# Virtualization Basics

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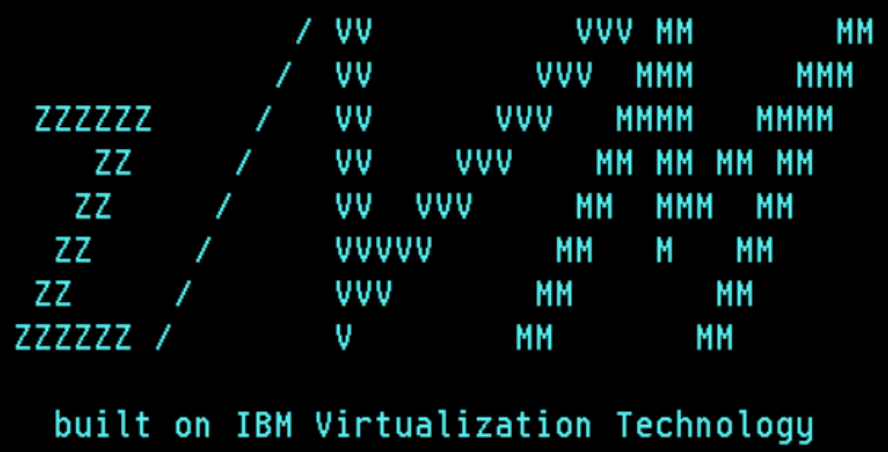
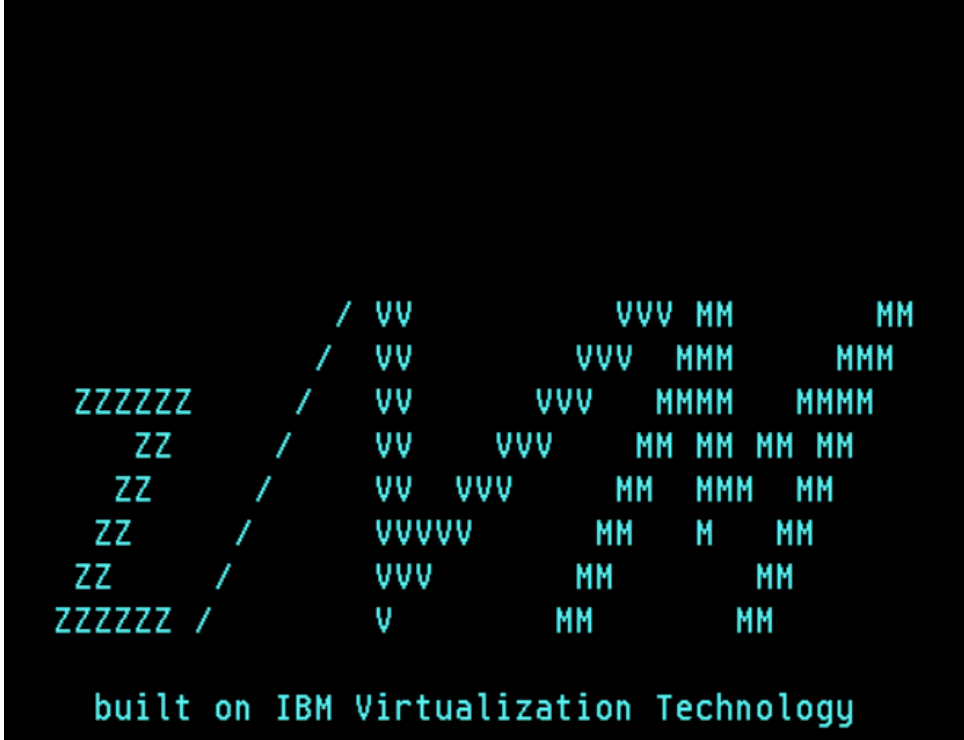


# Agenda:

Virtualization (As told from the view of z/VM)
- What is it
- A brief history
- How it's used today

What is a virtual machine?
Introduction to basic concepts
- Processor, Memory, I/O, etc...

Overcommitment of resources
How do you build z/VM?
Dynamic resource management
Monitoring your system
What happens when things go wrong?



# IBM Z Nomenclature

Level Set 

| Intel, System p, etc. | IBM Z |
|---|---|
| Memory | Storage (central storage) |
| Disk<br>Storage | DASD (Direct Access Storage Device)<br>FCP (Fibre Channel Protocol) |
| Computer<br>Host<br>System | CEC (Central Electronics Complex)<br>CPC (Central Processor Complex)<br>Server |
| Socket<br>Slot | Book, drawer or node |
| Chip (e.g., multiple cores on a chip) | Core (e.g., multiple processors on a core) |
| CPU<br>GPU<br>Processor<br>Core<br>HT Core | Processor or Engine<br>CPU or PU<br>CP (Central Processor)<br>IFL (Integrated Facility for Linux)<br>zIIP (zSeries Integrated Information Processor)<br>ICF (Integrated Coupling Feature)<br>SAP (System Assist Processor)<br>IOP (I/O Processor) |
| Boot | IPL (initial program load) |

# Why Virtualize?

# Why Virtualize?

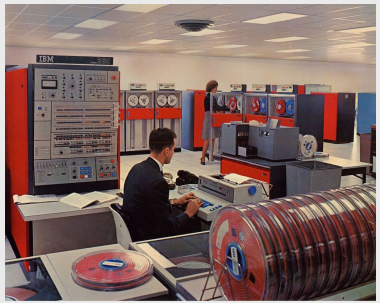
**Virtualization** is the creation of substitutes for real resources.

Benefits:

- **Consolidation** of physical resources reduces hardware cost
- **Optimization** of workloads that run near each other
- IT **flexibility** and responsiveness – make changes without  a hardware outage!

# Are we there yet?

| 1964 | 1972 | 1984 | 2001 | 2013 |
| --- | --- | --- | --- | --- |
| CP-40 development begun, this will be the predecessor of today's z/VM. | In 1972, VM/370 is launched, the first in the VM product line from IBM. | In 1984, Amdahl introduces MDF (multiple domain feature) to partition the real device into several separate machines. IBM releases LPAR technology in 1988 | VMware ESX Server is launched, marking the start of a new wave of virtualization. z/VM, the latest version of the VM operating system, debuted in 2000. | The first release of Docker, a containerization technology, released to open source. |

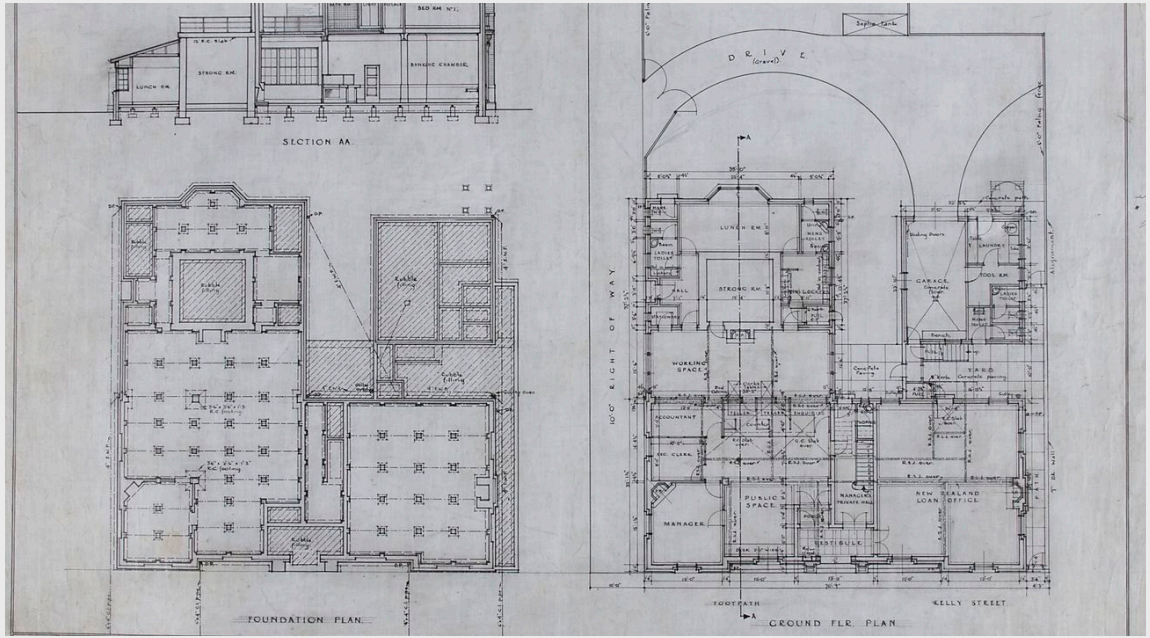


docker


Businesses continue to prize flexibility, portability and openness as they develop new applications and delve into piles of data.
The future is bright for virtualization.

