

Introduction to Linux on System z

2010 Blooming Basics T3 for z/VM Linux on IBM System z
June 22-23-24, 2010, 2:00 - 5:00 PM EDT (NY), T3 Conference Calls



Facts on Linux

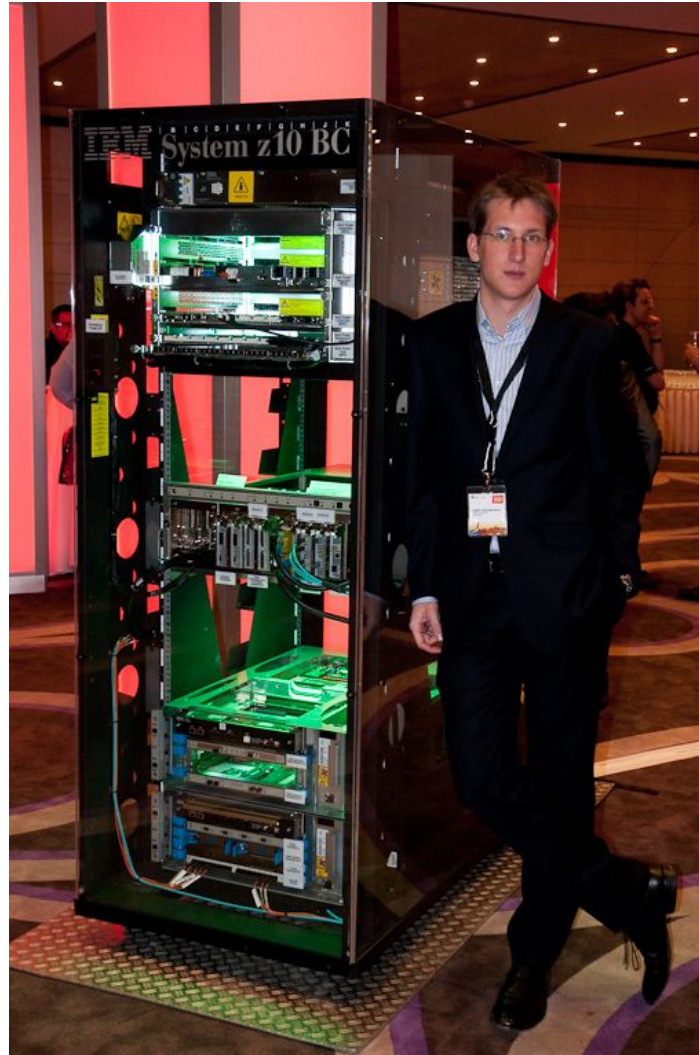
- Last year, **75%** of the Linux code was developed by **programmers working for corporations.**
- **\$7.37 billion:** projected cost to produce the 283 million lines of code which are contained in Linux Distribution **in a commercial environment.**
- IDC forecasts show that **Linux server revenue will grow by 85.5%** between 2008 and 2012 **in the non-x86 server space** equalling a four year compound annual growth rate of 16.7%.
- **Linux is Linux**, but ...features, properties and quality differ dependent on your platform

Source: Intelligence Slideshow: 40 Fast Facts on Linux <http://www.baselinemag.com/c/a/Intelligence/40-Fast-Facts-on-Linux-727574/>
<http://www.internetnews.com/dev-news/article.php/3659961>
http://public.dhe.ibm.com/software/au/downloads/IBM_zLinux_DAG_FINAL.pdf



What you see depends on the perception...or your background

<<This is a mainframe,
and can lately also
be used to run the
Linux Operating
System>>



<<This is a high
end server using
Linux
& Virtualization
Technology for
massive Server
Consolidation
(IBM Enterprise
Linux Server)>>



What is Linux on System z

Linux on System z exploits the strengths and reliability features of the System z hardware, while preserving the openness of Linux.

- Linux on System z is the synonym for Linux running on any IBM mainframe, including:
 - IBM System z10™,
 - IBM System z9®
 - IBM eServer™ zSeries™ (z990, z890, z900, z800)
 - S/390® (9672 G5, G6 and Multiprise® 3000 processors).
- It is a native System z operating environment
 - Pure Linux, an ASCII environment
 - Exploits IBM S/390 hardware, including IEEE floating point
- Not a replacement for other IBM System z operating systems
- Can be run under z/VM or in its own LPAR
- There is not a unique version of Linux or other operating system
 - Developed by the Open Source Community
 - Distributed and Supported by SuSE/Novell, Red Hat, and Others



What System z Hardware Brings to Linux

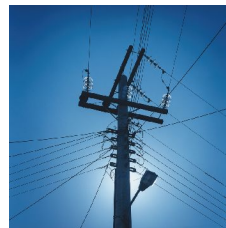
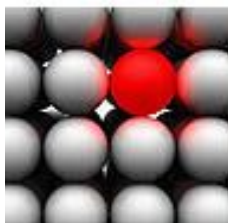
- The most reliable hardware platform available
 - MTF measured in decades
 - RAS features built into hardware
- Scalability
 - Both Physical and Logical
 - Non-disruptive capacity upgrade on demand
- Designed to support mixed work loads
 - Complete work load isolation
 - High speed inter-server connectivity
 - High Internal Bandwidth, sophisticated cache nest
 - Virtualization
- Hipersockets
 - Virtual network between LPARs, at memory speed
- Integrated Facility for Linux (IFL)
 - Lower priced hardware
 - Protects against software costs



Linux on System z Value Proposition

A Linux on System z infrastructure provides significant IT cost savings opportunities:

- **People Cost** – increase the productivity of the IT staff
- **Software Costs** – reduce software license fees by consolidating a large number of virtual machines per System z core
- **Energy Costs** – dramatic reduction in power usage
- **Facilities Costs** – reduce floor space with dense server consolidation on System z
- **Networking Costs** – consolidate networks inside the box too



Linux vs. Mainframe Terminology

- **Linux**

- System administrator
- Network management
- Boot
- 4-processor machine
- Main memory
- Disk
- Scheduler
- NIC

- **Mainframe**

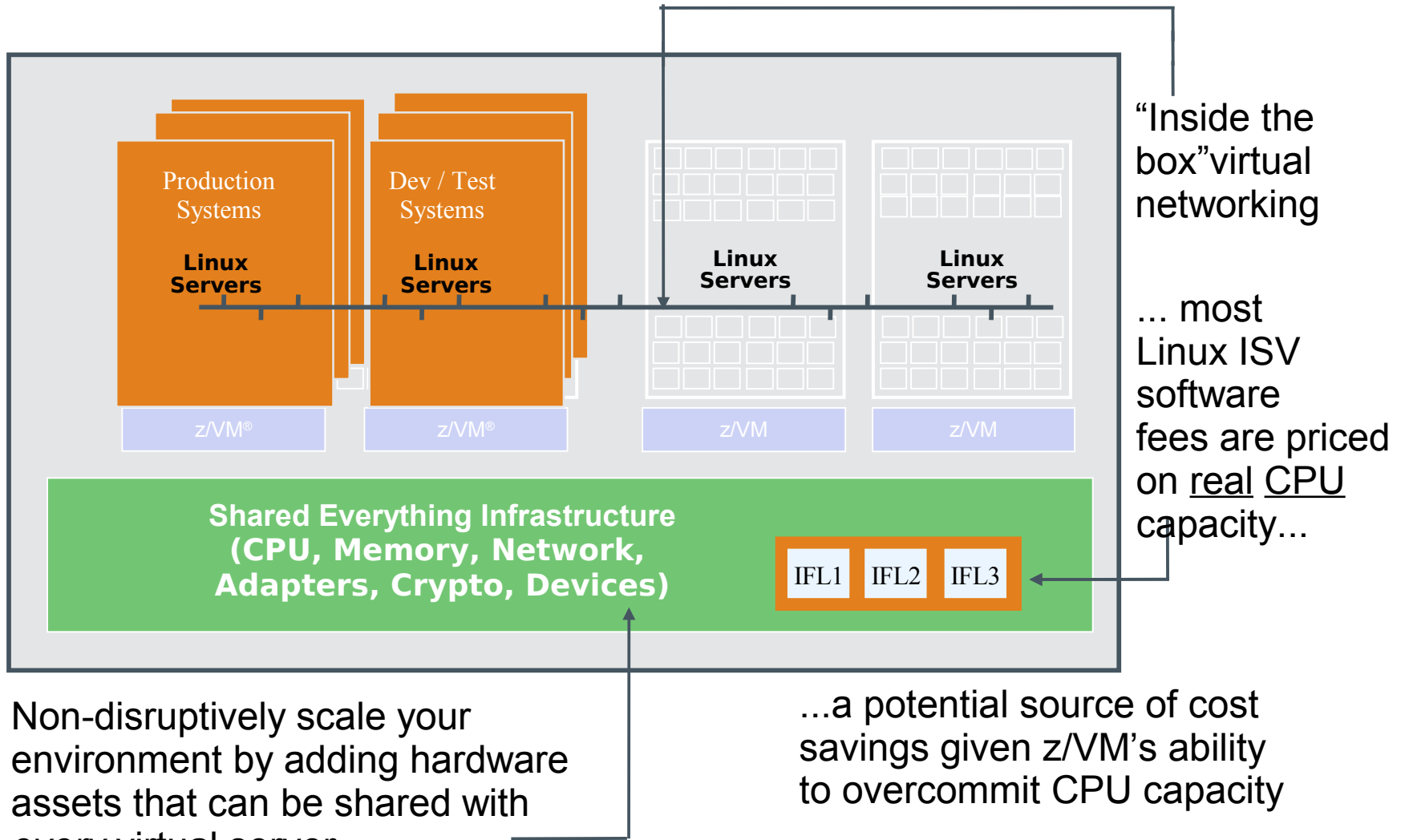
- System programmer
- Systems management
- IPL
- 4-way
- Main storage
- DASD
- Dispatcher
- OSA

