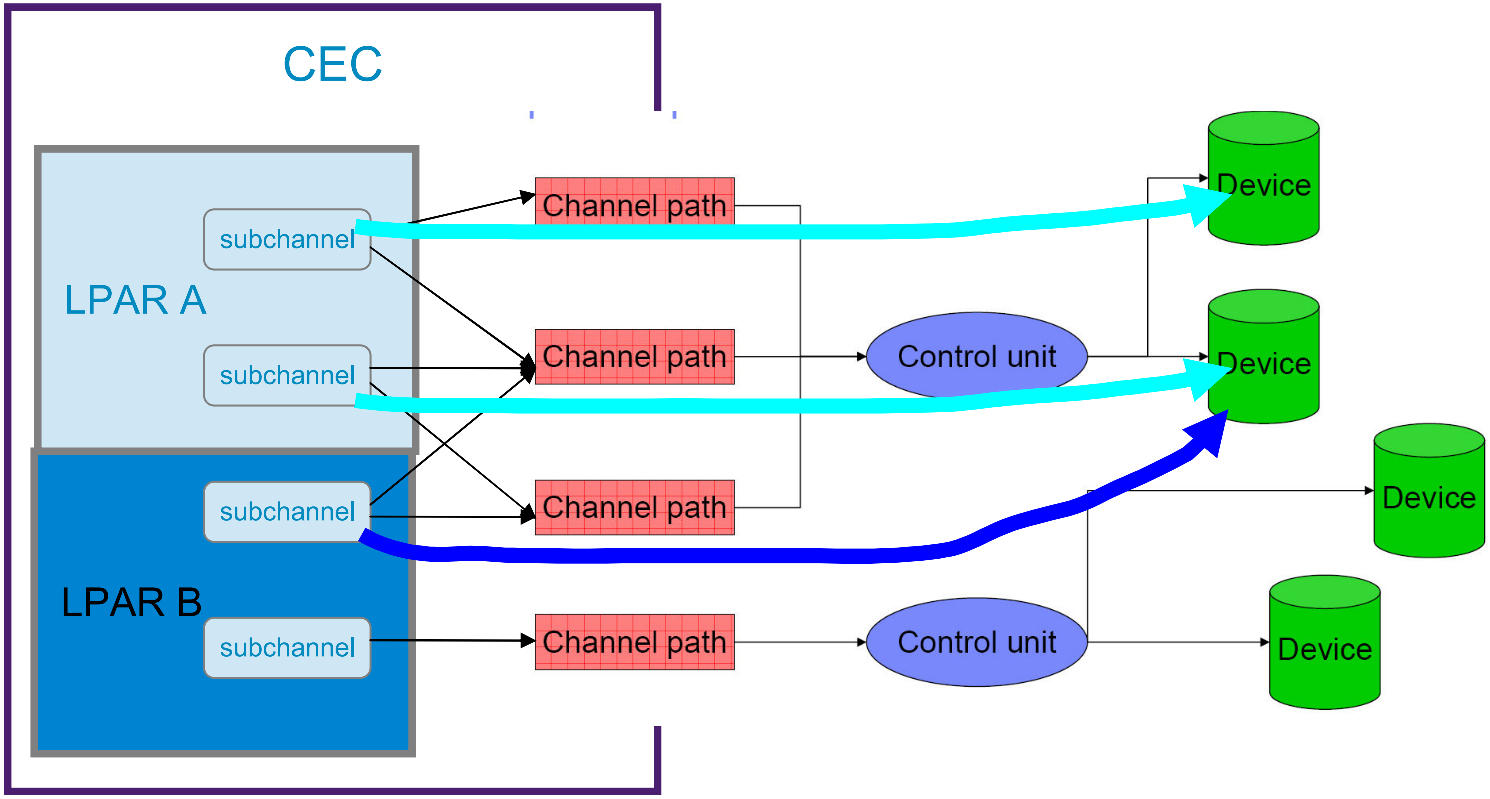
Traditional System z I/O model



IOCDS:

```
CHPID PCHID=240,PATH=(CSS(0),40),TYPE=FC,PART=(LP1, LP3)
CNTLUNIT CUNUMBR=240,UNITADD=((00,4)),UNIT=FC,PATH=((CSS(0),40,41))
IODEVICE ADDRESS=(2C00,4),CUNUMBR=240,UNIT=FC,UNITADD=00,              *
               STADET=Y,SCHSET=1
```

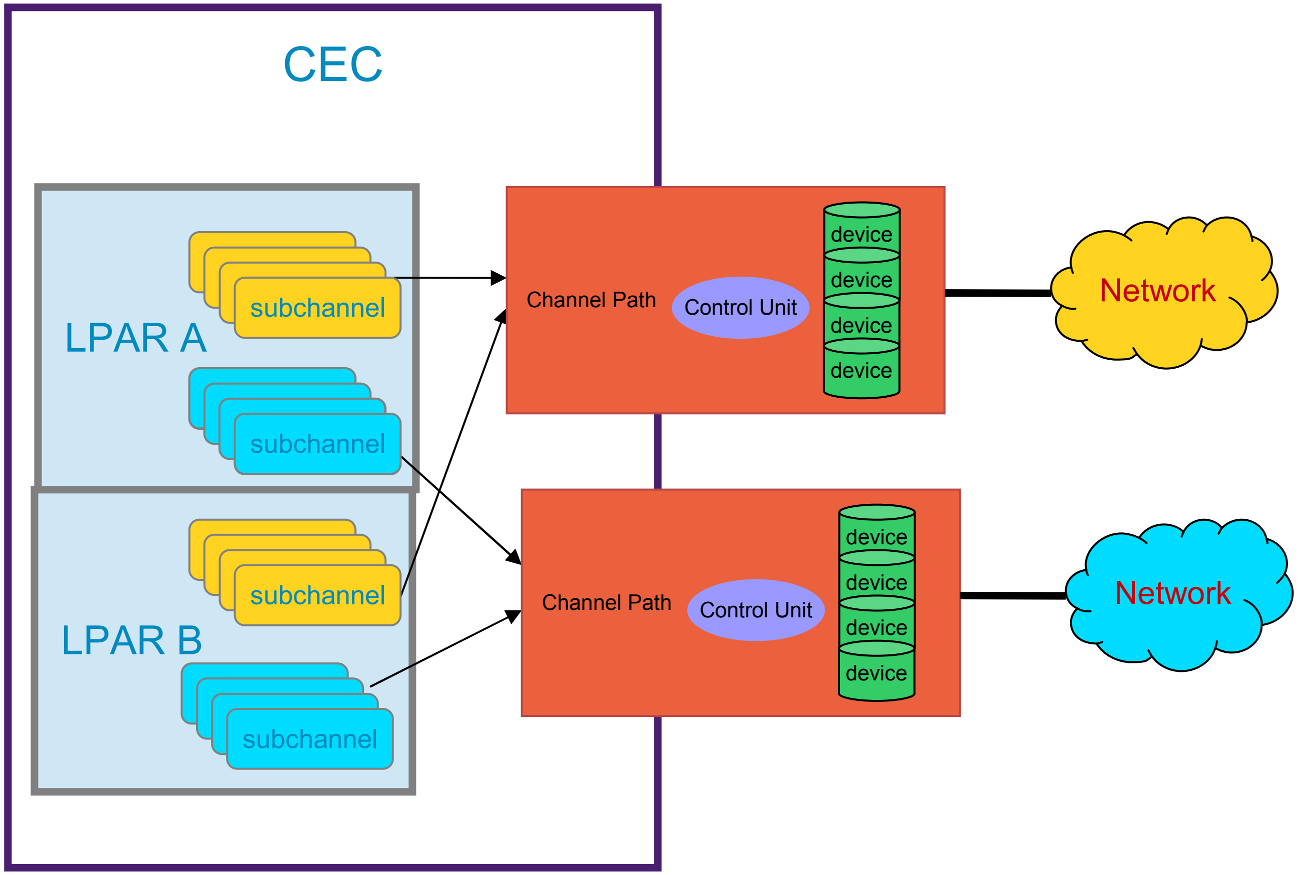
Traditional System z I/O model



IOCDS:

```
CHPID PCHID=240,PATH=(CSS(0),40),TYPE=FC,PART=(LP1, LP3)
CNTLUNIT CUNUMBR=240,UNITADD=((00,4)),UNIT=FC,PATH=((CSS(0),40,41))
IODEVICE ADDRESS=(2C00,4),CUNUMBR=240,UNIT=FC,UNITADD=00,          *
               STADET=Y,SCHSET=1
```