# What are we virtualizing? z/Architecture

- Every computer system has an **architecture**
  - It's the specs for how to build software on the system
  - Defined in z/Architecture Principles of Operation
  - z/VM must both **follow** and **implement** z/Architecture



# What does virtualization mean on IBM Z?

z/VM allows the **sharing** of the mainframe's physical resources such as

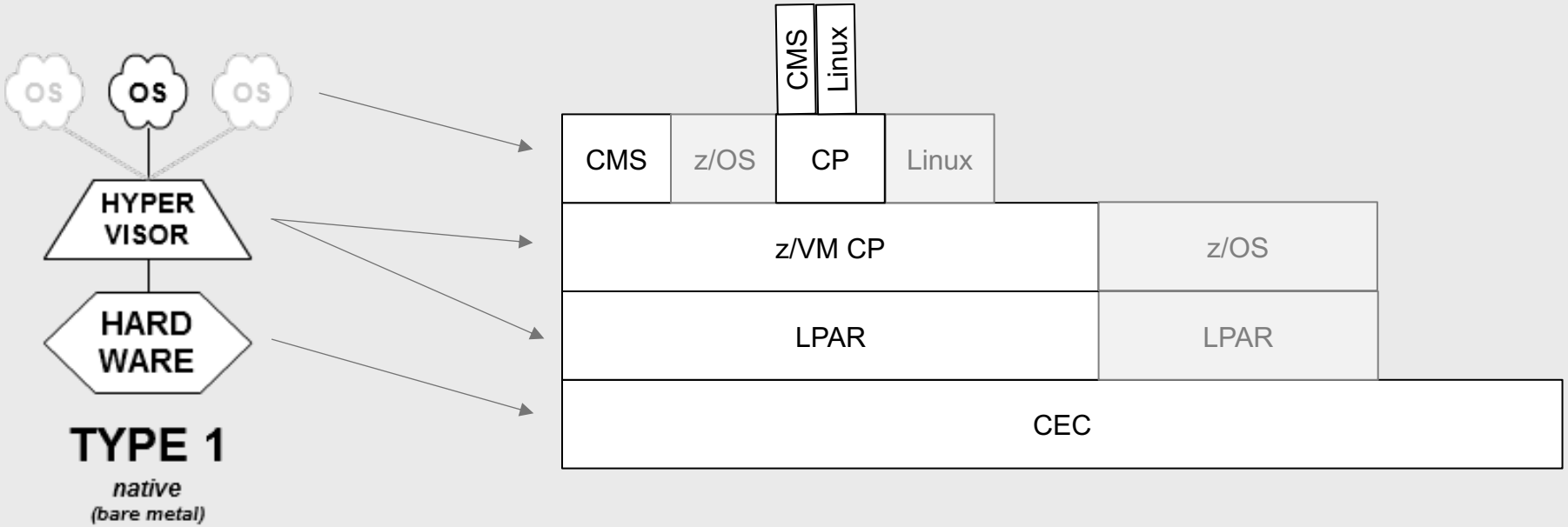
- Disk
- Memory
- Network adapters
- CPUs

These resources are managed by a **hypervisor**.

Virtualization enables four fundamental capabilities:

- resource sharing
- resource aggregation
- emulation of function
- insulation

# What does Virtualization look like on IBM Z?



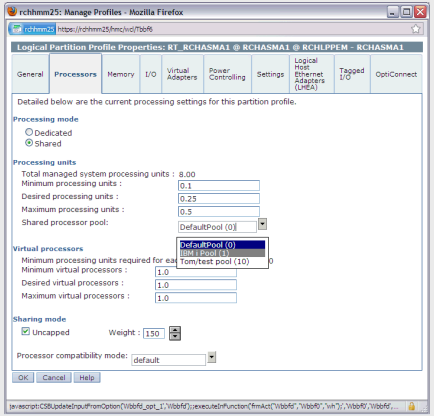
# Real, Logical, & Virtual

Level Set

**It's important that everyone understands which view YOU are talking about!**

What the accounting team sees
**(REAL)**

What the system programmer sees
**(LOGICAL)**




What the application developer sees
**(VIRTUAL)**

# Why z/VM?


z/VM has an awesome **community**.

World-class **clustering** and **mobility**, allowing virtual machines to move to new hardware without an outage.

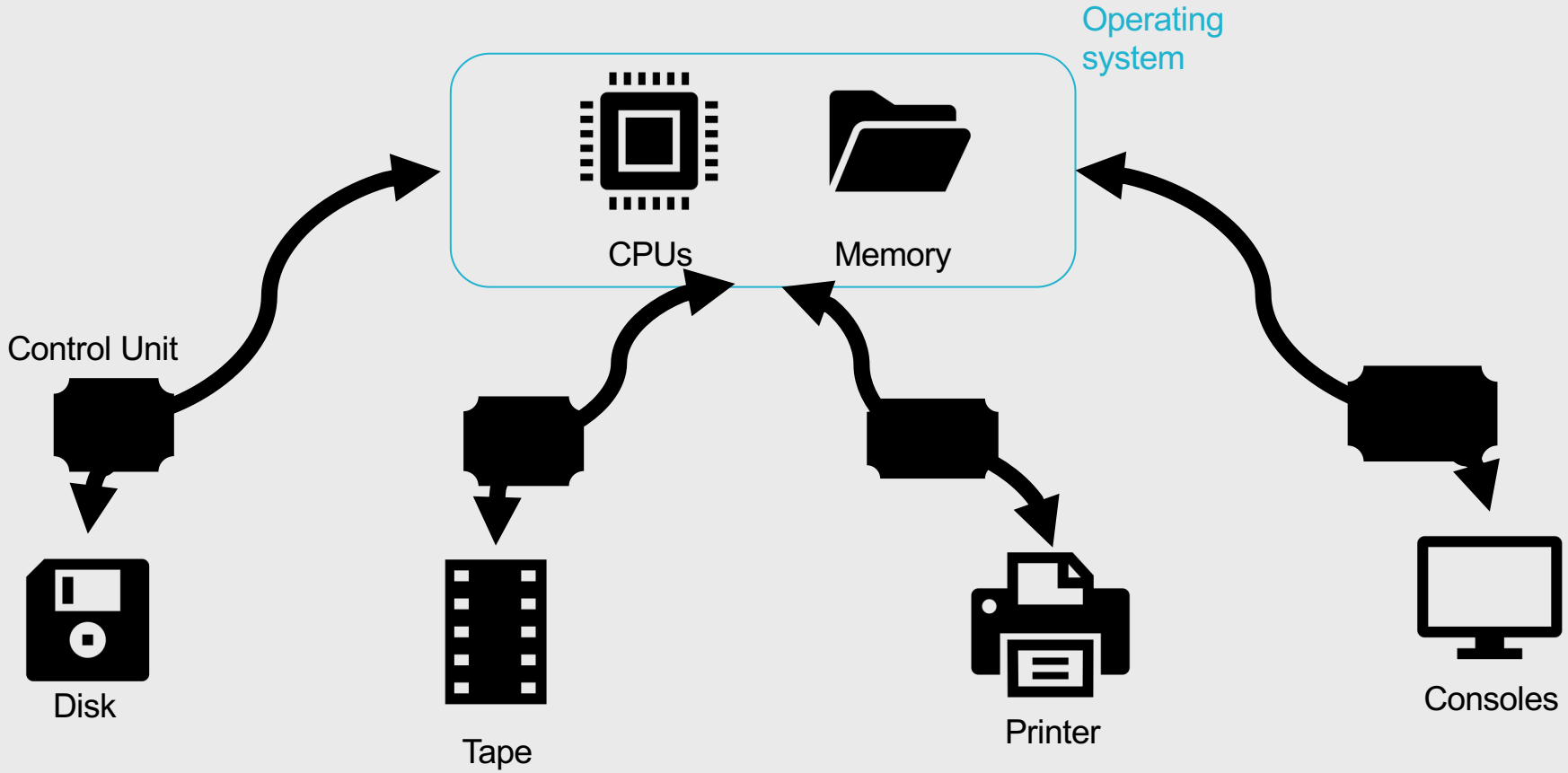
**Scale** – not just large machines, but fully utilized large machines