While I worked as a Linux consultant for 8 years people said: “You don’t look like someone doing Linux” (no long hair and geeky look)

After I joined IBM to work in the mainframe world people said: “You don’t look like someone doing mainframe” (some years ago half of today’s mainframe pros were at least 50 years old and nearing retirement)

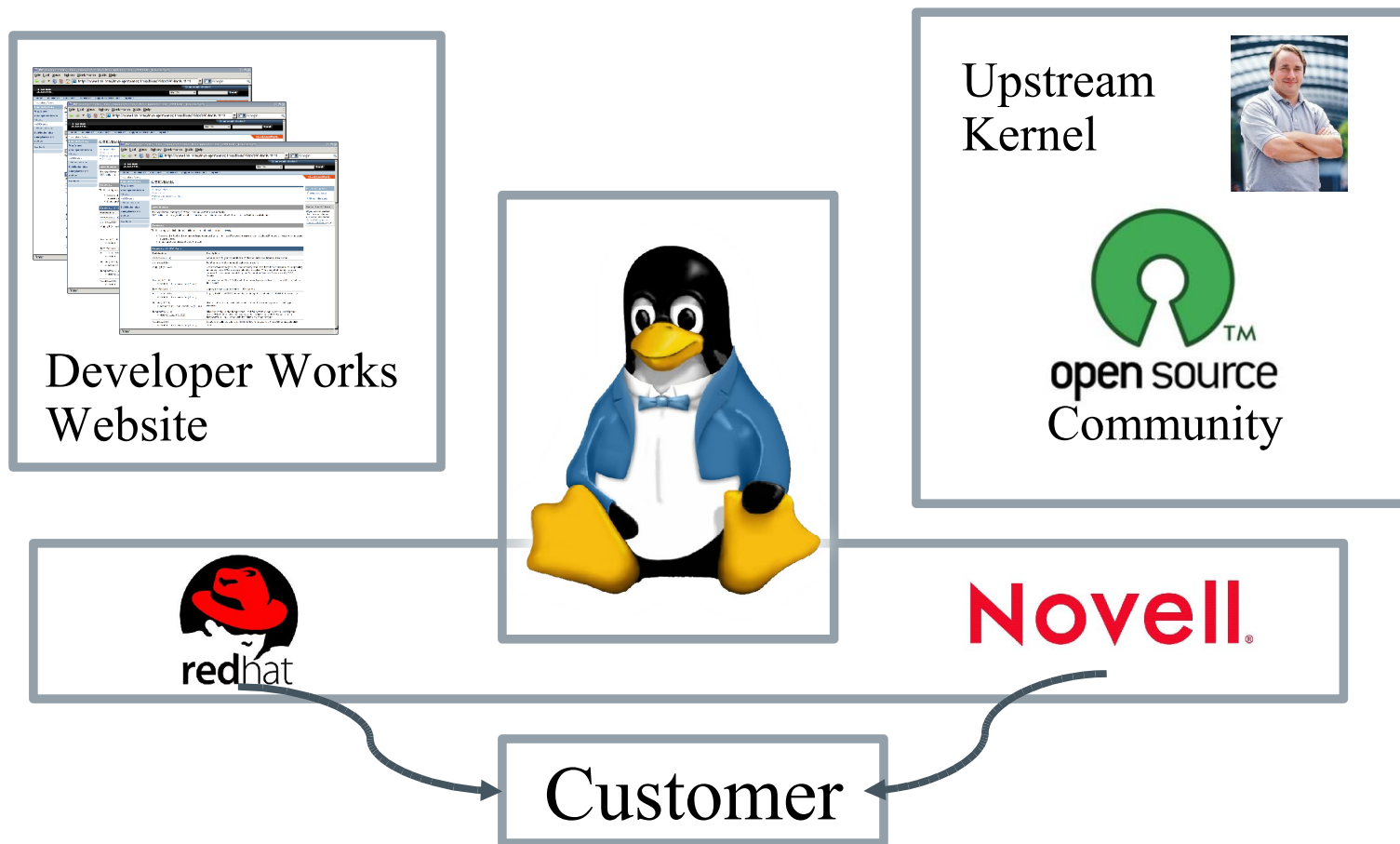


The Linux on System z Server High Level Architecture

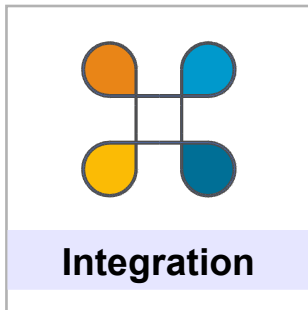


IBM Linux on System z Development

IBM Linux on System z Development contributes in the following areas: Kernel, s390-tools, Open Source Tools (e.g. eclipse, ooprofile), GCC, GLIBC, Binutils



Linux on System z Development Focus

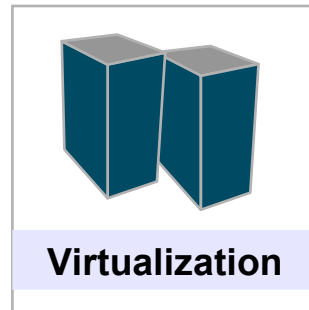


Application Serving

- z/OS integration

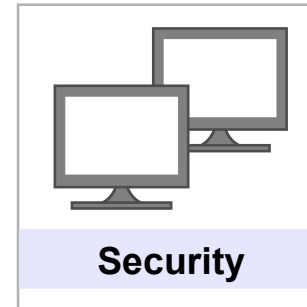
Data Hub

- Database Consolidation



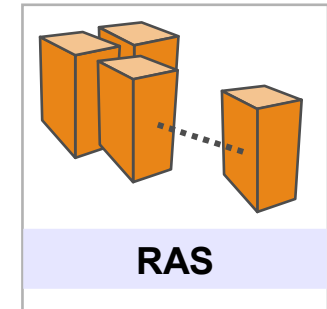
Virtualization & Virtualization Management