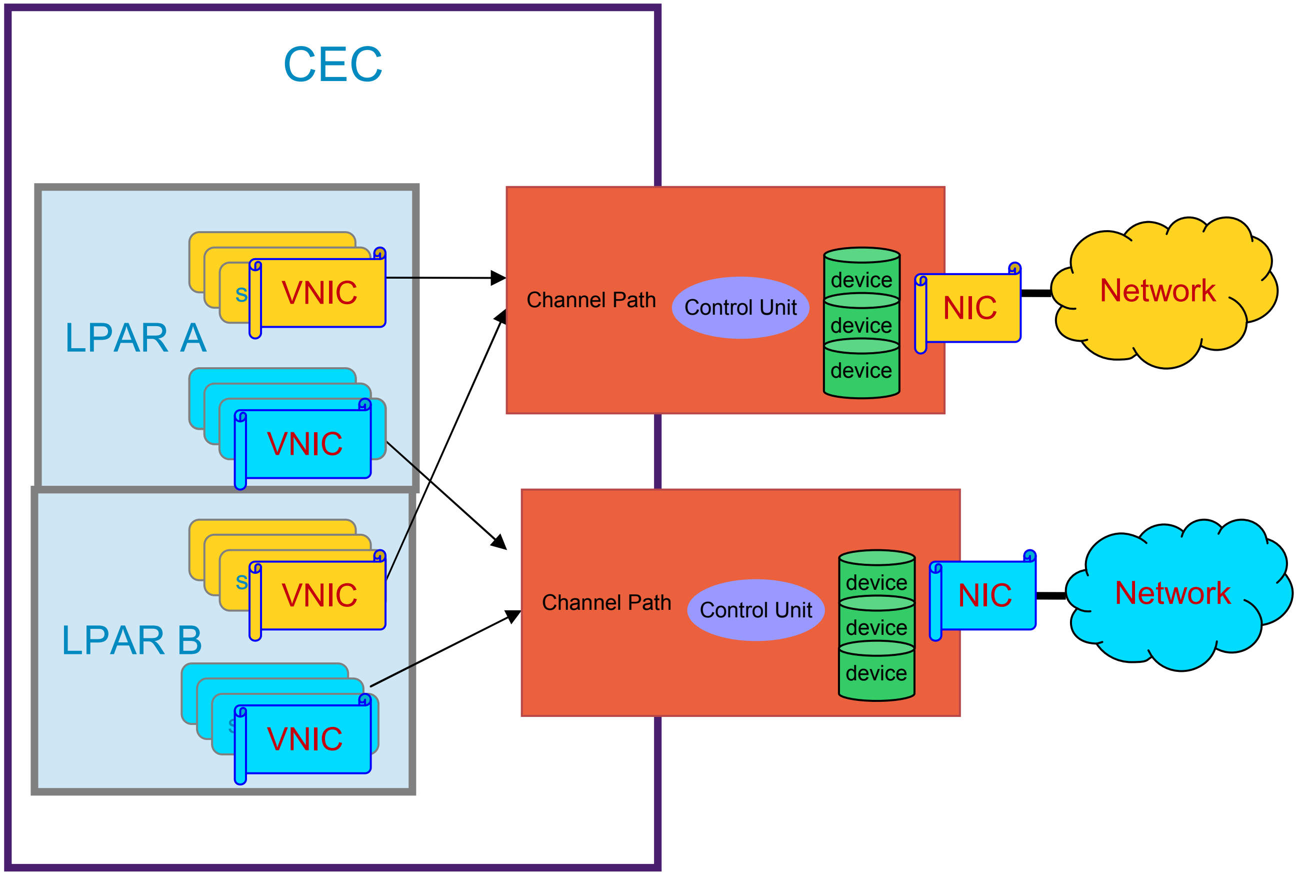
Network Channels



IOCDS:

```
CHPID PCHID=272,PATH=(CSS(0),72),TYPE=OSC,PART=(LP1, LP3)
CNTLUNIT CUNUMBR=272,PATH=(CSS(0),72),UNIT=OSA
IODEVICE ADDRESS=(2720,4),CUNUMBR=272,UNIT=OSA,UNITADD=00
```

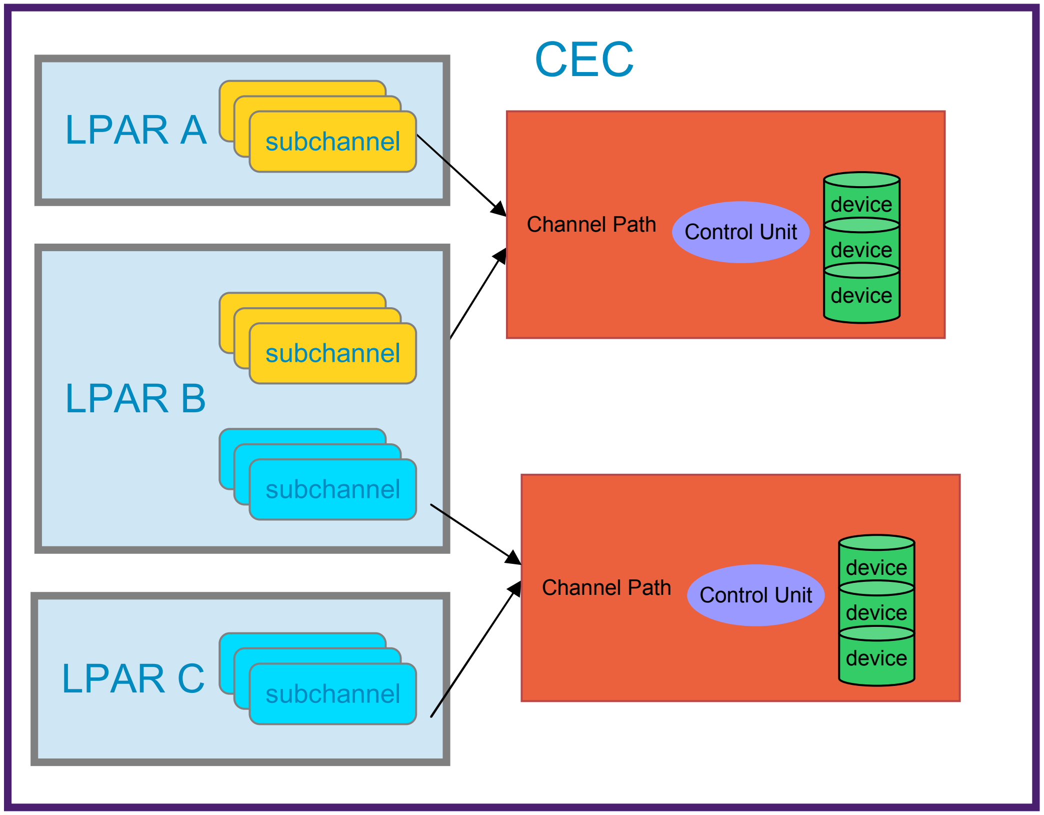
Network Channels



IOCDS:

```
CHPID PCHID=272,PATH=(CSS(0),72),TYPE=OSC,PART=(LP1, LP3)
CNTLUNIT CUNUMBR=272,PATH=(CSS(0),72),UNIT=OSA
IODEVICE ADDRESS=(2720,4),CUNUMBR=272,UNIT=OSA,UNITADD=00
```

HiperSockets Channels

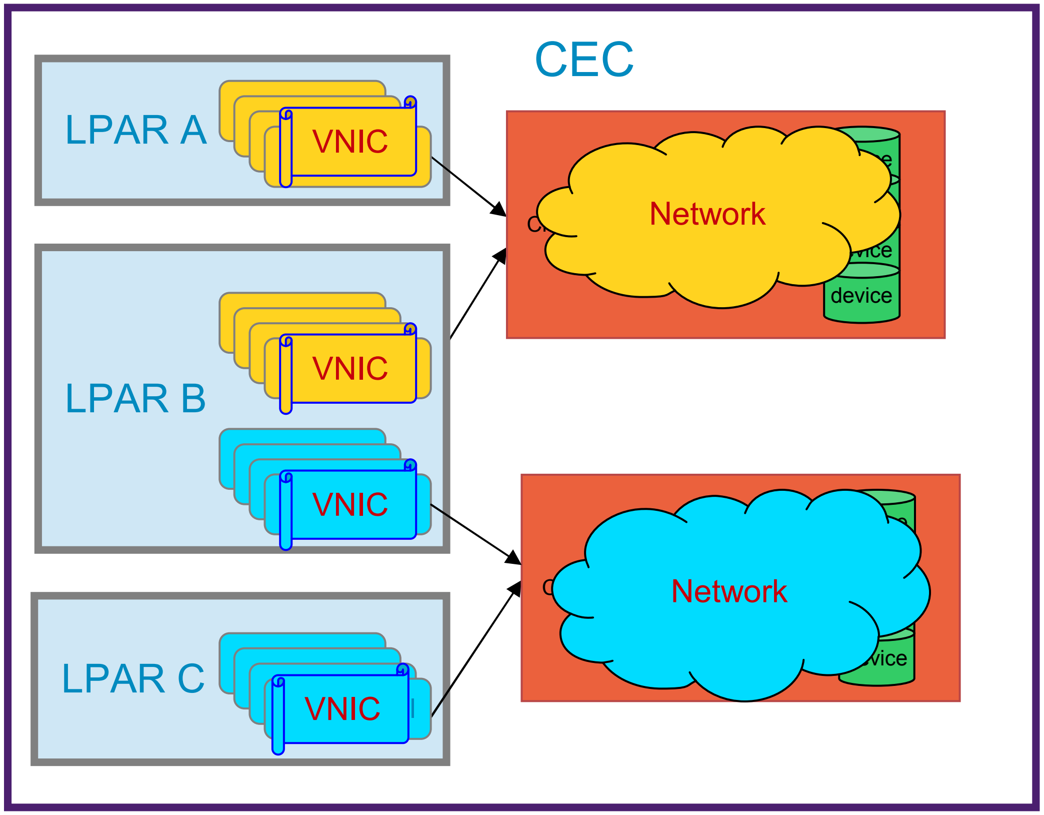


Maxima per CEC:
32 IQD CHPIDs
12 288 IQD subchannels

IOCDS:

```
CHPID PATH=(CSS(3),FA),TYPE=IQD,PART=(LP1, LP3),CHPARM=C0
CNTLUNIT CUNUMBR=FA,PATH=(CSS(3),FA),UNIT=IQD
IODEVICE ADDRESS=(FA00,16),CUNUMBR=FA,UNIT=IQD,UNITADD=00
```

HiperSockets Channels



Maxima per CEC:
32 IQD CHPIDs
12 288 IQD subchannels

IOCDS:

```
CHPID PATH=(CSS(3),FA),TYPE=IQD,PART=(LP1, LP3),CHPARM=C0
CNTLUNIT CUNUMBR=FA,PATH=(CSS(3),FA),UNIT=IQD
IODEVICE ADDRESS=(FA00,16),CUNUMBR=FA,UNIT=IQD,UNITADD=00
```

HiperSockets CHPARM

Maximum Frame Size / Maximum Transfer Unit:

CHPID Parameter	MFS	max. MTU
CHPARM=0x (default)	16kByte	8kByte
CHPARM=4x	24kByte	16kByte
CHPARM=8x	40kByte	32kByte
CHPARM=Cx	64kByte	56kByte

- Allows optimization per HiperSockets LAN for small packets versus large streams
- MFS == size of 1 Input buffer
- MTU defined for device driver <= max. MTU in CHPARM;
  device driver may put multiple frames in a HiperSockets message

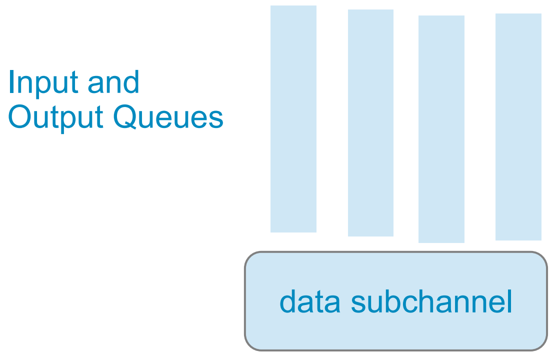
Channel flavor:

CHPID Parameter	usage
CHPARM=x0 (default)	traditional HiperSockets
CHPARM=x2	HiperSocktets for IEDN (IQDX)
CHPARM=x4	HiperSockets for External Bridge

QDIO architecture (history)

- **Queued Direct IO**
- Adapter accesses **Queues in customer memory** without using SSCH and CCW as in traditional IO
- Invented for OSA Ethernet adapters
- HiperSockets was modeled after OSA (**iQDIO: internal QDIO**)
- QDIO is also exploited by FCP
- VM GuestLAN and VM VSwitch emulate either OSA devices or HiperSockets devices