Resource **management** facilities for large and diverse workloads.

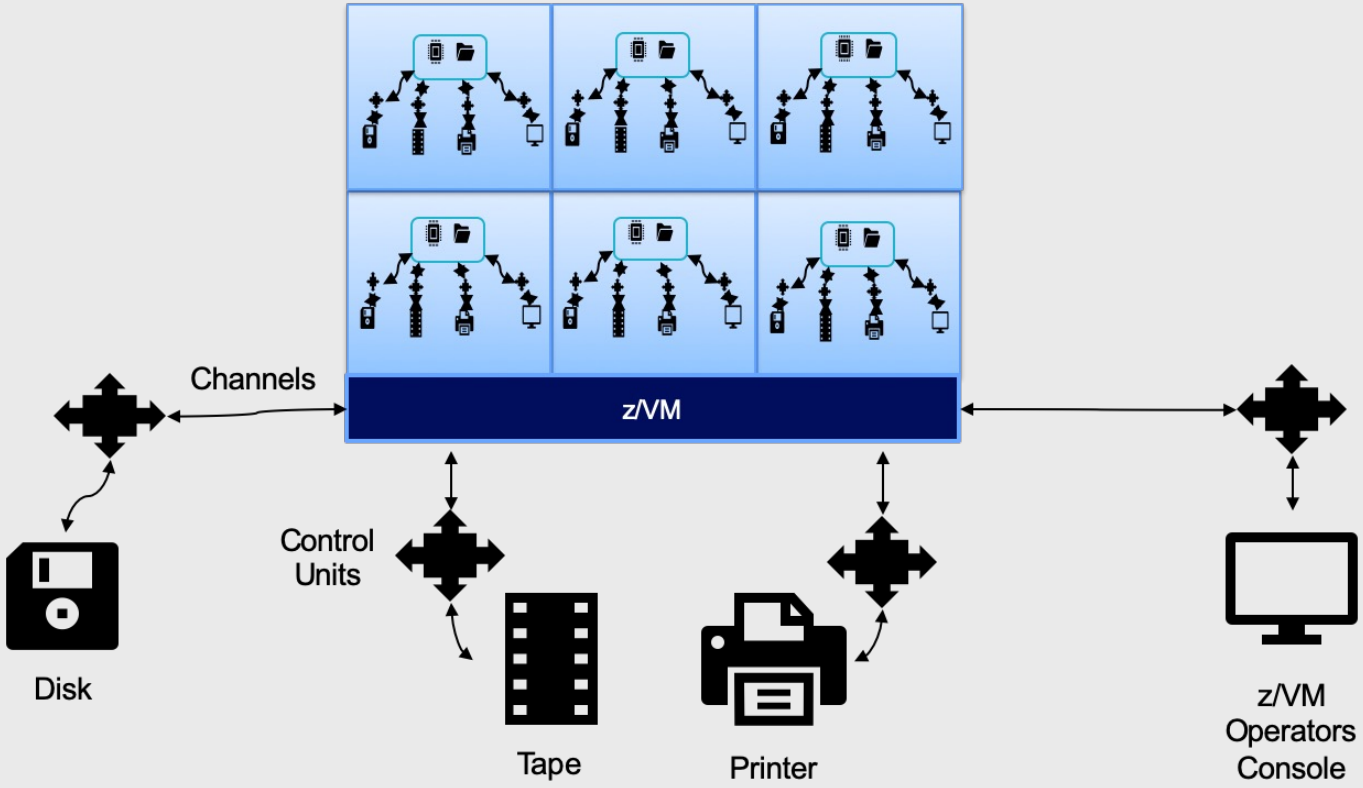
IBM has the **entire IBM Z stack**, with special assists that bring the hardware and software closer together.

# Virtual Machines

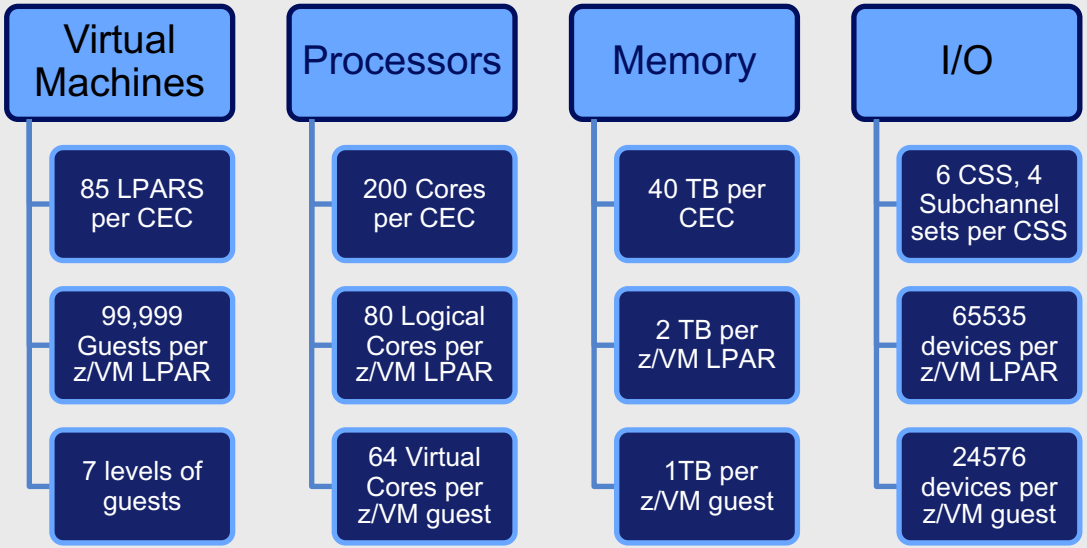
# Just like the real thing, we have



# Just lots of them!

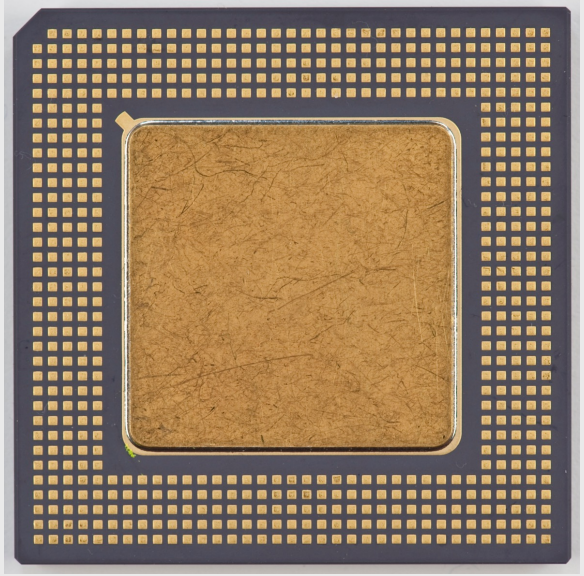


# Testing the Limits (z16)



# Intro to Processors and z/VM

Running CPUs 90% busy doesn't scare us.
We want you to get what you pay for!



z/VM supports **logical** processors

z/VM as a Hypervisor

Z/VM faithfully replicates **virtual** processors

z/VM as a guest

# Intro to Memory and z/VM

Fully utilizing your memory is not a bad thing - z/VM expects to have to move some memory to paging media.