- Ease of Use
- Serviceability
- Hosting capacity



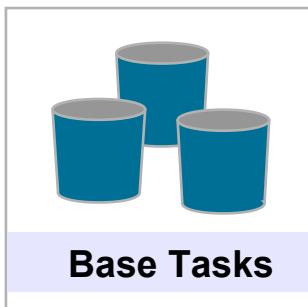
Security

- Certifications
- Data security & privacy



Continuous Availability & Data Replication

- RAS
- Differentiation for mission critical workloads



Customer Requirements

- Address customer observed deficiencies

Competitiveness

- Close competitive gaps
- Differentiation / innovation that matters

Hardware Support

- Exploitation of new System z HW
- Storage exploitation

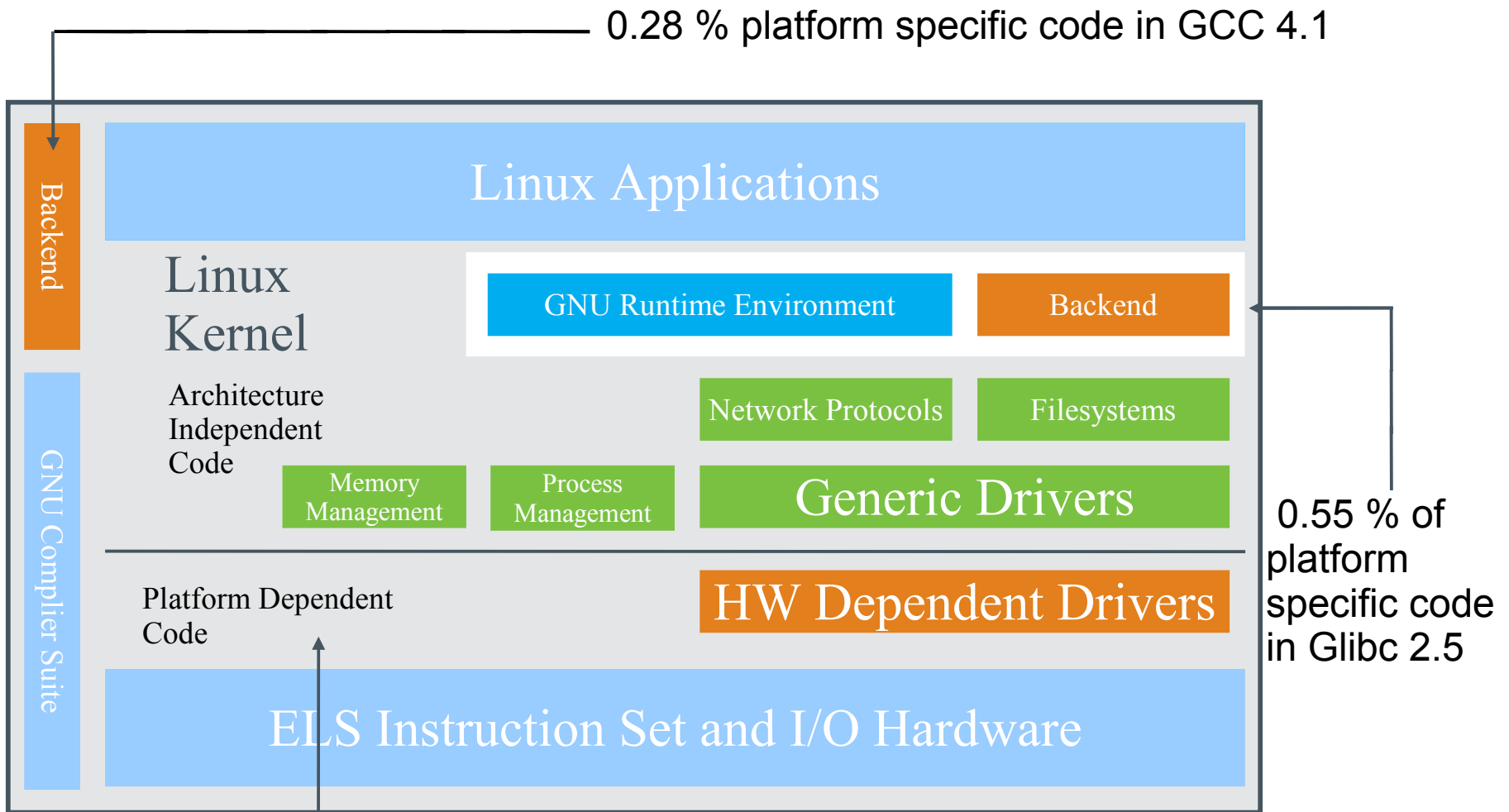
Linux

- Maintainership & code currency



Structure of Linux on System z

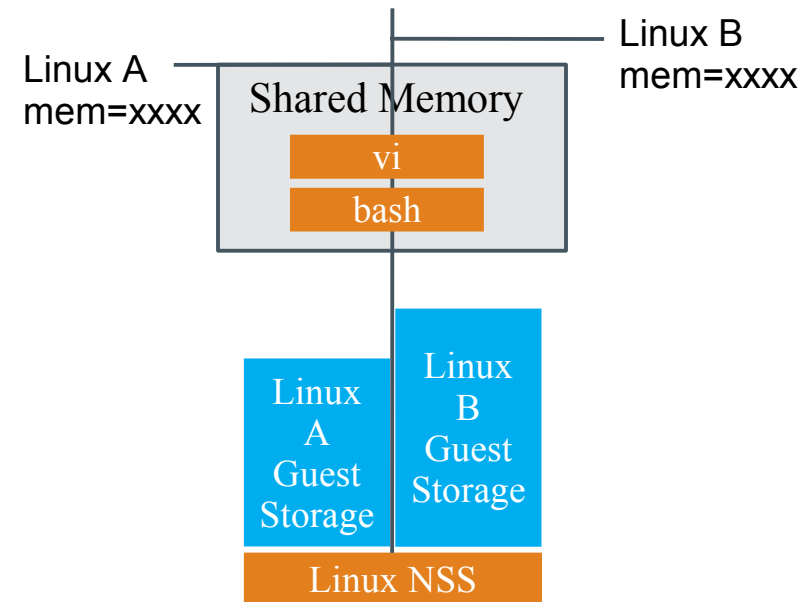
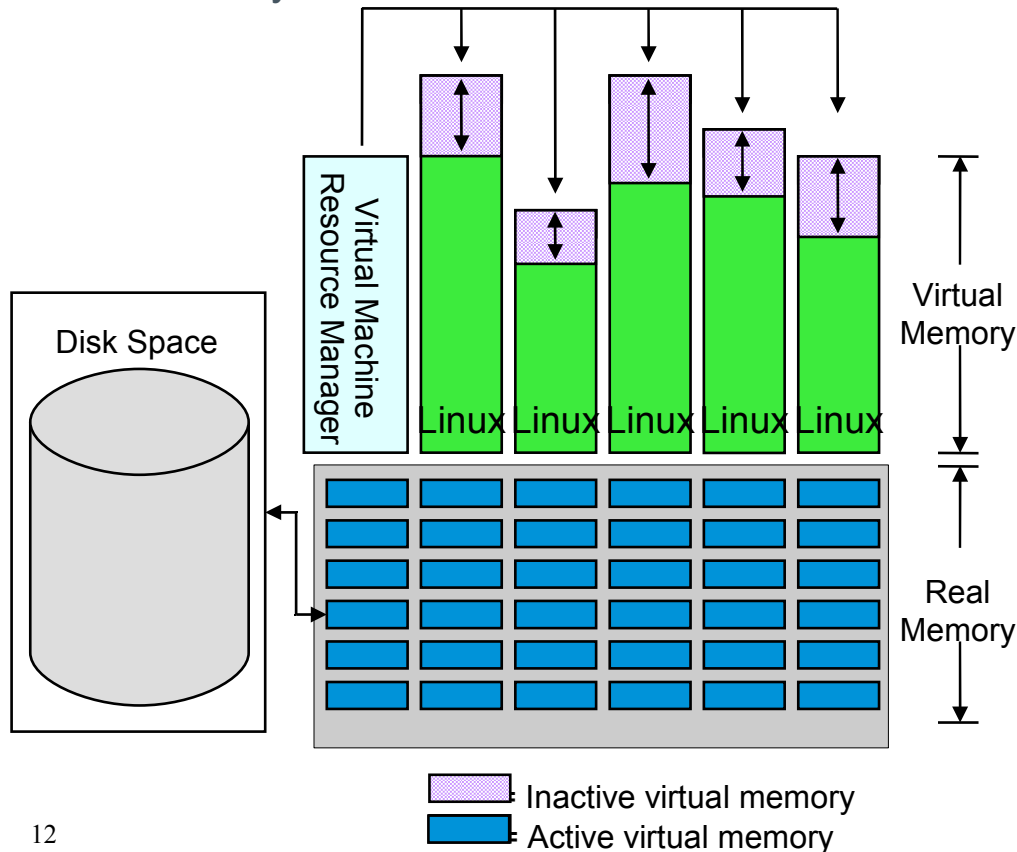
Many Linux software packages did not require any code change to run on Linux on System z



Advanced Virtualization Capabilities

A fundamental strength of ELS running the z/VM hypervisor is its ability to overcommit system resources: **“Do more with less”**