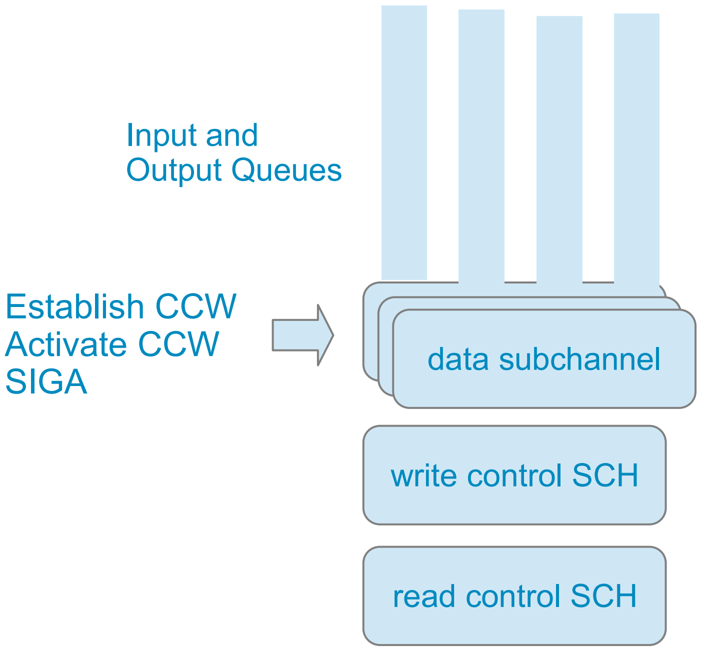
QDIO subchannels



- Establish CCW to data sch – links queues to subchannel
- Activate CCW to data sch – long running CCW
  - SCH status : active
  - HALT SCH / CLEAR SCH to de-activate subchannel
  - device end by Firmware in case of problems

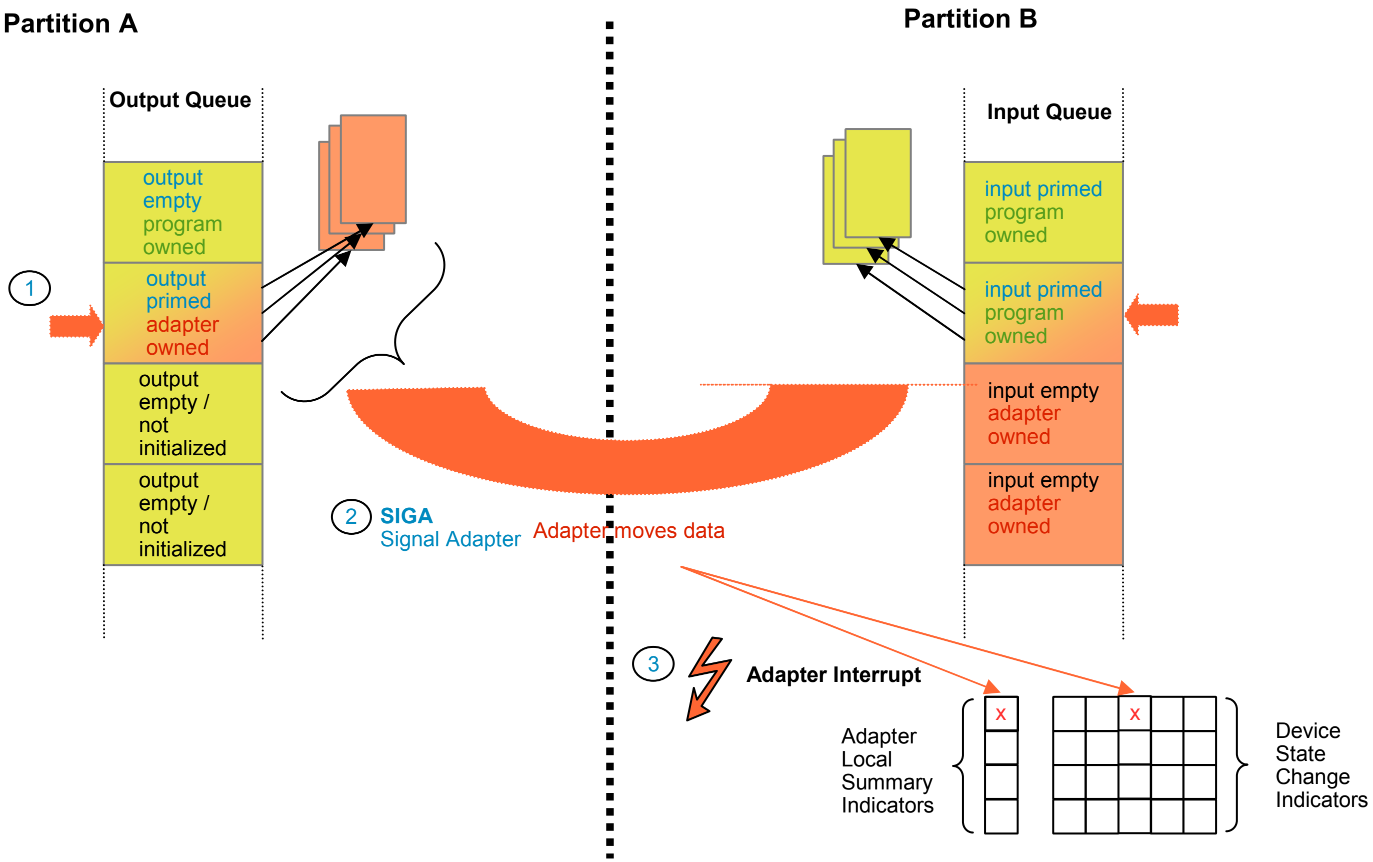
- Signal Adapter Opcode to trigger data transfer
- Adapter Interrupts to indicate reception of incoming data

QDIO subchannels - 2



- Write Control to send Control information to adapter
  - IP / MAC Address
  - VLAN information, etc...
- Read Control to receive responses / Control Information
- MPC group: 1 write control, 1 read control, 1-8 data
  - Linux: 1 data – MPC group: 3 subchannels => max 4k VNICs / CEC

QDIO architecture


Partition A
Partition B
Output Queue
output empty program owned
1
output primed adapter owned
output empty / not initialized
output empty / not initialized
Input Queue
input primed program owned
input primed program owned
input empty adapter owned
input empty adapter owned
2
SIGA
Signal Adapter
Adapter moves data
3
Adapter Interrupt
x
x
Adapter Local Summary Indicators
Device State Change Indicators

- HiperSockets SIGA is synchronous!!
  Sending CPU is moving the data inside SIGA operation !!