Flexibility to grow or shrink your memory

Strength to handle many VMs

# Intro to I/O and z/VM

z/VM can accommodate an extremely large variety of I/O devices, allowing for incredible flexibility



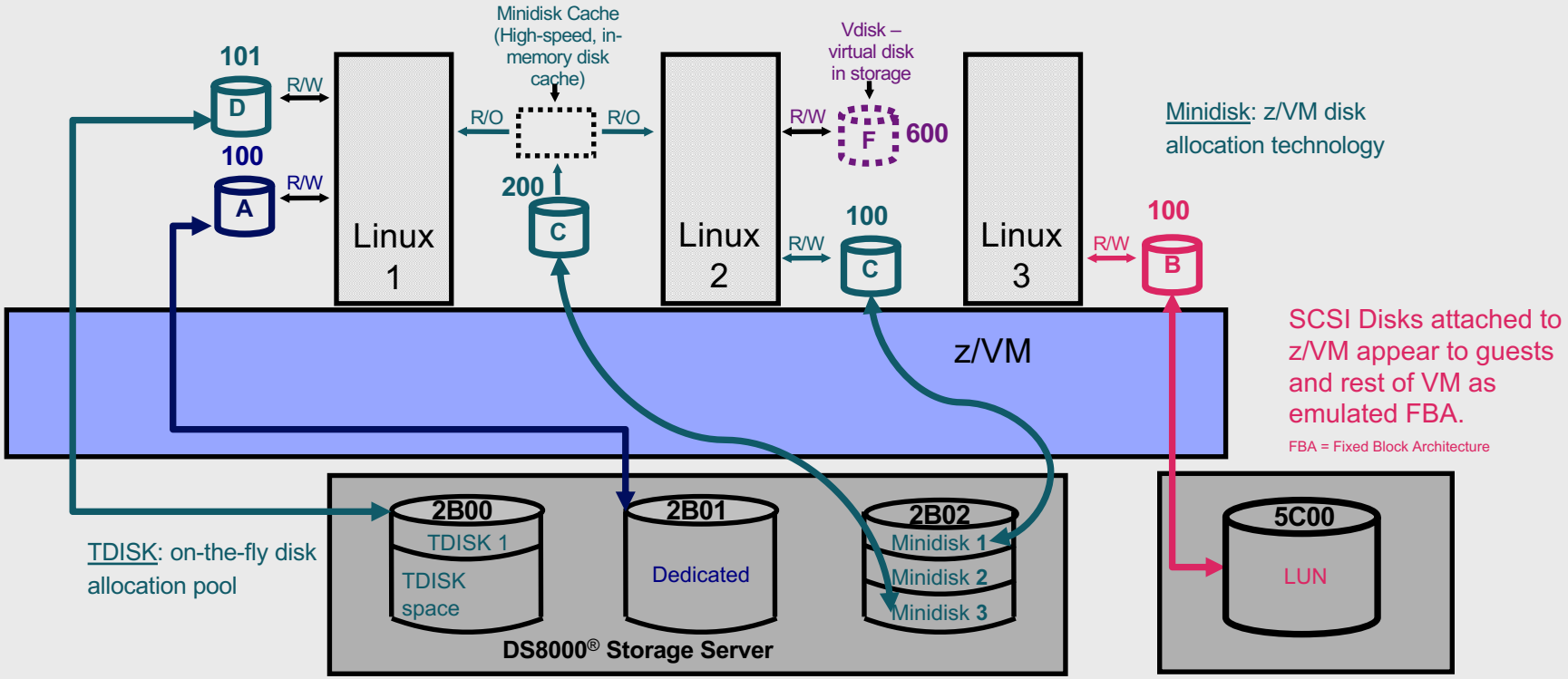
# Device Management Concepts

Level Set 

## How can I get from my house to the mall?

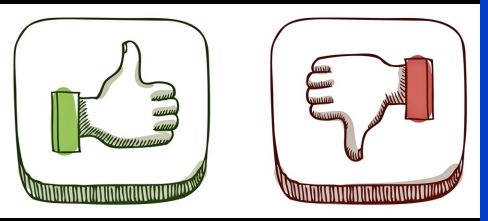
- Dedicated or attached
  - My parents give me my own car to go to the mall
- Virtualized
  - I have to share the car keys with my whole family, so I can go to the mall sometimes
- Simulated
  - I shop online so I don't have to go anywhere physically
- Emulated
  - I take the bus to the mall

# Device Management Concepts



# FICON vs FCP vs PCIe

What's right for you?



Fiber Connection (FICON)

- Fiber-optic channel technology
- Well established on IBM Z
- Command driven

Fiber Channel Protocol (FCP)

- Small Computer System Interface (SCSI) protocol
- Utilizes Fiber channel connection

Peripheral Component Interconnect Express (PCIe)

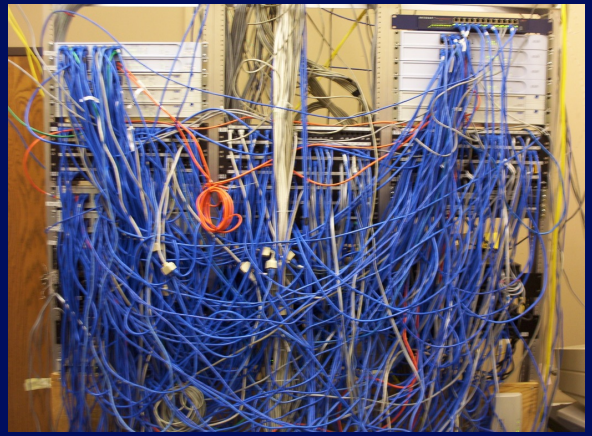
- PCI standard used to connect high-speed devices
- New kid on the block

# Intro to Networking and z/VM

Users have many options for networking connections on z/VM

Virtualizing network infrastructure saves complexity and time

From this



To virtual!

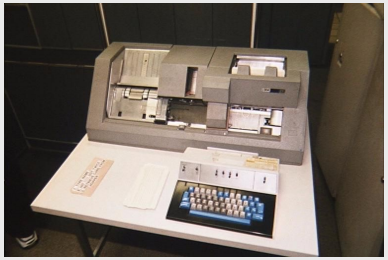
# Intro to SPOOL in z/VM

- z/VM simulates unit-record devices for virtual machines
  - Simulated reader, punch, printer, console for every virtual machine

- Simulated UR devices are still widely used on z/VM; upcycled to
  - Exchange application data
  - Share data files among multiple virtual machines
  - Collect console output
  - Store data collected by various system functions

- "Intermediary" between information in memory and information that you might devote long term storage to