- This can translate into cost savings for hardware *and* software
- Consider a Linux environment with a 25-to-1 overcommitment of CPU capacity
- Memory Overcommitment 1.5-3:1 for Production, 4+:1 for Non Production Systems



z/VM included advanced memory concepts to save real memory: Cooperative Memory Management & Shared Memory Technologies (NSS, XIP)



Enhancing scalability of Linux on z/VM using execute-in-place technology

- Applications are being executed directly from where they are permanently stored
- Was invented for embedded systems that do not have disk drives
- Applications can be run directly in flash or ROM memory
- Reduces memory consumption

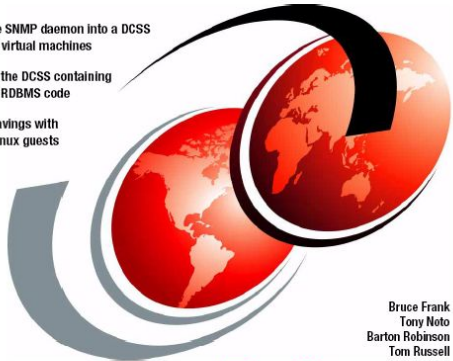
IBM

Using Discontiguous Shared Segments and XIP2 Filesystems With Oracle Database 10g on Linux for IBM System z

Putting the SNMP daemon into a DCSS to support virtual machines

Setting up the DCSS containing the Oracle RDBMS code

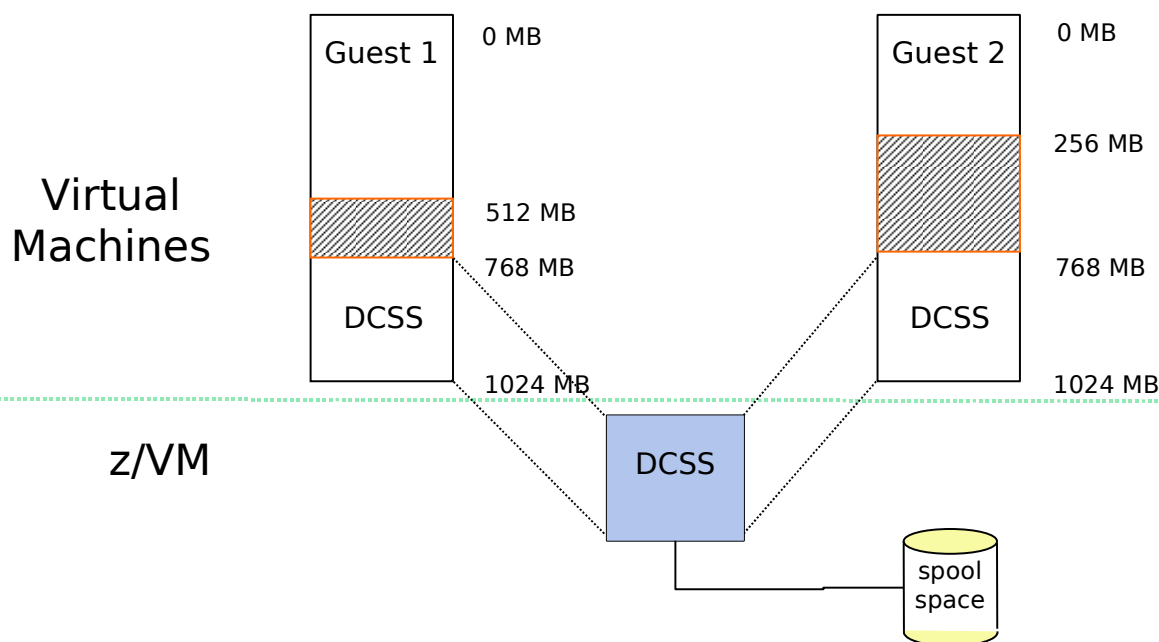
Memory savings with multiple Linux guests



Bruce Frank
Tony Nolo
Barton Robinson
Tom Russell

Redbooks

ibm.com/redbooks



Where's SYS1.PARMLIB Kept?

(This chart is borrowed from Mark Post)

- Just about everything you need is kept under /etc (at some level of hierarchy)
- Individual text files (or groups of them), since no concept of a PDS in Linux.
- Some fairly important ones:
 - /etc/passwd
 - /etc/group
 - /etc/shadow
 - /etc/inittab
 - /etc/fstab
 -
- Do I Really Have to Know All This Stuff?
 - No, but shouldn't you?
 - Would you let a junior systems programmer or system operator loose on SYS1.PARMLIB or SYSTEM CONFIG via a GUI?
 - If you really don't want to know what's going on or have a large virtual farm used the graphical tool from Red Hat & Novell



How to discover that you are logged into a Linux System on a different Hardware Architecture?

```
hans@tuxmaker:~> cat /proc/cpuinfo
vendor_id      : IBM/S390
# processors   : 8
bogomips per cpu: 3761.76
features      : esan3 zarch stfle msa ldisp eimm dfp edat
processor 0: version = 00,  identification = 28C03F,  machine = 2097
processor 1: version = 00,  identification = 28C03F,  machine = 2097
processor 2: version = 00,  identification = 28C03F,  machine = 2097
processor 3: version = 00,  identification = 28C03F,  machine = 2097
processor 4: version = 00,  identification = 28C03F,  machine = 2097
processor 5: version = 00,  identification = 28C03F,  machine = 2097
processor 6: version = 00,  identification = 28C03F,  machine = 2097
processor 7: version = 00,  identification = 28C03F,  machine = 2097
hans@tuxmaker:~> uname -a
Linux tuxmaker 2.6.16.60-0.42.10-default #1 SMP Tue Apr 27 05:11:27
UTC 2010 s390x s390x s390x GNU/Linux
```



Using a Terminal / Console on System z

- Line-mode terminal for booting, then SSH connection
 - In case of network/setup problems line-mode terminal may be required
 - ed may safe your system...

The screenshot shows a terminal window titled "z/VM ONLINE" with a Java Applet Window overlay. The terminal displays the following text:

```

z/VM ONLINE

LOGICALLY
CONNECTED
SCREEN

ZZZZZZ /
ZZ      /
ZZ      /
ZZ      /
ZZZZZZ /

VV      VVV MM      MM
VV      VVV MMM     MMM
VV      VVV MMMM    MMMM
VV      VVV MM MM MM MM
VV      VVV MM MM MM MM
VVVVV   MM M MM
VVV     MM MM MM
V       MM MM MM
        MM MM

E M E A V M 1

MD Server Systems Operation Competency

Use this system
for IBM management approved business only.

Fill in your USERID and PASSWORD and press ENTER
(Your password will not appear when you type it)
USERID  ===> hans
PASSWORD ===>

COMMAND ===> █

RUNNING  EMEAVM1
042/017
  