Performance example

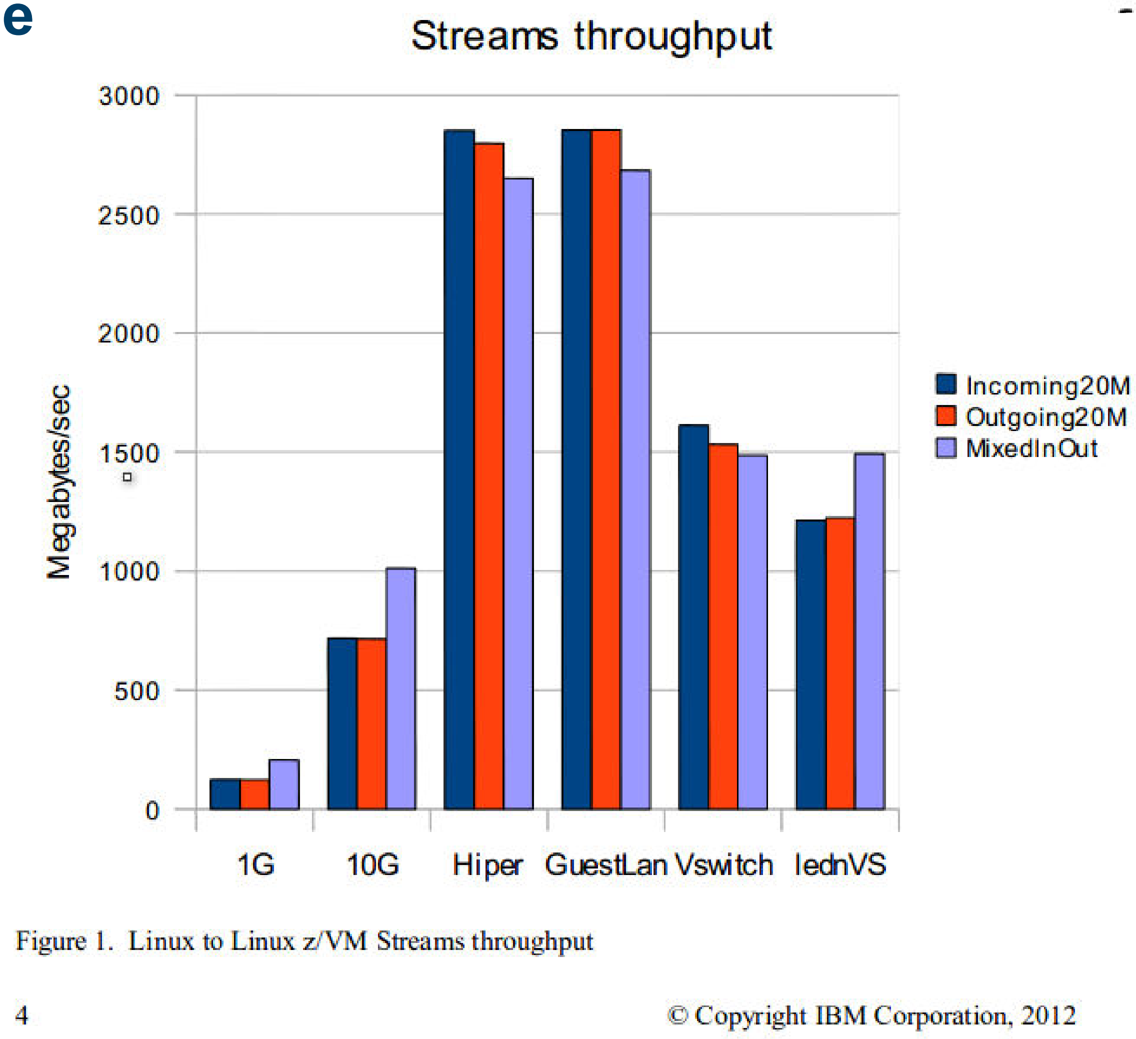


Figure 1. Linux to Linux z/VM Streams throughput

4

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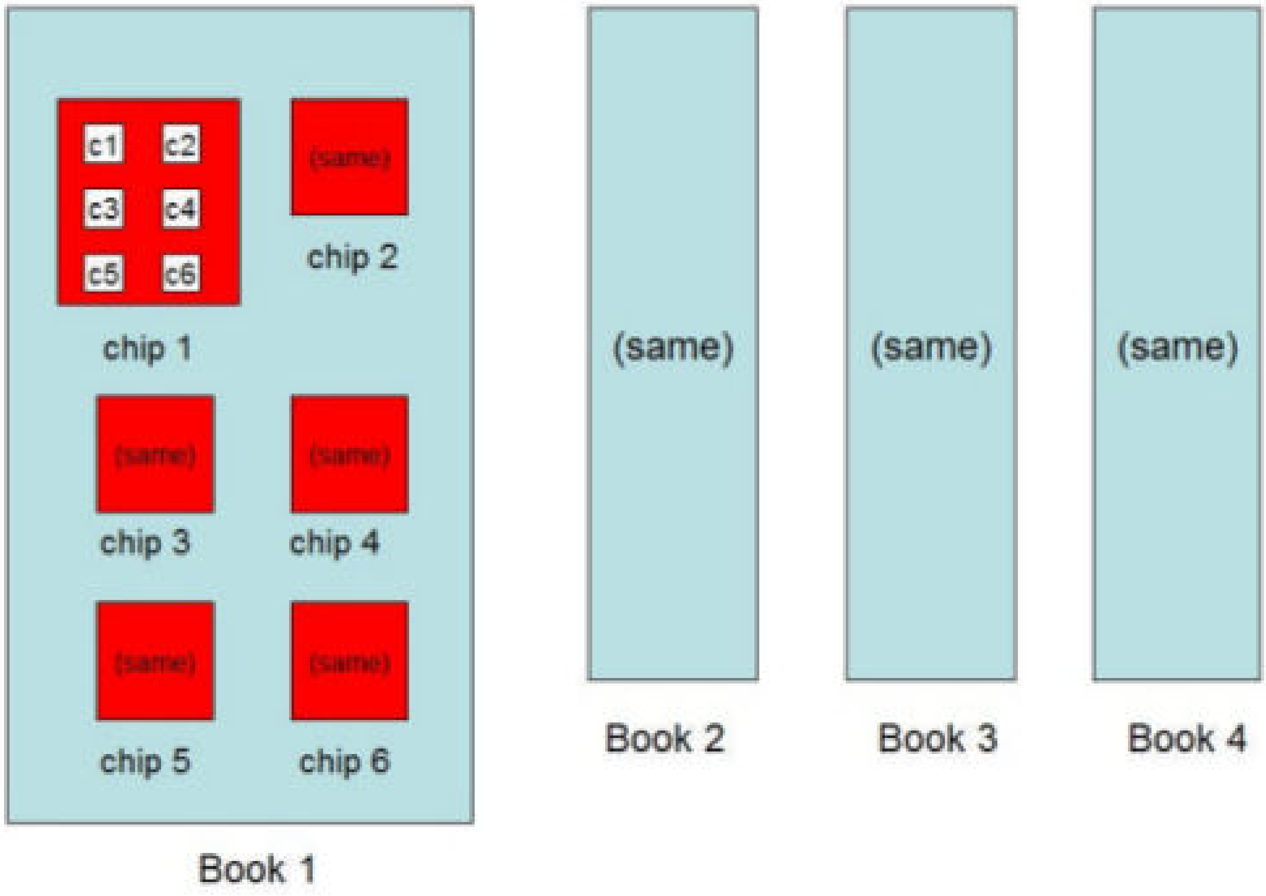
- Source: IBM Techdocs - A Study of Network Performance on the IBM System z196 http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102175

Performance

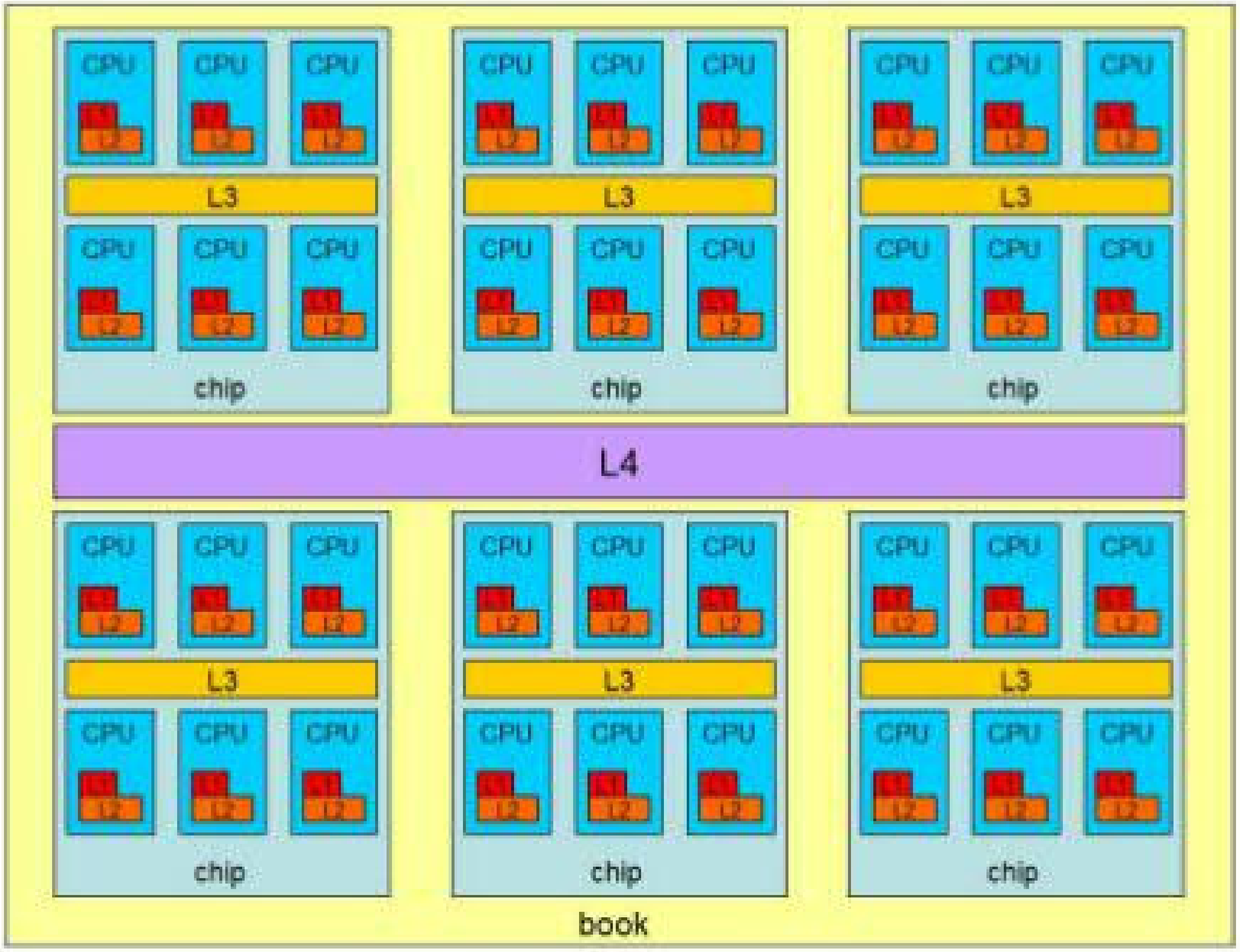
- **synchronous memory moves**
  - very **low latency**
  - **high throughput** for large data
  - throughput for small packets is more restricted by SW path length
- What influences HiperSockets performance?
  - **available CPU** processing power (number, sharing rate, ..)
  - HW model (sub-capacity CPs do not reduce Firmware performance)
  - physical structure of memory (1 book vs multiple books, cache effects)
  - MTU size for streaming (→ memory consumption for input queues)
  - **input buffer count** (→ memory consumption for input queues)
  - software settings (TCP/IP buffer size, number of sessions, scheduling, memory management, ..)

IBM System z CPU–Chip-Book Relationship



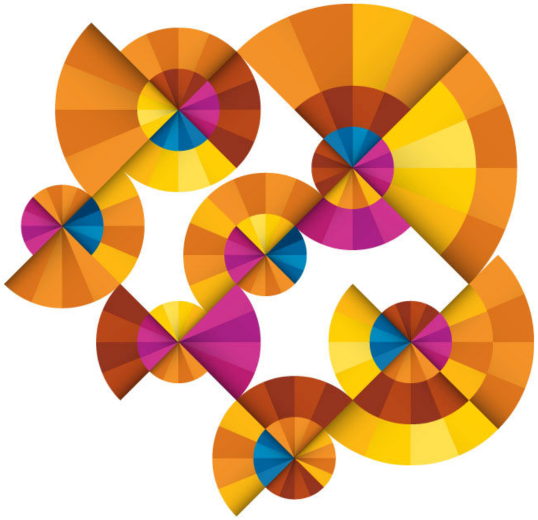
Drawing by B. Wade zVM development

IBM System z Cache Layering



Drawing by B. Wade zVM development

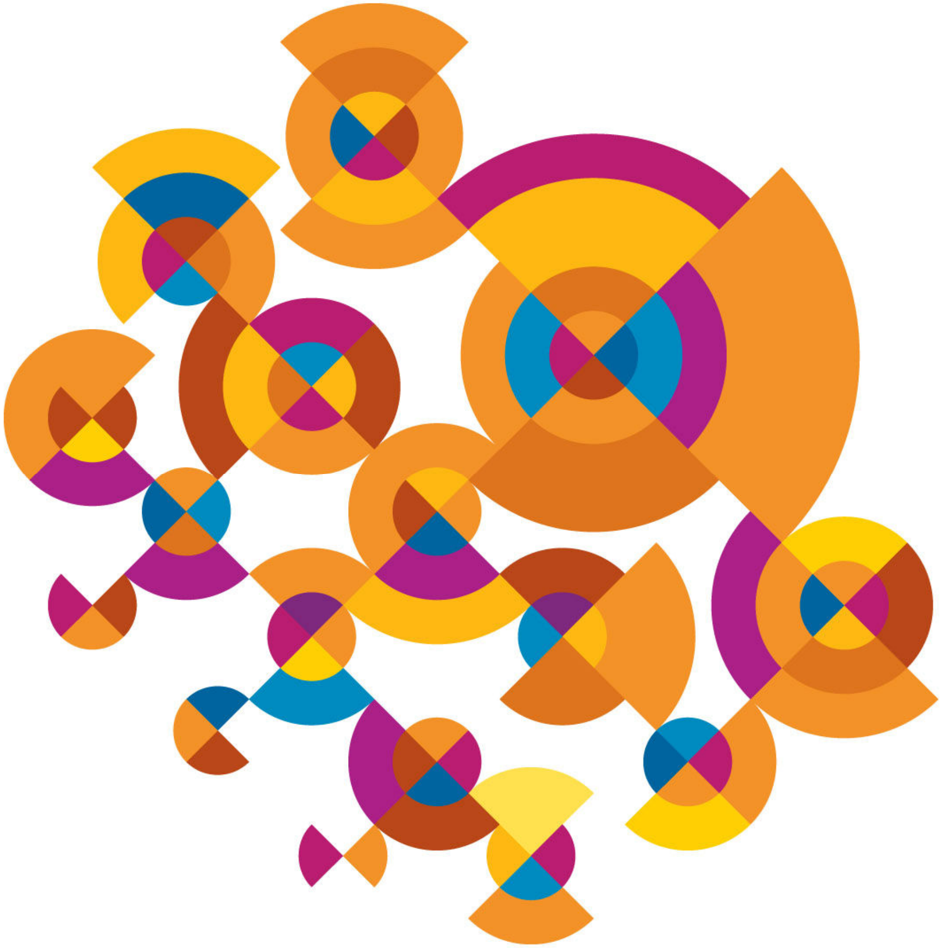
Why HiperSockets?