*Card Reader*



*Card Punch*

*Printer*

*Console*

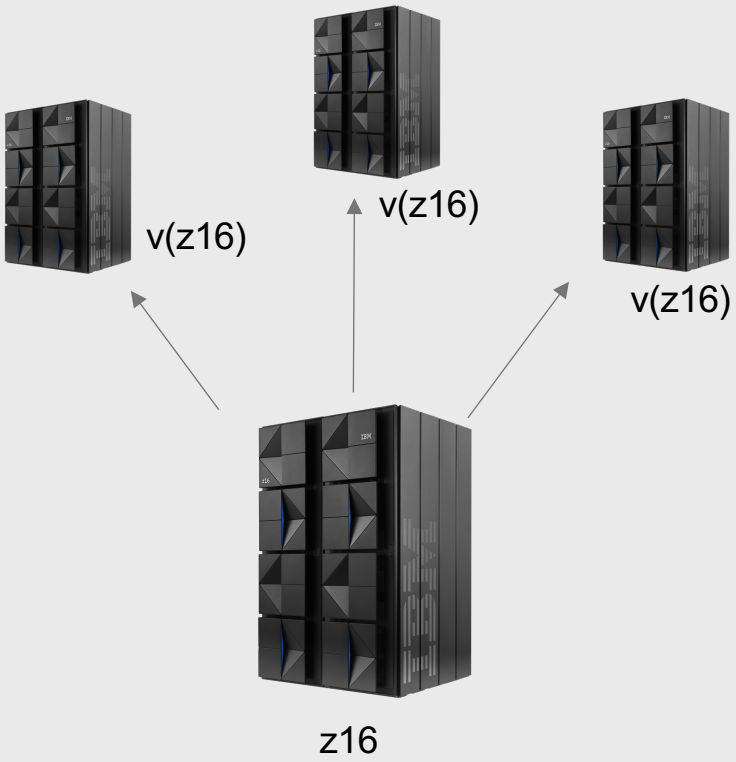
# Intro to Security and z/VM

Crypto accelerators offload the hard math of cryptography, making security faster and easier.

# Overcommitment

Doing more with less

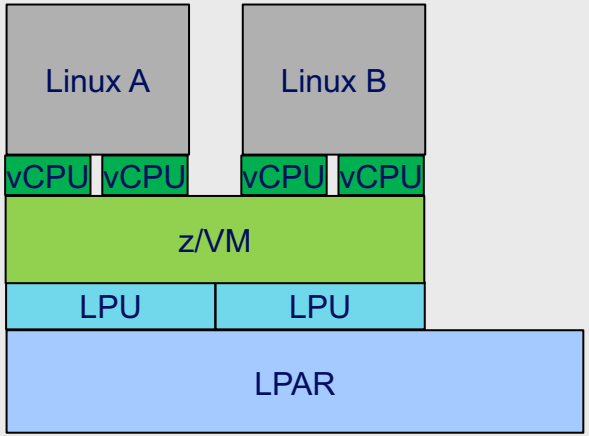
# Resource Overcommitment




## What is it?

- When the virtual resources defined to an OS (Or multiple OS's) exceed the physical resources of the machine
- **Fundamental** to the idea of virtualization
- Possible because a virtual resource will not need 100% of the physical resource 100% of the time
- What things can be overcommitted? CPU, Memory, I/O, Networking, Crypto

# Overcommitting CPU




## How's it work?

- When vCPUs need to run they must be **dispatched** onto the logical processor
- Hypervisor must manage vCPU access to the LPU

# Determining "Who's on first?!"


**Gather Partition Information:**

- Processor **Topology**
- LPAR weights
- Processor Utilization

**Gather Hypervisor Information:**

- Share Settings
  - Absolute/Relative
  - Hard/Soft
- Resource Pool Information
- Processor Affinity

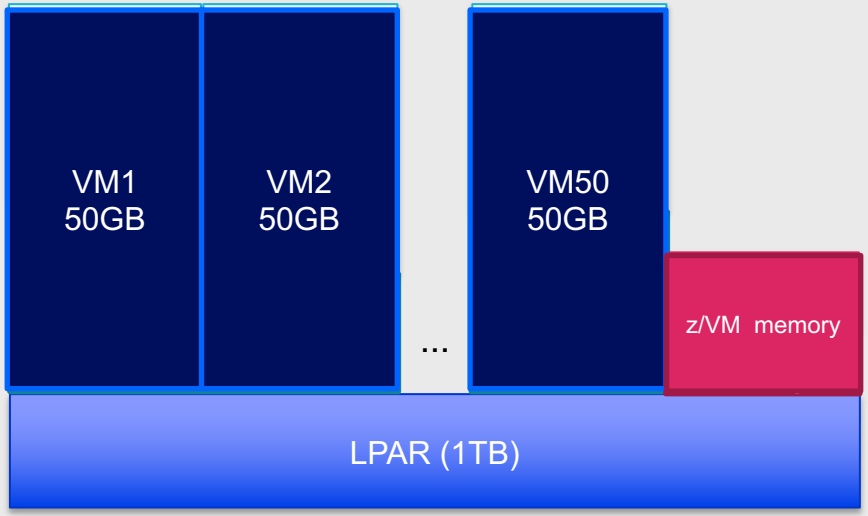
**Schedule vCPU based on relative priority:**

- Use partition and Hypervisor information to choose the best logical processor to run on.

**Dispatch vCPU onto Logical Processor:**

- Run CPU under **SIE**
- Let vCPU run for AT LEAST a **Minor Time Slice.**
- Compete with other vCPUs for unused or **until Elapsed Time Slice.**

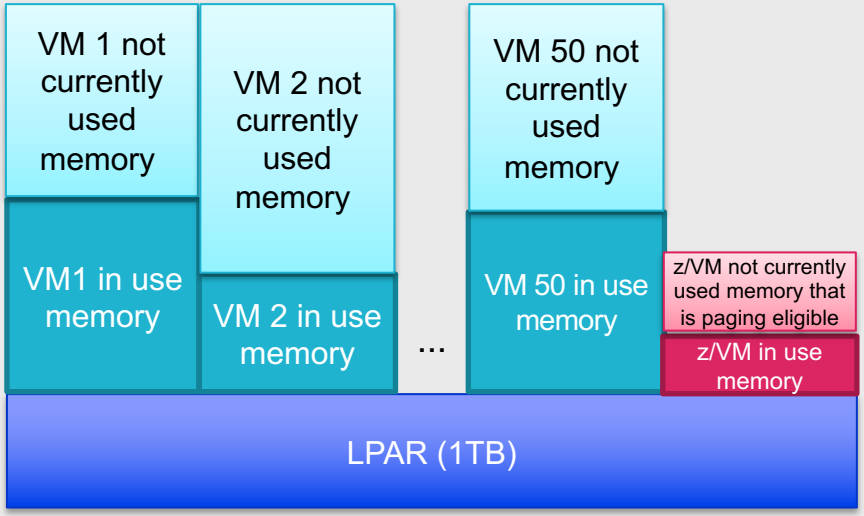
# Overcommitting Memory




## How's it work?

- We can only keep so much in memory
  - The 1TB must have z/VM's own structures and memory as well as guest memory
- So we choose some memory to page out to disk