```

The Java Applet Window displays the following system boot logs:

```

Starting cups:
[ OK ]
Starting sendmail:
[ OK ]
Starting sm-client: [ OK ]
Starting crond: [ OK ]
Starting xfs:
[ OK ]
Starting anacron: [ OK ]
Starting atd: [ OK ]
Starting yum-updatesd:
[ OK ]
Starting Avahi daemon...
[ OK ]
Starting HAL daemon:
[ OK ]
Red Hat Enterprise Linux Server release 5.1 (Tikanga)
Kernel 2.6.18-53.el5 on an s390x
t631p37 login:
qeth: Link failure on eth0 (CHPID 0x76) - there is a network proble
pulled the cable or disabled the port.
qeth: Recovery of device 0.0.f500 started ...
qeth: Device 0.0.f500/0.0.f501/0.0.f502 is a OSD Express card (1lev
with link type OSD_1000 (portname: OSAPORT)
qeth: Using SW checksumming on eth0.

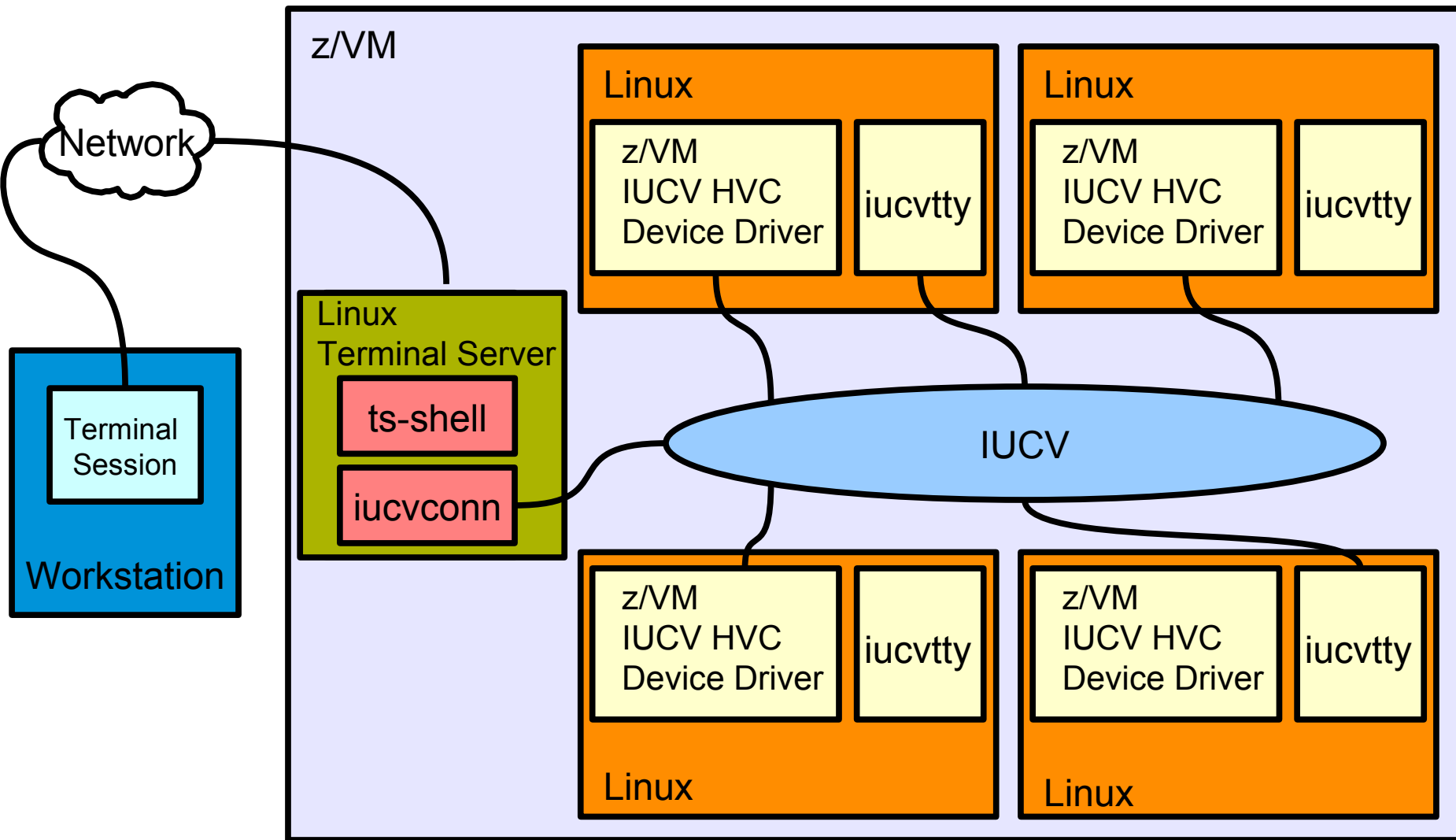
Command:
 Priority (select this when responding to priority (red) messages)

Send Respond Delete

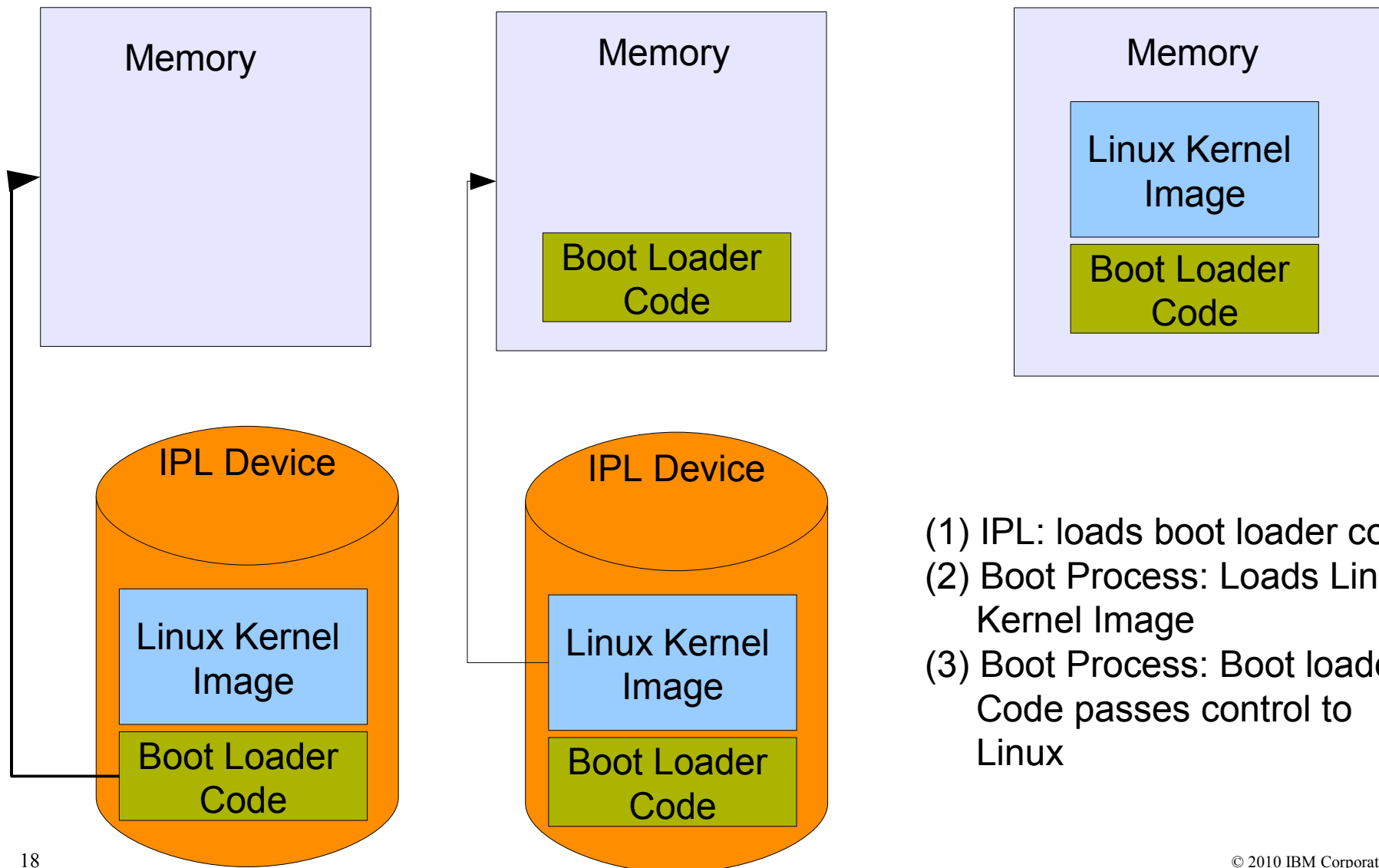
Close Help
  
```



IUCV terminal environment



Linux IPL (Initial Program Load)



The Bootmanager - /etc/zipl.conf

```
[defaultboot]
defaultmenu=menu
[2.6.25]
    image=/boot/vmlinuz-2.6.25
    ramdisk=/boot/initrd-2.6.25.img
    target=/boot/
    parameters="root=/dev/disk/by-path/ccw-0.0.beef TERM=dumb"
[... ]
:menu
target = "/boot"
1 = "2.6.25"
2 = "2.6.27"
default = 2
prompt = 1
timeout = 10
```



How device drivers are accessed by Linux

- The Linux kernel represents the character and block devices it knows as a pair of numbers **<major>**:<minor>.
- Some major numbers are reserved for particular device drivers, others are dynamically assigned to a device driver when Linux boots or the driver is loaded.
- For example, major number 94 is always the major number for DASD devices while the device driver for channel-attached tape devices has no fixed major number.

```
hans@larsson:~> ls -la /dev/dasd*
brw-r----- 1 root disk 94, 0 Sep 14 22:52 /dev/dasda
brw-r----- 1 root disk 94, 1 Sep 14 22:52 /dev/dasda1
brw-r----- 1 root disk 94, 2 Sep 14 22:52 /dev/dasda2
[...]
```