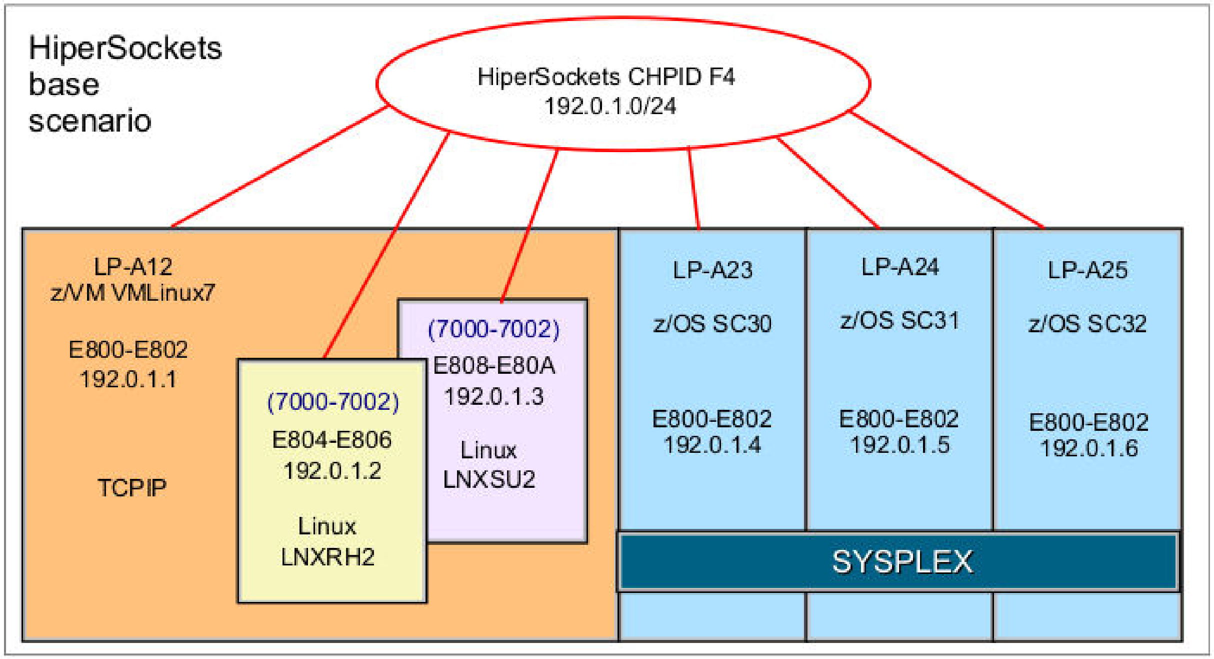
- **Performance**
  - low latency
  - high throughput
- **No hardware required**
  - **Flexibility**
    - no re-cabling for network configuration changes
  - OSA bandwidth fully available for external traffic
  - **Security**
    - no wires or external components
    - no encryption required (→ performance)
  - **Reliability**
    - no mechanical parts

HiperSockets Features and functions

- What is available to you?
- What is new?



Dedicated QDIO devices for VM guests



Source: HiperSockets Implementation Guide www.redbooks.ibm.com

- **QDIO ASSIST / QEBSM**
  (also for OSA, FCP)
- interface definition with VM Hipervisor
  - (1:1 mapping of virtual devices to real devices)
- support in guest OS required
  - available in zLinux and zVSE
- direct pass-through for data transfer, without interception to the VM Hipervisor
- delivery of interrupts to the VM guest without interception to the VM Hipervisor

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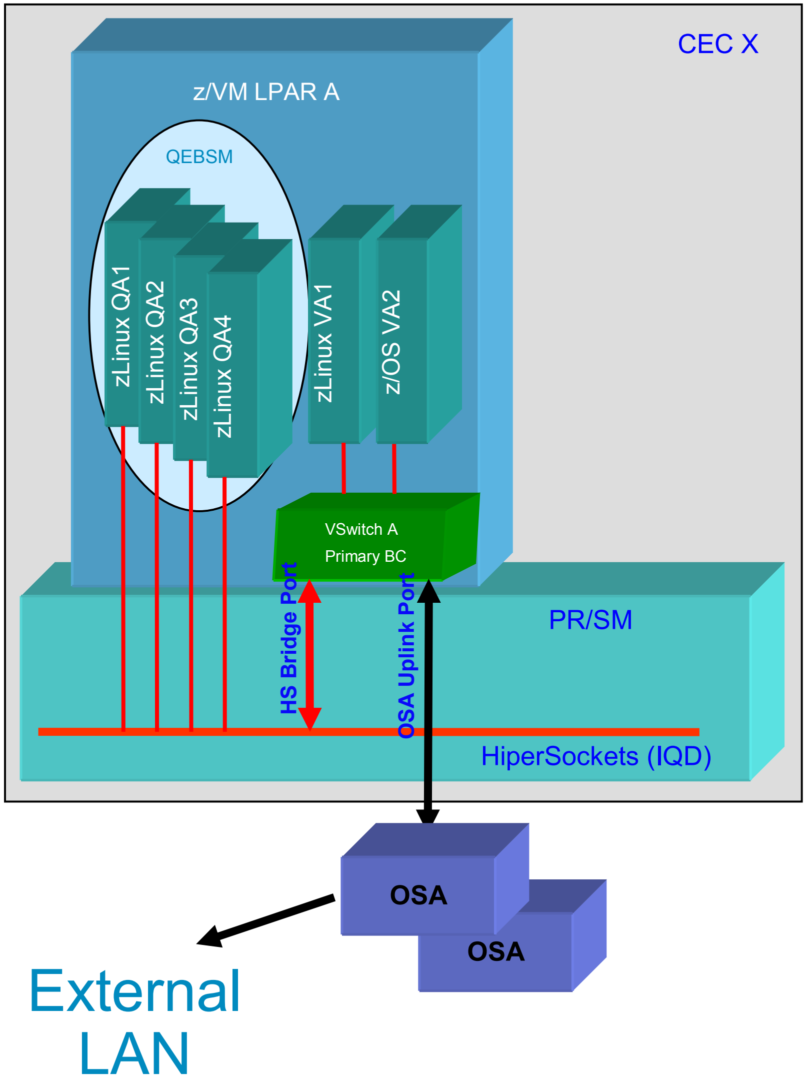
Layer 3 versus Layer 2

- A HiperSockets VNIC can be defined by the device driver either as
  - **Layer 2** device (MAC addressing, ethernet frames) or as
  - **Layer 3** device (IPv4 or IPv6)
- L2 and L3 devices can be defined on the same channel, but cannot communicate with each other!
- Only L2 devices can be activated on IQDX / IEDN and External Bridge Channels

Miscalleaneous features

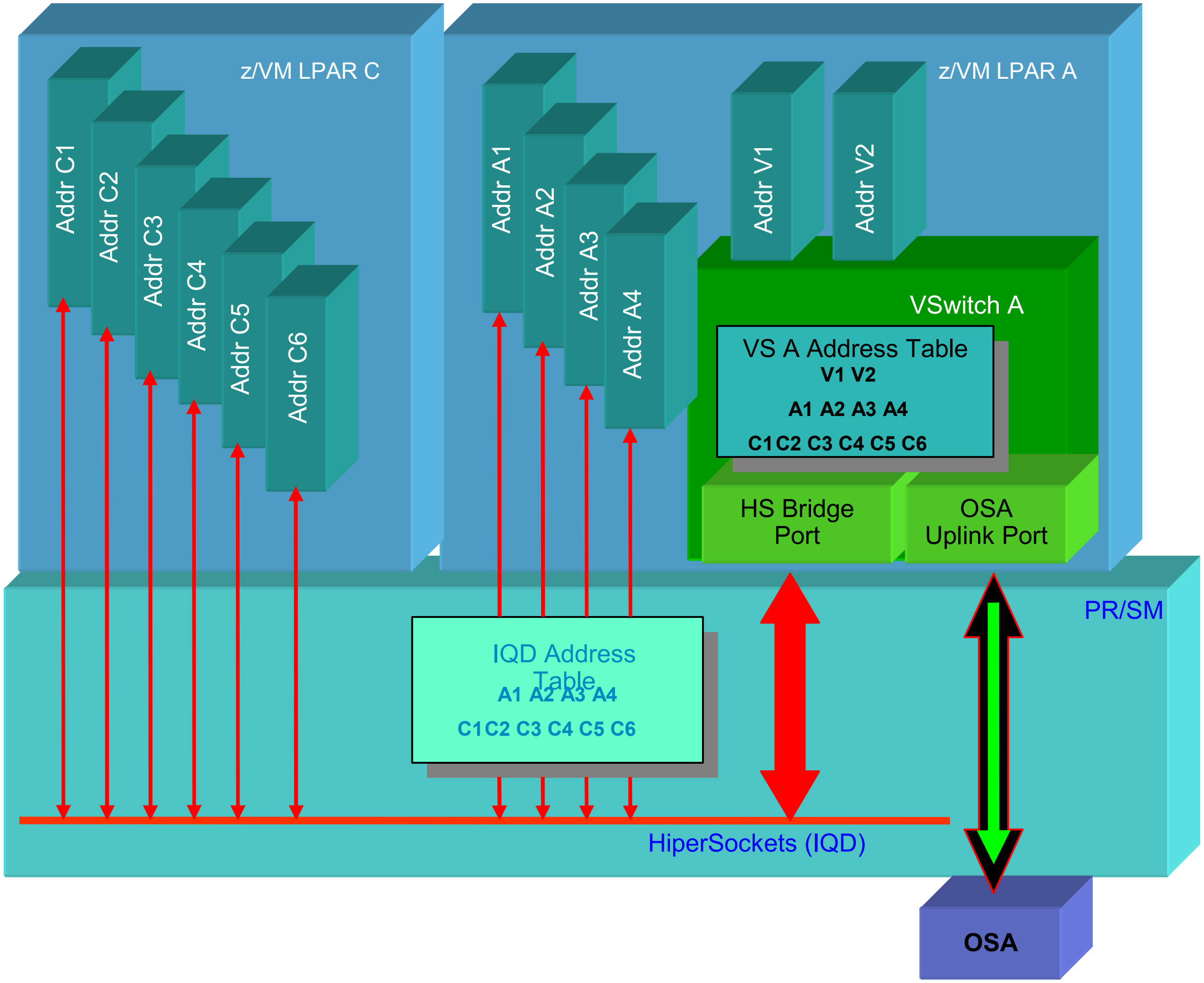
- **MULTIWRITE**
  - exploited by z/OS, send multiple output buffers in one SIGA
- **Network Traffic Analyzer**
  - set one IQD VNIC in 'promiscuos mode' and get a copy of all traffic on this channel
  - Authorization and 'filtering' on SE required
    - Which LPAR is authorized to run a NTA?
    - Traffic between which LPARs will be sniffed?
  - Linux exploitation for `tcpdump` is available
  - (see ZSQ03039USEN white paper)
- **VLAN**
  - VLAN support available
  - device driver defines which VLAN this device is allowed to use
  - out-of-band VLAN management only for IQDX (zManager)
- **Network concentrator**
  - Linux tool to connect L3 IPv4 HiperSockets to external network
  - see “Linux on System z, Device Drivers, Features, and Commands” www.ibm.com/developerworks
  - see also VM Bridge