# Overcommitting Memory

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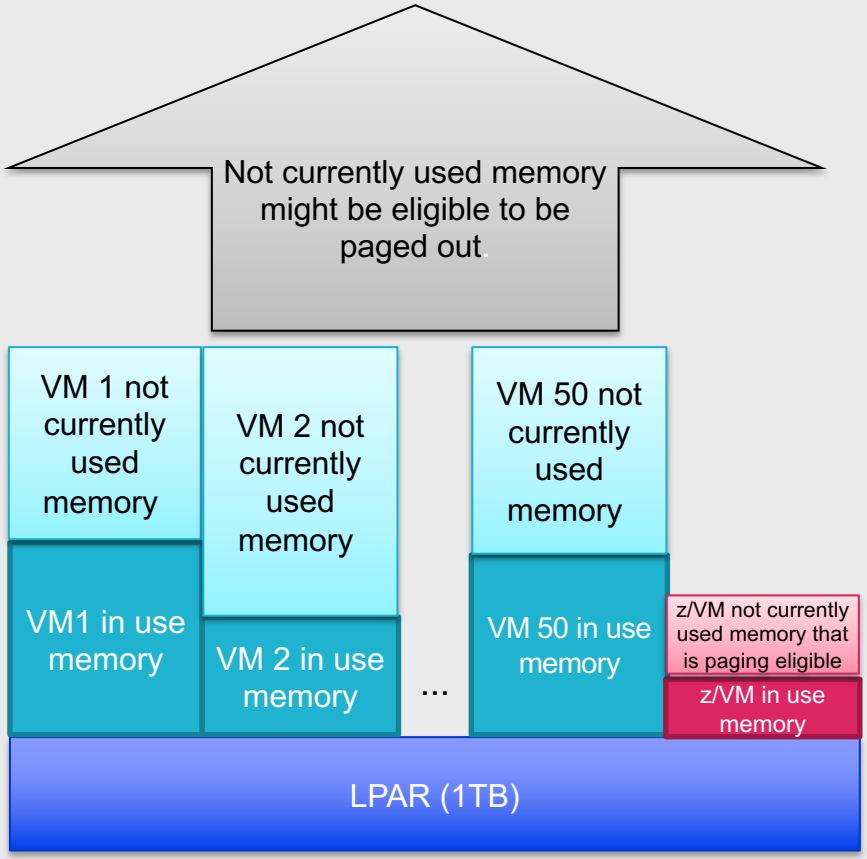


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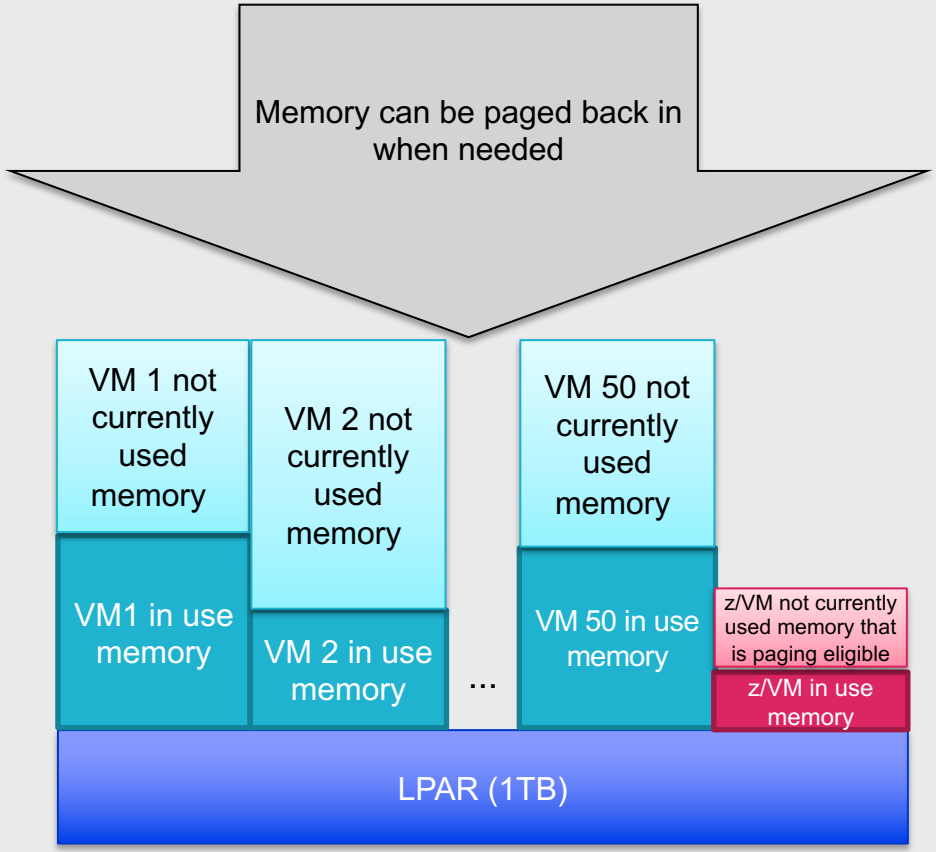


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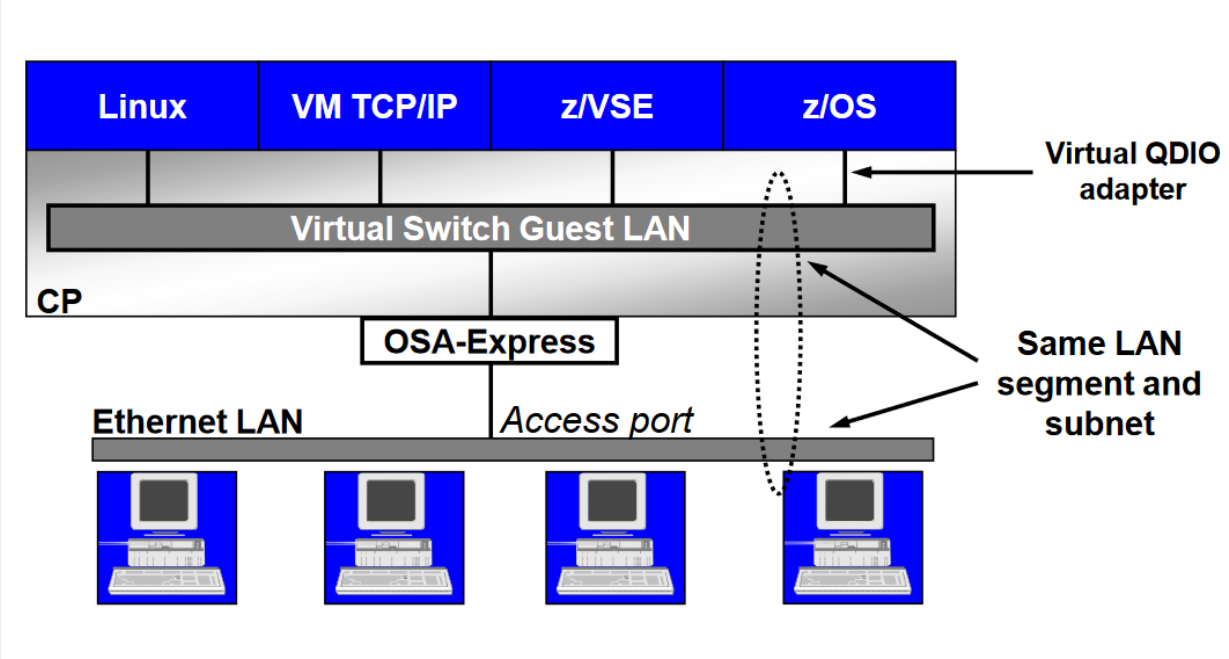
# Overcommitting network with a VSWITCH



# How do you Build z/VM?

# What do you need?

- LPAR definition - HMC/SE, what PR/SM controls
- IOCDS - I/O definition – or use DPM to give you both IOCDS & PR/SM
- System Config – What's defined to the z/VM system
- User Directory – What's defined to the z/VM users

# System Config: What makes up my system?

What is defined in the system configuration file?