Querying information about the current DASD Setup & Activating a new Disk

Printing a list of active DASD devices (The same information can also be obtained from the file `/proc/dasd/devices`)

```
hans@larsson:~> lsdasd
```

Bus-ID	Status	Name	Device	Type	BlkSz	Size	Blocks
0.0.ec24	active	dasda	94:0	ECKD	4096	7043MB	1803060

Activating a new Disk

```
root@larsson:~> modprobe dasd_mod dasd=ec27
root@larsson:~> modprobe dasd eckd mod
root@larsson:~> chccwdev -e ec27
Setting device 0.0.ec27 online
Done
root@larsson:~> dmesg|tail|grep dasd
dasd(eckd): 0.0.ec27: 3390/0C(CU:3990/01) Cyl:10017 Head:15 Sec:224
dasd(eckd): 0.0.ec27: volume analysis returned unformatted disk
```

The device needs to be activated, after the driver
 21 Is loaded. Otherwise it can't be used



DASD low level format:

```
root@larsson:~> dasdfmt -d cd1 -b 4096 -f /dev/dasdb -p
Drive Geometry: 10017 Cylinders * 15 Heads = 150255 Tracks
```

I am going to format the device /dev/dasdb in the following way:

```
Device number of device : 0xec27
Labelling device        : yes
Disk label              : VOL1
Disk identifier         : 0XEC27
Extent start (trk no)  : 0
Extent end (trk no)    : 150254
Compatible Disk Layout : yes
Blocksize               : 4096
```

--->> ATTENTION! <<---

All data of that device will be lost.

Type "yes" to continue, no will leave the disk untouched: **yes**

Formatting the device. This may take a while (get yourself a coffee).

```
cyl   385 of 3339 |#####-----|
11%
```



DASD: Partitioning

Compared to other architectures, Linux on System z makes use of its own partitioning tool for DASD devices.

The common Linux tool fdisk can not be used in this environment! Nevertheless the handling is similar. **The system is limited to 3 partitions per disk when using DASD**

```
root@larsson:~> fdasd /dev/dasdb
reading volume label ...: VOL1
reading vtoc .....: ok
```

Command action

```
  m  print this menu
  p  print the partition table
  n  add a new partition
  d  delete a partition
  v  change volume serial
  t  change partition type
  r  re-create VTOC and delete all partitions
  u  re-create VTOC re-using existing partition sizes
  s  show mapping (partition number - data set name)
  q  quit without saving changes
  w  write table to disk and exit
```

Command (m for help):



Filesystem

Now we have a new device partition (e.g. /dev/dasdb1) which can be used as any other Linux Disk

```
root@larsson:~> mke2fs -j /dev/dasdb1
mke2fs 1.41.4 (27-Jan-2009)
[...]
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done

This filesystem will be automatically checked every 28 mounts or
180 days, whichever comes first.  Use tune2fs -c or -i to override.
```

For a static setup the driver has to be loaded using the bus id during system startup

```
root@larsson:~> echo "options dasd_mod dasd=ec27" >>
/etc/modprobe.conf
```



Miscellaneous

In case of debugging performance problems:

```
root@larsson:~> echo "set on" > /proc/dasd/statistics
root@larsson:~> cat /proc/dasd/statistics
```

I highly recommend the use of a technology like Logical Volume Manager: Why?

- You can combine several hard disks or partitions
- You can enlarge a logical volume when free space is exhausted
- You can add hard disks to the volume group in a running system
- You can add logical volumes in a running system
- You can use several hard disks with improved performance in the RAID 0 (striping) mode
- You can add up to 256 logical volumes
- The Snapshot feature enables consistent backups

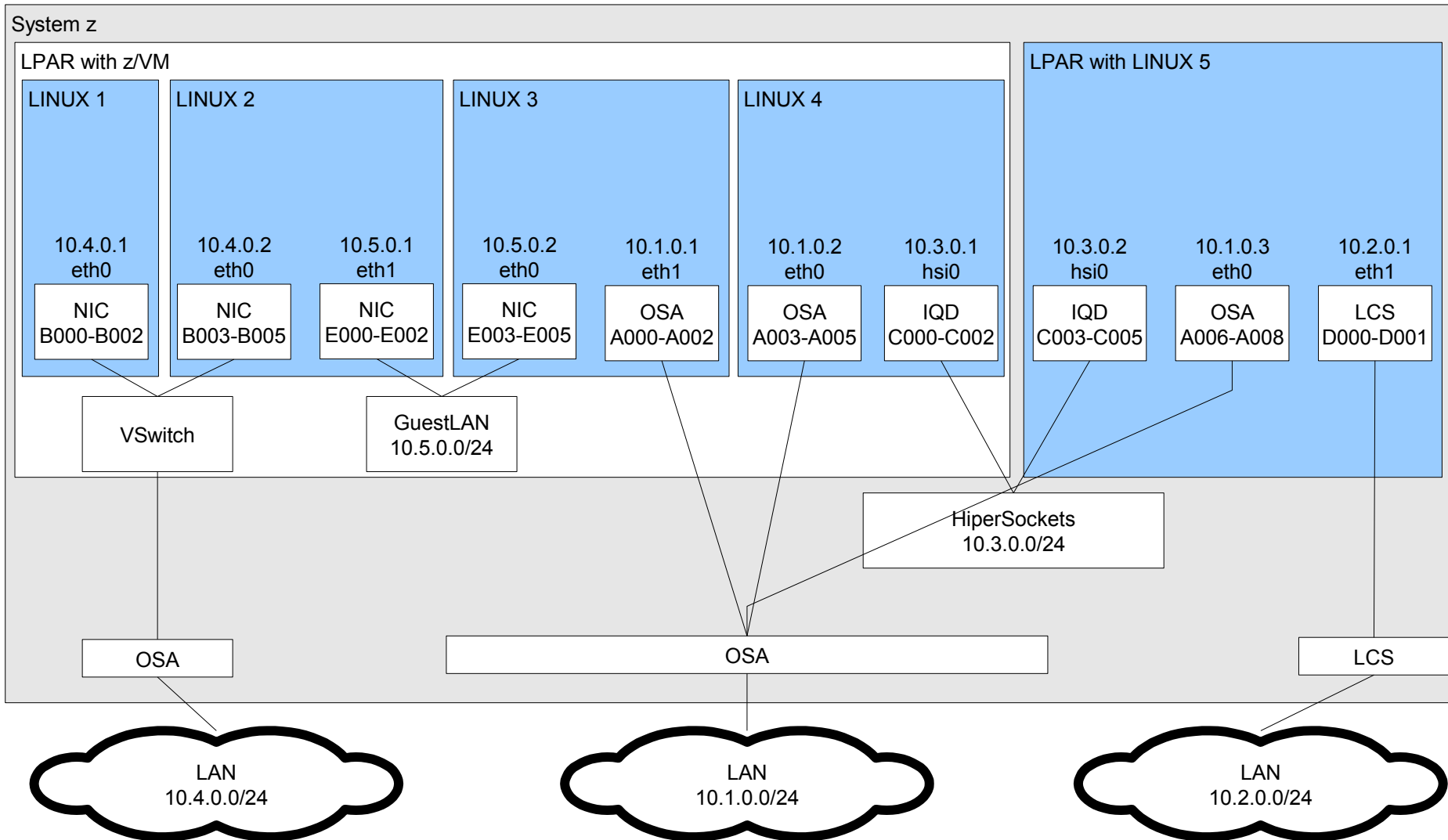
Benefits for Linux on System z

Minidisks on z/VM cannot span more than one physical DASD volume.

Without a volume management system like LVM the size of a file system is limited to the size of a DASD volume.



Networking Example



cio_ignore

- When a Linux on System z instance boots, it senses and analyses all available devices.
- You can use the `cio_ignore` kernel parameter to specify a list of devices that are to be ignored.
- The following applies to ignored devices:
 - Ignored devices are not sensed and analyzed. The device cannot be used unless it has been analyzed.
 - Ignored devices are not represented in `sysfs`.
 - Ignored devices do not occupy storage in the kernel.
 - The subchannel to which an ignored device is attached is treated as if no device were attached.
 - `cio_ignore` might hide essential devices such as the console under z/VM. The console is typically device number 0.0.0009.
- This example specifies that all devices in the range 0.0.b100 through 0.0.b1ff, and the device 0.0.a100 are to be ignored.

```
cio_ignore=0.0.b100-0.0.b1ff,0.0.a100
```



cio_ignore (cont.)