z/VM vSwitch HS Bridge (z196)



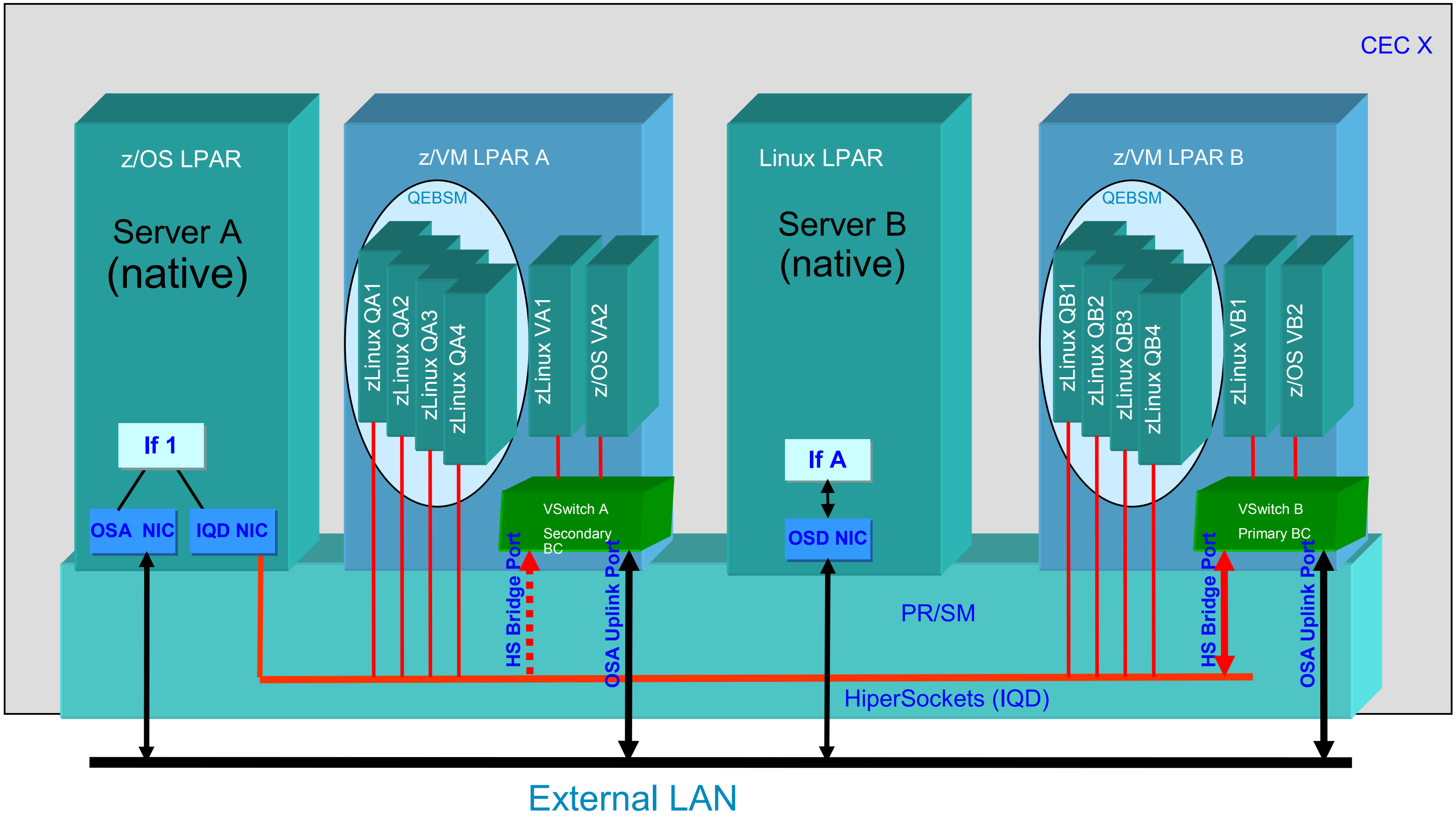
- No transport mode conversions
  - The z/VM VSwitch and HS must be operating in **layer 2**
- Supports both **IEDN** and **External Bridged** IQD channel customer networks
- Only traffic to/from QEBSM VNICs will flow over the bridge
- Guests QA1,QA2, QA3 and QA4 have real (*dedicated*) QEBSM connections to HS CHPID.
  - Optimum performance config requiring almost no z/VM involvement
  - Bridged by default (Connectivity to HS and external LAN segments0
- Guests VA1 and VA2 have virtual (NIC) connections through VSwitch A
  - Optimum performance config for guests that are not deployed with QEBSM on z/VM. Eliminates "shadow" queue overhead
  - Connectivity to HS and external LAN segments
- OSA uplink port BAU no changes is current support

z/VM VvSwitch HS Bridge Port - 2



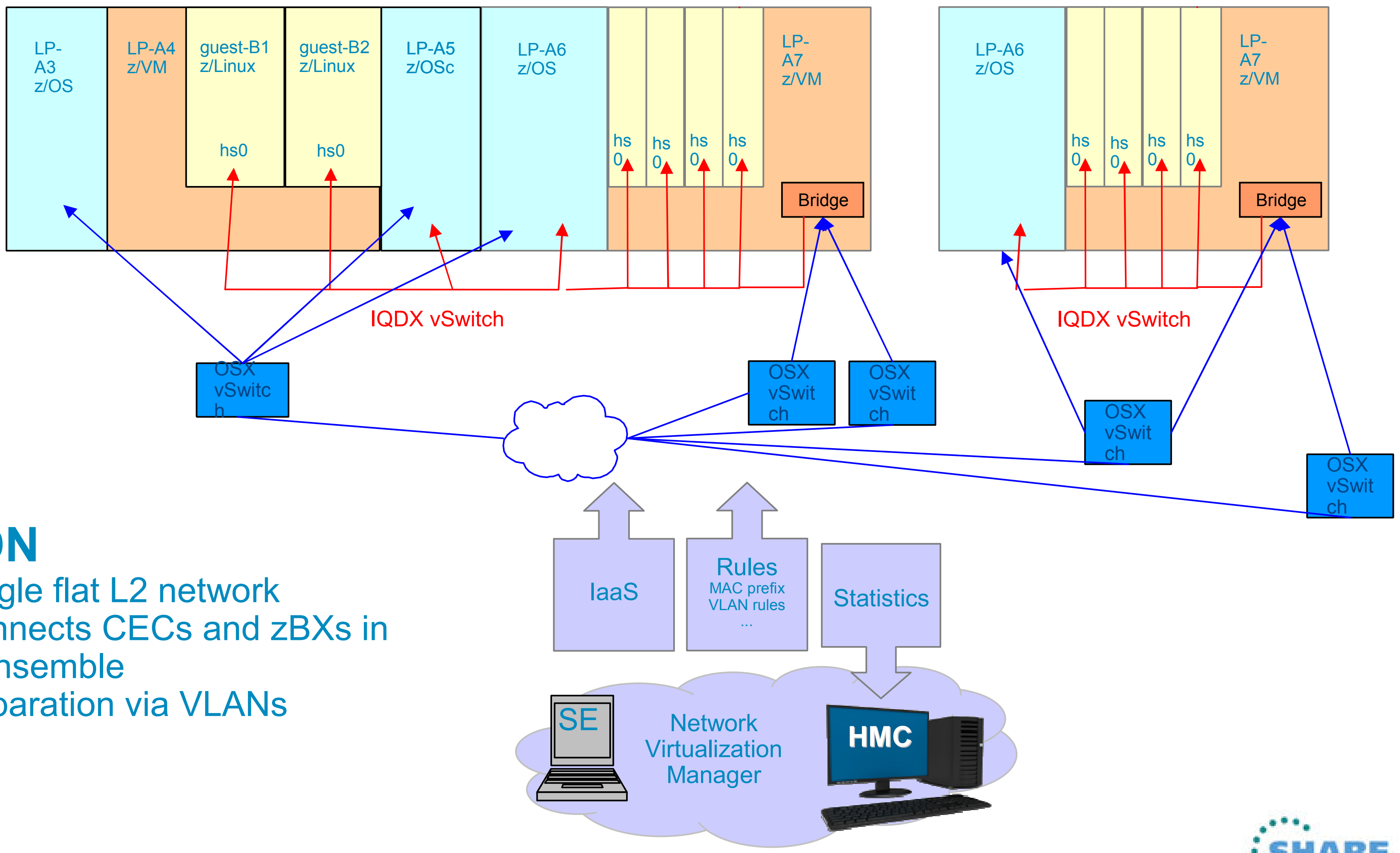
- VSwitch A provides bridging service for both LPARs
- Bridgeable servers may be added or removed dynamically
- HS keeps z/VM VSwitch A bridge in synch through asynchronous table entry updates
- z/VM VSwitch keeps OSA in synch with LAN residency

z/VM Vswitch HS Bridge Failover Configuration



- One active bridge port per IQD channel; max of 1 primary and 4 secondary
- native LPARs are not bridged
- z/OS uses concept of converged devices (IEDN only)