- Operator_Consoles statement to find a console
- vSWITCH statements to define our virtual network
- CP_Owned statements to define the residence volume
- And so much more!!!

```
/*********************************************/
/* Set up Console                            */
/*********************************************/

operator_consoles  01F 009  3E0  500

 /*********************************************/
/* Set up VSWITCHES                          */
/*********************************************/

DEFINE  VSWITCH VSWITCH1 RDEV  7080  CONNECT CONTR DTCVSW1 ETH
MODIFY VSWITCH VSWITCH1 GRANT TCPIP
MODIFY VSWITCH VSWITCH1 GRANT LINUX01
DEFINE VSWITCH VSWITCH2 RDEV  6240  CONNECT CONTR DTCVSW1 ETH

/*********************************************/
/* Set up CP Volumes                         */
/*********************************************/

CP_owned slot  001  2ND600
CP_owned slot  002  2ND601
CP_owned slot  003  2ND603
CP_owned slot  004  2ND604
```

# User Directory: What Does a Virtual Machine Definition Look Like?

## What is defined in a directory entry?

- Login credentials
- Authorizations
  - Access to system resources
  - Command privileges
- Virtual machine characteristics

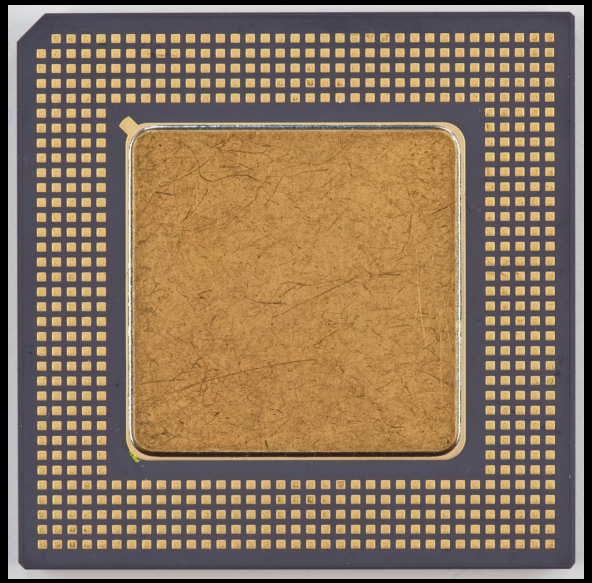
## Tools to help you

- DIRECTXA – creates and compiles your user directory
- Directory manager – Does this work for you!

```
USER LINUX01 MYPASS 512M 1024M     G
MACHINE  ESA 2
IPL  190  PARM AUTOCR
CONSOLE 01F  3270   A
SPOOL   00C  2540   READER *
SPOOL   00D  2540   PUNCH  A
SPOOL   00E  1403   A
SPECIAL 500  QDIO   3 SYSTEM MYLAN
LINK    MAINT 190  190  RR
LINK    MAINT 19D  19D  RR
LINK    MAINT 19E  19E  RR
MDISK   191 3390 012  001   ONEBIT  MW
MDISK   200 3390 050  100   TSOBIT  MR
```

# Dynamic Resource Management

# Dynamic **Processor** Management



**VARY PROC/CORE**

SMT Enabled – CORE
SMT Disabled – PROC

**DYNAMIC SMT**

**HIPERDISPATCH (Park/Unpark)**

Adjustable via:
CP SET SRM UNPARKING

# Dynamic **Memory** Management


**DEFINE STORAGE**

Used to change the memory on a guest.

**chmem**

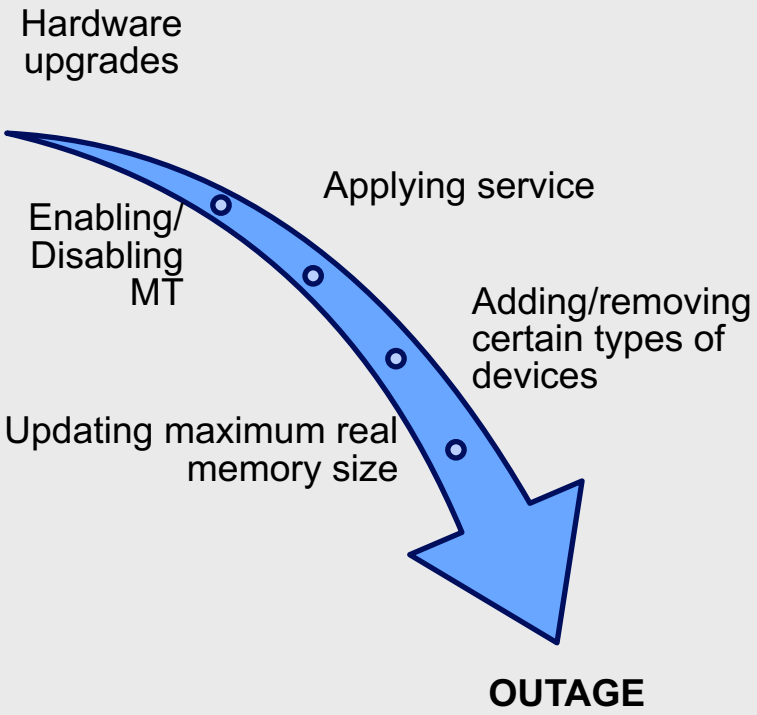
Linux commands are provided to bring more memory online, or take memory offline to the Linux OS.

**SET STORAGE**

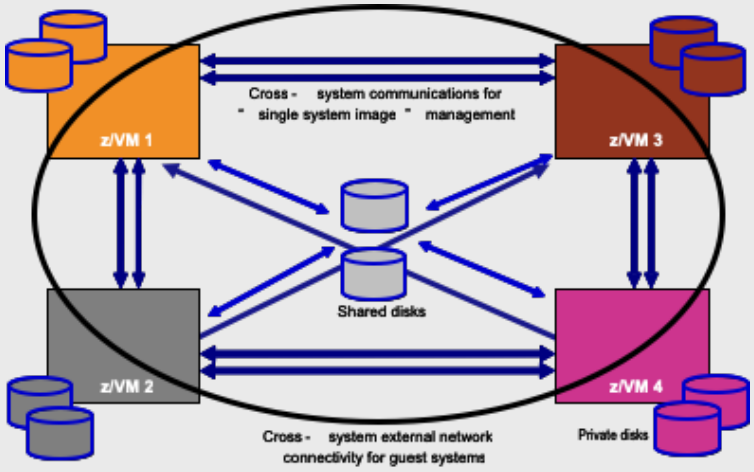
Use to add more memory to your z/VM system.

On the z14 and later machines, use this command to remove memory.