Display ignored devices:

```
root@larsson:~> cat /proc/cio_ignore  
0.0.0000-0.0.78ff  
0.0.f503-0.0.ffff
```

Free a individual device from the ignore list

```
root@larsson:~> echo free 0.0.4711 >/proc/cio_ignore
```

Free all devices from the ignore list

```
root@larsson:~> echo free all >/proc/cio_ignore
```



dbginfo.sh

dbginfo.sh is a script to collect various system related files, for debugging purposes.

- It generates a tar-archive which can be attached to PMRs / Bugzilla entries
- It is similar to the RedHat tools sosreport / Novell supportutils

```
root@larsson:~> dbginfo.sh  
Create target directory /tmp/DBGINFO-2010-04-25-22-06-20-  
t6345057  
Change to target directory /tmp/DBGINFO-2010-04-25-22-06-  
20-t6345057  
Get procfs entries  
Saving runtime information into runtime.out  
Get file list of /sys  
Get entries of /sys  
[...]
```

Please use the data from this tool if you open a Bugzilla (Novell/ RedHat) or a PMR !!!



vmcp

Using the z/VM CP interface device driver (vmcp), you can send control program (CP) commands to the VM hypervisor and display VM's response.

```
root@larsson:~> modprobe vmcp
root@larsson:~> vmcp q v cpus
CPU 02  ID  FF20012320978000 CP          CPUAFF ON
CPU 00  ID  FF00012320978000 (BASE) CP  CPUAFF ON
CPU 01  ID  FF10012320978000 CP          CPUAFF ON
root@larsson:~> vmcp q priv
Privilege classes for user HANS
    Currently: GU
    Directory: GU
The privilege classes are not locked against changes.
root@larsson:~> vmcp def store 32G
HCPDST094E Storage size (32G) exceeds directory maximum (5G)
Error: non-zero CP response for command 'DEF STORE 32G': #94
```

Be careful, when executing disruptive commands!



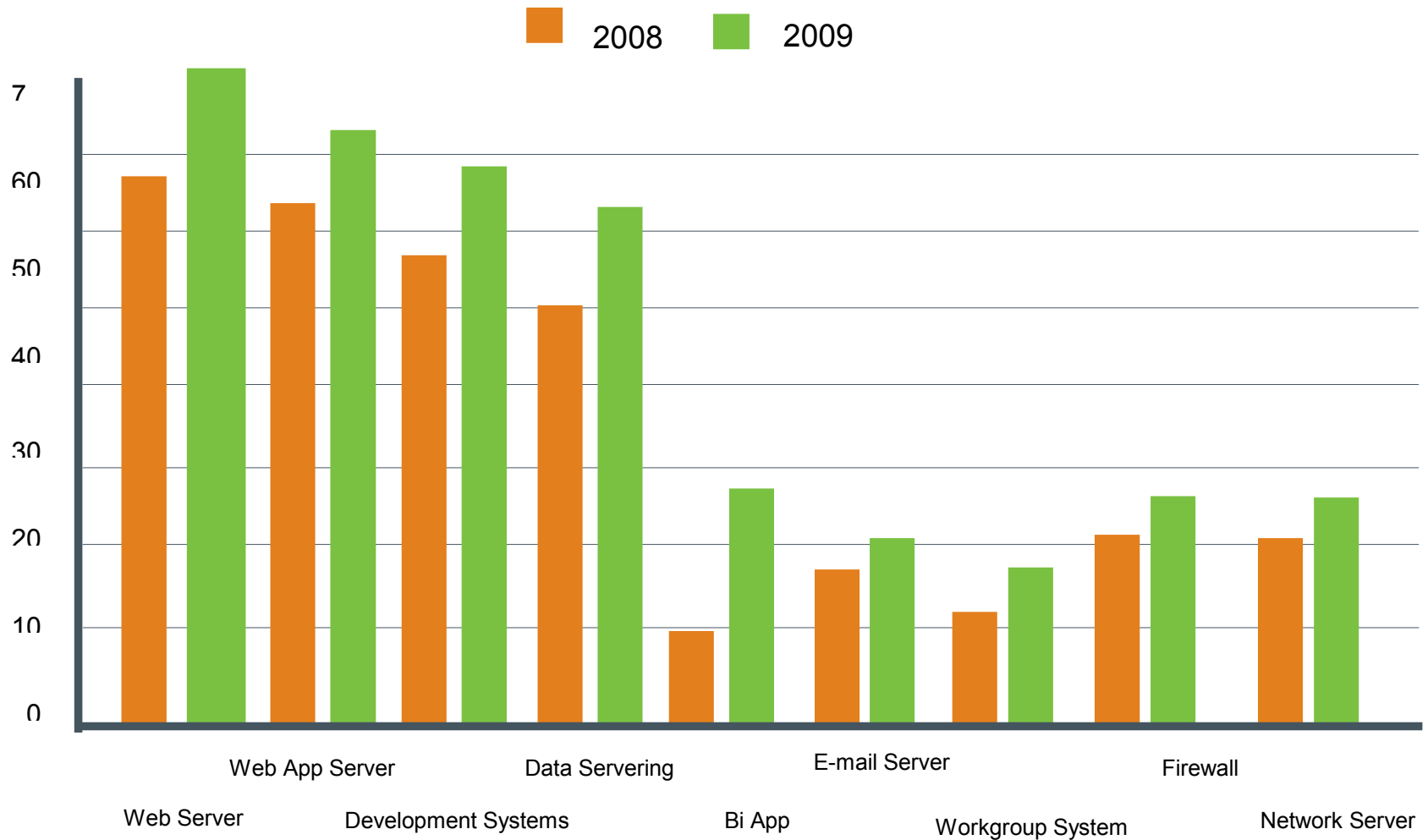
Workload share on utilized IFLs

Primary applications in the past

60%	Application serving for z/OS e.g. WebSphere, SAP, CICS TG, DB2 Connect
30%	Data serving e.g. Oracle DB, DB2 UDB
5%	Workplace serving e.g. Domino, Scalix, other e-mail
5%	Infrastructure serving e.g. Apache, Samba, NFS, etc.
<1%	Linux application development/deployment



What are Clients Consolidating to Linux on System z?



A “typical” customer: ACME Inc.

- During the second half of 2008 ACME Inc. purchased an IBM System z mainframe to act as a server consolidation platform.
- Hardware (excerpt)
 - IBM System z10 Enterprise Class
 - Model: 2097-E12
 - 96GB memory
 - 3 Integrated Facility for Linux (IFL) CPU's
 - IBM System Storage DS6800 Disk
 - Model: 1750 522
 - Parallel Access Volume (PAV) licence.
- In z10 has been configured with 4 LPARs: Production, Development, Software and one reserved for future use.
- The system is going to be used as a server consolidation platform.
 - Multiple WebSphere servers running on Intel machines will be consolidated to
 - Linux servers running as virtualized guests hosted by the z/VM operating system.
 - Each LPAR will run a z/VM 5.4 operating system.