System z Network Virtualization Manager (z196)



IEDN

- single flat L2 network
- connects CECs and zBXs in an ensemble
- separation via VLANs

IEDN / IQDX

- Only 1 IQDX channel per CEC
- Layer 2 only
- VLAN mandatory
- Bridged via VM bridges to OSX (Linux as VM guest) or

merged interface with OSX VNIC (z/OS)

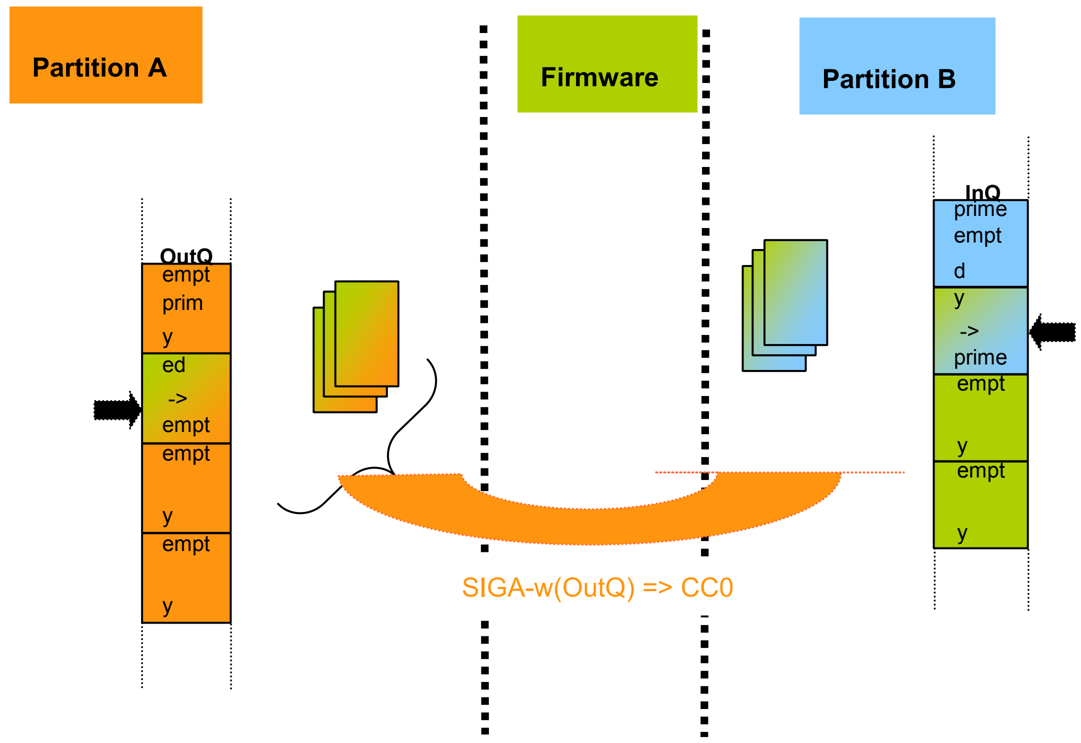
- Managed by Network Virtualization Manager (NVM) component of zManager / URM
  - MAC address management (prefix)
  - VLAN management
  - Monitoring
  - definition of VM bridges to OSX / IEDN

Completion Queues (z196)

- HiperSockets messages are sent **synchronously, in-order and reliably**
- if the target has no free input buffers, bad return code is delivered to the sender
- sender can retry, but does not know when new target buffers are available
- performance impact!
- OSA has the capability to buffer 512 packets. In a high sharing environment OSA may perform better than Hipersockets, packet buffering may be a reason.

- **Completion queues:**
  - **deliver synchronously if possible, asynchronously if necessary**
  - messages remain at sender
  - when target provides free input buffers, messages are delivered and completion messages are reported to sender

SIGA-w with normal completion (CC0)



Partition A

Firmware

Partition B

OutQ

empt
prim
y

ed
->
empt

empt
y

empt
y

InQ

prime
empt
d

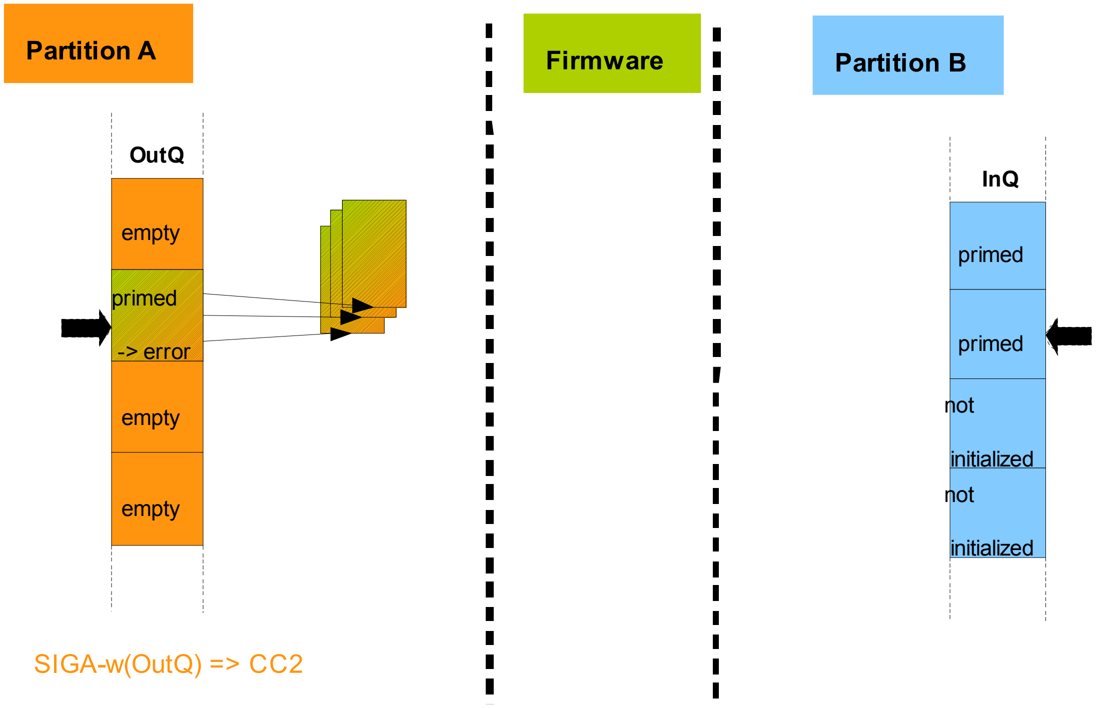
y
->
prime

empt
y

empt
y

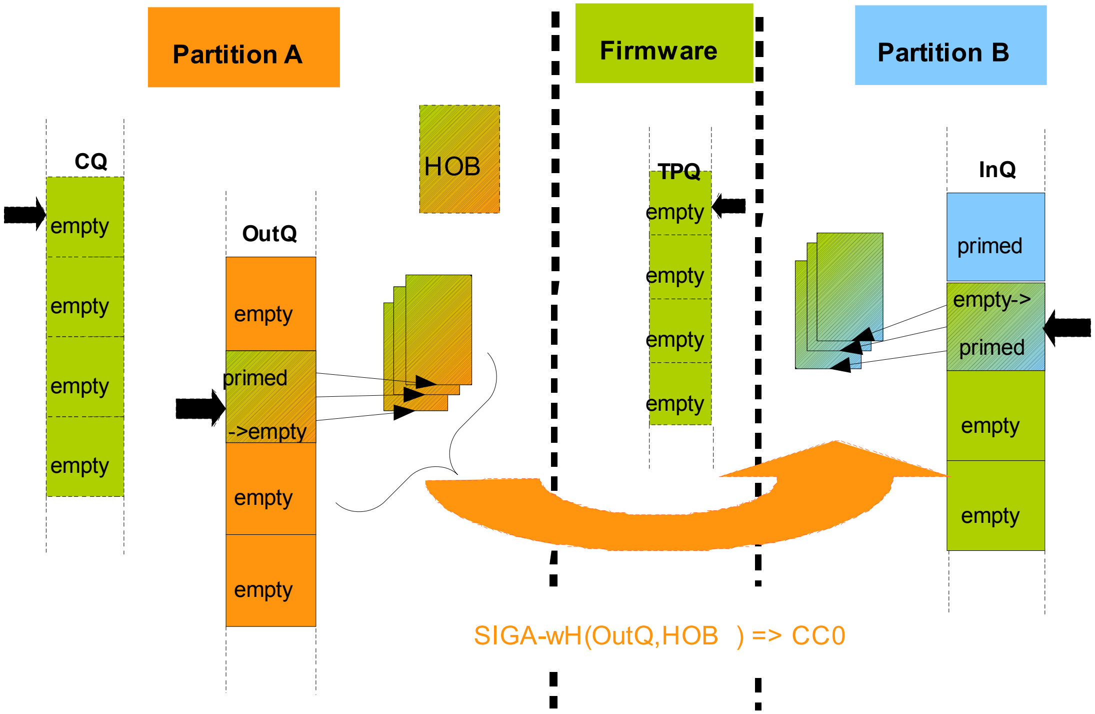
SIGA-w(OutQ) => CC0

SIGA-w with target Q full (CC2)



SIGA-w(OutQ) => CC2

SIGA-wq good case (CC0)