# What needs a planned outage?



# Single Systems Image (SSI) Feature




z/VM SSI

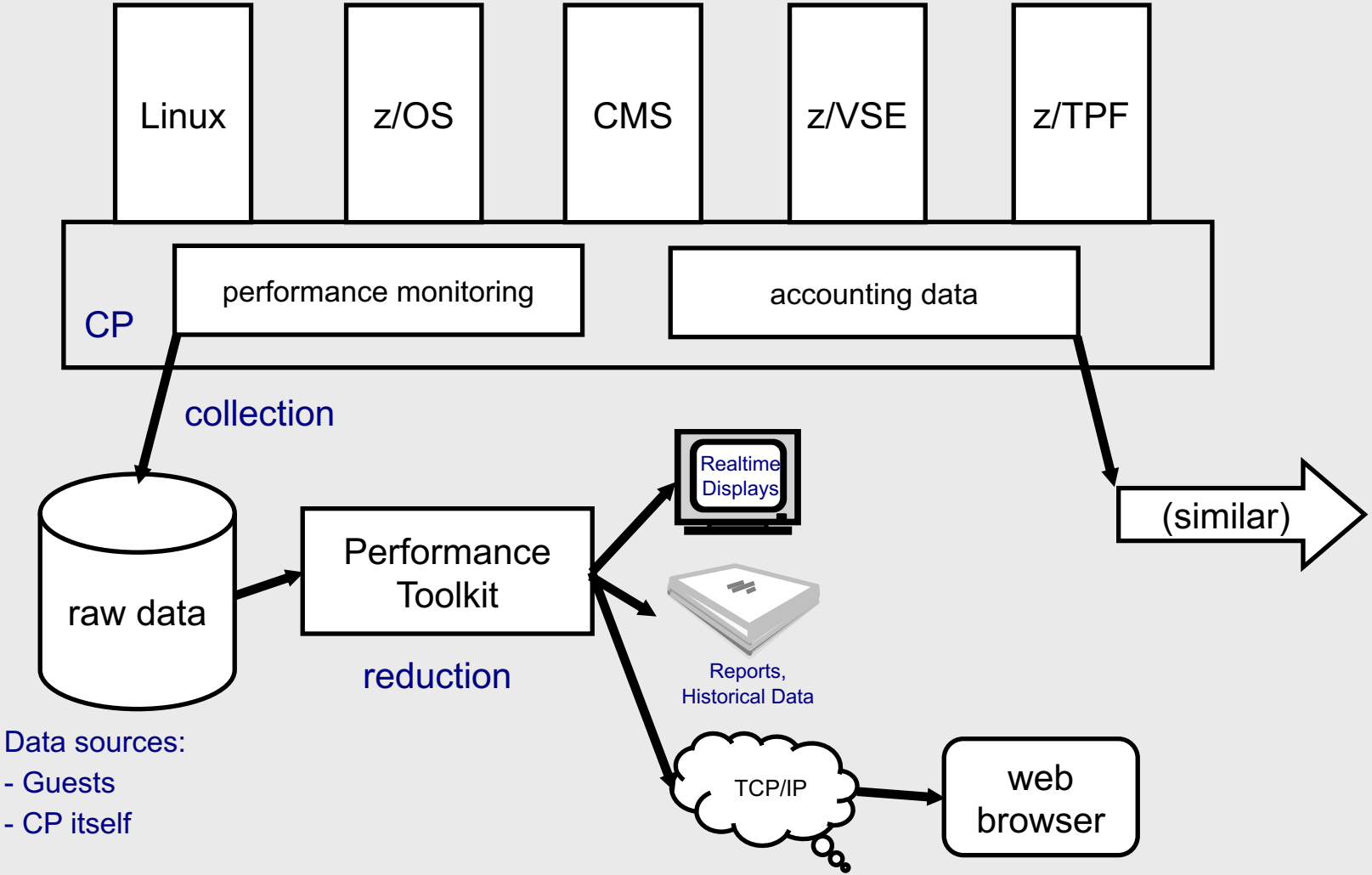
z/OS Parallel Sysplex

1. Manage a **single** user directory
2. Cluster management from any member
   - Apply maintenance to **all members** in the cluster from **one location**!
   - Issue commands from one member to operate another!
3. Built-in **cross-member capabilities**
4. Resource coordination and protection of network and disks
5. Relocate a **running** Linux guest from one system to another

**FREE** in z/VM 7.1

# System services

There are ways to connect into the system to monitor what's going on at a deeper level, or to issue commands to the hardware.


Linux
z/OS
CMS
z/VSE
z/TPF
CP
performance monitoring
accounting data
collection
raw data
Performance Toolkit
reduction
Realtime Displays
Reports, Historical Data
(similar)
TCP/IP
web browser
Data sources:
- Guests
- CP itself

# Houston...we have a problem

# What happened?

**Soft ABEND**

- Something went wrong in the program, but CP is ok.

- System stays up, Virtual Machine may terminate.

**Hard ABEND**

- Something went wrong with the control program.

- The entire system terminates.

**Hung User**

- A specific user is stuck in CP and cannot continue.

- The rest of the system continues operation.

**Hung System**

- The entire system is stuck in CP and cannot continue.

# Determining Why

CP will dump system storage to aid debug for a hard or soft abend.

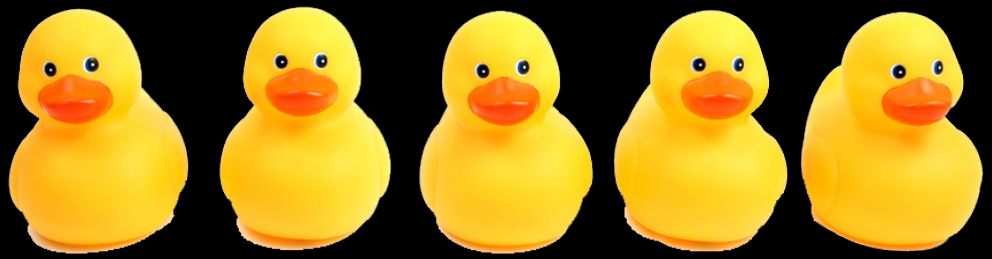
**SNAPDUMP** or **RESTART** dumps help gather information for system or user hangs.

**IMPORTANT**: configuring your system with adequate dump space will reduce headaches should you need to use it!

Dumping z/VM is not instantaneous and can take on the order of minutes depending on the size of your system. The longer you wait, the more information you'll have.

# If you stay ready, you don't have to get ready

# Installing z/VM



# Installing z/VM

Have your device information ready before you start installation: Disk, Networking for the z/VM TCPIP stack, CTCs if you're using SSI

Pictures help! As much as you can, make layouts of your device configurations, networking layouts, and SSIs.

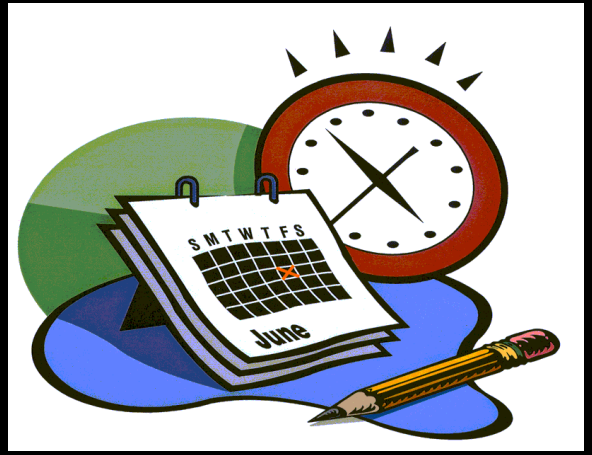
- z/VM install guide has worksheets to help you gather the information you need, fill these out first!
- Many shops install z/VM second level to try out the process and test new levels

**Optional Features**

If you've purchased DirMaint, Perfkit, RACF or any additional paid features, have their Program Directories available when you install.

There are special codes necessary to enable these.

# Servicing z/VM



# Servicing z/VM

- Every 2 years, in the 3rd quarter, z/VM releases a new level of the product.
  - We'll always have one "stable" and one "new function" release in service
  - Releases will be out of service 6 months after the N+2 release comes out (e.g., z/VM 7.1 would end service 6 months after z/VM 7.3 was available)
- z/VM 7.2 is our current stable release
- z/VM 7.3 is our current new function release
- In between releases, new function and fixes are shipped via APARs.

**PMR**
Problem Management Report
what you open when you find a problem,
e.g., 65118,442,000

**APAR**
Authorized Program Analysis Report
for new function and problem fixes between releases,
e.g., VM66209

**PTF**
Program Temporary Fix
actual code for the APAR,
e.g., UM35371

**RSU**
Recommended Service Upgrade
group of PTFs we think all customers should apply,
e.g., z/VM 7.1 RSU 1901

# Where to go when you're stuck

**Community Forums**

- IBMVM Listserv (z/VM community) http://listserv.uark.edu/cgi-bin/wa?A0=IBMVM
- LINUX 390 Listserv (Linux on Z) http://www.cavmen.org/list390.html
- Additional Listserv can be found here https://www.vm.ibm.com/techinfo/listserv.html

**Technical Publications**

- VM Library https://www.vm.ibm.com/library/
- IBM Knowledge Center https://www.ibm.com/support/knowledgecenter/en/

**Redbooks**

- IBM Z Redbooks http://www.redbooks.ibm.com/redbooks.nsf/domains/zsystems

**Ask an IBMer**

- Attend Conferences
- Engage User Groups
- Contact the z/VM experts! https://www.vm.ibm.com/forms/

# Conclusion


Flexibility
Community
Overcommittment
Testing and Debugging
Hardware Integration
IBM
z

# BACKUP