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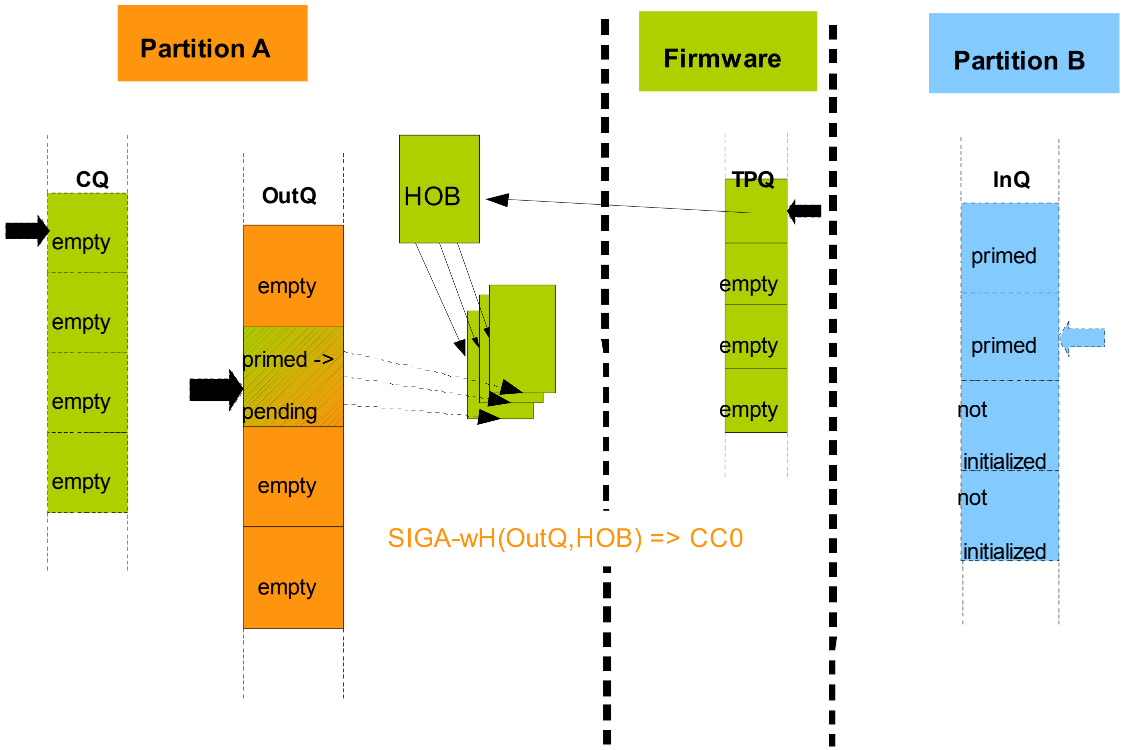
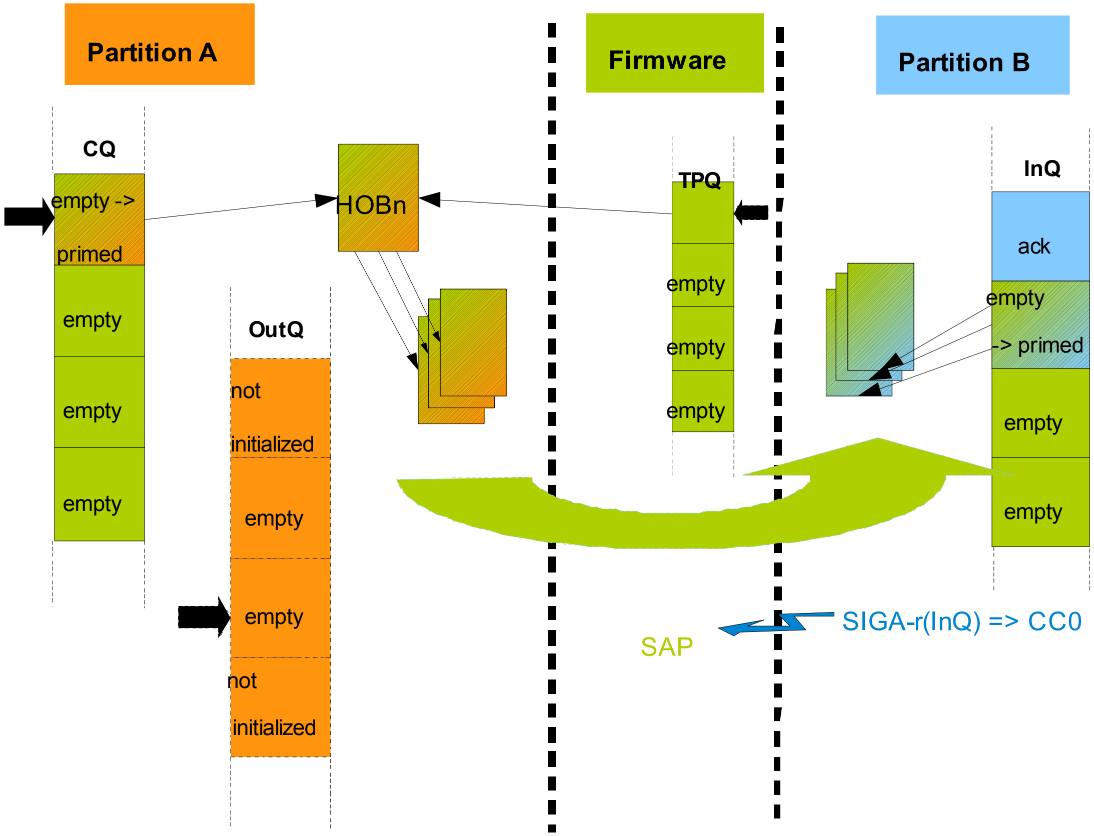
SIGA-wq with target queue full –> pending state

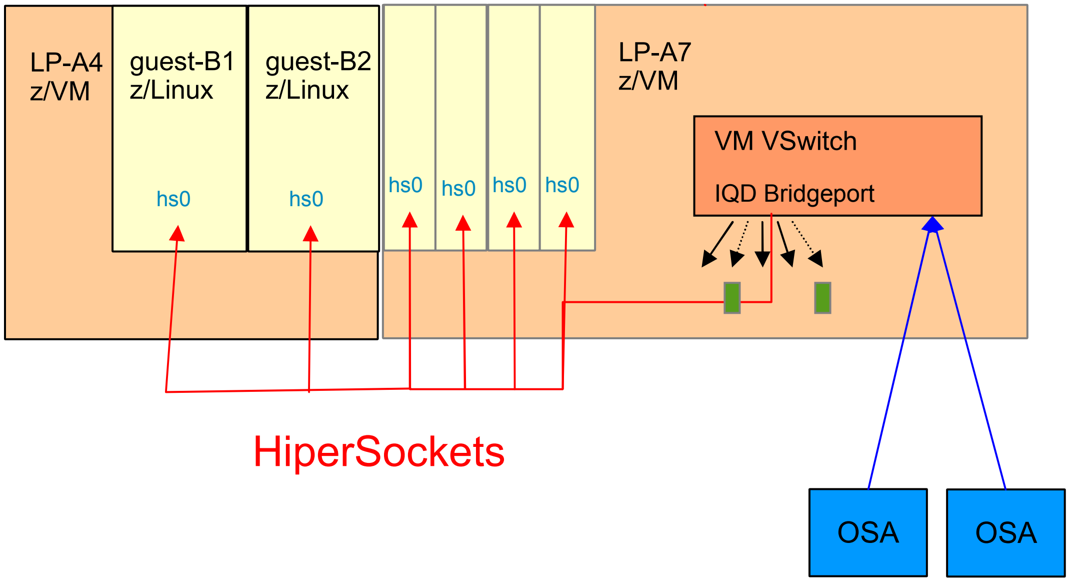


SIGA-r with pending data



Completion Queue exploitation

- exploitation possible per server
  only sender needs support
- amount of buffered messages counted by **Resource Measurement Facility (RMF)** and **NVM Monitoring** as 'unavailable receive buffers'
- exploited today by **VM bridge ports**



More information

- www.ibm.com/developerworks
  - “Linux on System z, Device Drivers, Features, and Commands”
- IBM Redbooks
  - http://www.redbooks.ibm.com
  - – HiperSockets Implementation Guide, SG24-6816
  - – IBM System z Connectivity Handbook, SG24-5444
  - – I/O Configuration Using z/OS HCD and HCM, SG24-7804
  - – Building an Ensemble Using Unified Resource Manager, SG24-7921
- System z HiperSockets web page:
  - http://www.ibm.com/systems/z/hardware/networking/products.html
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  - http://www.ibm.com/support/techdocs
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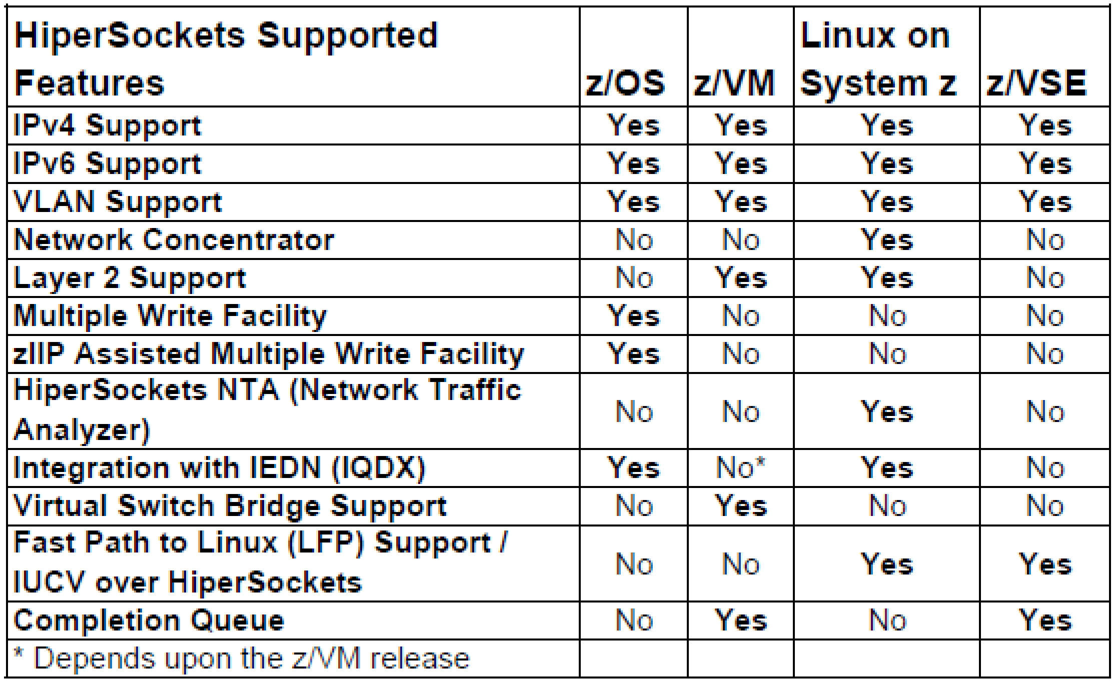

HiperSockets Supported Features	z/OS	z/VM	Linux on System z	z/VSE
IPv4 Support	Yes	Yes	Yes	Yes
IPv6 Support	Yes	Yes	Yes	Yes
VLAN Support	Yes	Yes	Yes	Yes
Network Concentrator	No	No	Yes	No
Layer 2 Support	No	Yes	Yes	No
Multiple Write Facility	Yes	No	No	No
zIIP Assisted Multiple Write Facility	Yes	No	No	No
HiperSockets NTA (Network Traffic Analyzer)	No	No	Yes	No
Integration with IEDN (IQDX)	Yes	No*	Yes	No
Virtual Switch Bridge Support	No	Yes	No	No
Fast Path to Linux (LFP) Support / IUCV over HiperSockets	No	No	Yes	Yes
Completion Queue	No	Yes	No	Yes
* Depends upon the z/VM release				

THANK YOU