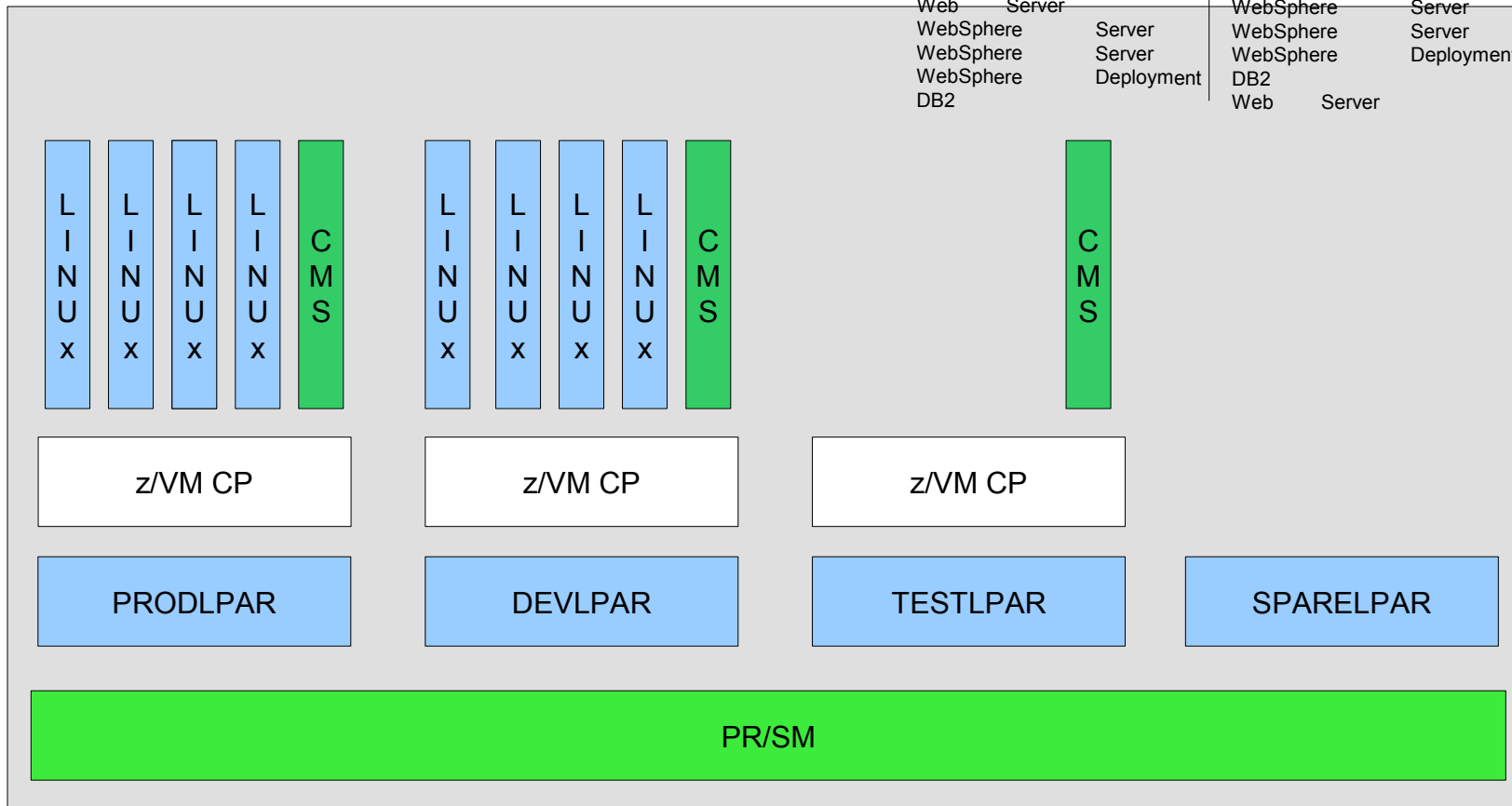
Linux & z/VM environment at ACME Inc.

- Excerpt from the customer documentation:
- In order to build a new Linux guest virtual machine a number of steps need to be completed.
 - Identify DASD required for the new Linux guest
 - Edit the CP User Directory file – adding definitions for the new guest
 - Complete RACF changes for the new guest
 - Grant access to the relevant VSWITCH
 - Edit the Kickstart files
 - Run the Kickstart process to install the Linux system
- In addition to the base **z/VM** operating system ACME Inc. has licensed a number of z/VM products.
 - Performance Toolkit
 - Omegamon XE on z/VM and Linux
 - Operations Manager for z/VM
 - Backup/Restore Manager for z/VM
 - Tape Manager for z/VM
 - Hardware Configuration Definition (HCD)/Hardware Configuration Manager/(HCM)
 - RACF
 - DFSMS/VM



Architectural Setup: ACME Inc.

System z10 2097 E12

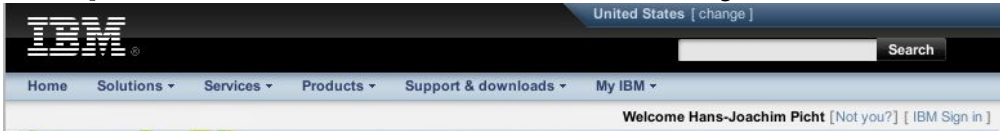


For the initial implementation each LPAR has been given access to 3 shared IFL's i.e. no dedicated IPL's have been configured
 IFL Weight: 70% Production, 10 % Development, 10 % Test, 10 % Spare LPAR



More Information

<http://www-03.ibm.com/systems/z/os/linux/els.html>



The Enterprise Linux Server – Consolidation

Leading virtualization, massive scalability and high resiliency

Consolidation through virtualization is today's remedy to get an effective and efficient. The Enterprise Linux Server runs up to hundreds of virtual Linux servers concurrently, providing isolation and protection of each virtual server environment.

Comprehensive infrastructure

The Enterprise Linux Server (ELS) brings a complete infrastructure for virtualization and consolidation within the grasp of all shapes and sizes of business.

While a variety of server options is available, the ELS provides a uniquely powerful and comprehensive solution for virtualizing, consolidating and managing Linux workloads.

Single-server Simplicity.

Having all your modern applications on one single server saves management costs, floor space and energy.

The ELS allows you to do that, through its advanced virtualization, automation features and

Virtualization to grow horizontally

Enterprise Linux Server virtualization runs directly on the hardware, simplifying the task of managing the virtual server environment.

Its ability to virtualize processing, memory, storage, I/O and networking provides advanced resource allocation and dynamic allocation.

Unmatched Resiliency, Availability and Security

The ELS is based on an IBM System z10 server, which is considered by many industry experts to be the most resilient server in the marketplace.

IBM Case Study



Computacenter helps clients cut costs with the Enterprise Linux Server offering from IBM



IBM Case Study



Atos Origin builds a cost-effective hosting solution on the IBM Enterprise Linux Server platform



IBM Case Study



Marsh achieves cost-effective Web-enablement of legacy applications with IBM Rational HATS and an IBM Enterprise Linux Server solution



Overview

- The Challenge**
Marsh wanted to make it easier for employees to use its green-screen Eurosys back-office processing application by creating an intuitive Web-based user interface. The IT team decided to deploy IBM Rational HATS, and looked for the most cost-effective platform to run the new solution.
- The Solution**
Following a detailed cost-benefit analysis, the team decided to run the solution on the IBM Enterprise Linux Server platform, creating Red Hat Enterprise Linux partitions under IBM z/VM and activating an IBM Integrated Facility for Linux (IFL) engine in Marsh's existing IBM System z9 Business Class mainframe.
- Key Benefits**
 - Web-enablement with Rational HATS reduces training costs and enables more business users to access the Eurosys application.
 - Rational HATS gives Marsh the ability to easily enhance the Eurosys application and integrate it with new solutions.
 - Even though the Linux environment is relatively small, an IBM Enterprise Linux Server solution is significantly more cost-effective than comparable low-core x86-based architectures.

- The Challenge**
With many of its clients keen to move their business-critical systems onto Linux, Computacenter wanted to find a way to deliver world-class availability and security for Linux environments at a competitive price-point.
- The Solution**
IBM has an IBM (ELS) at Computacenter, run production demonstrations of Linux on traditional architectures.



Com

- The Challenge**
To introduce new applications for major clients in the insurance and rail transport industries, Atos Origin needed to be able to support large numbers of users and high transaction volumes. The company required a high-performance infrastructure that could offer 24/7 availability.
- The Solution**
Atos Origin deployed the new application on an IBM (ELS). The System z10 provides excellent performance and reliability.



Atos

Customer case stories:
ibm.com/systems/z/os/linux/success

M Corporation



More Information

<http://www.ibm.com/developerworks/linux/linux390/>

The screenshot shows the IBM developerWorks website. At the top, there is a navigation bar with the IBM logo, a search bar, and a 'Country/region [select]' dropdown. Below the navigation bar, there are several tabs: 'Home', 'Solutions', 'Services', 'Products', 'Support & downloads', and 'My IBM'. The main content area is titled 'Documentation for Development stream' and includes sub-sections for 'Development stream', 'Novell SUSE', and 'Red Hat'. There are also links for 'Introduction' and 'Linux on System z documentation for Development stream'.

Linux on System z



How to use Execute-in-Place Technology with Linux on z/VM

March, 2010

Linux on System z



How to use FC-attached SCSI devices with Linux on System z

Development stream (Kernel 2633)

Linux on System z



How to Set up a Terminal Server Environment on z/VM

June 2009

Linux Kernel 26 - Development stream

SC94-2584-01

Linux on System z



Device Drivers, Features, and Commands

Development stream (Kernel 2633)

SC93-8413-04

Linux on System z



Using the Dump Tools

Development stream (Kernel 2633)



Questions?



Hans-Joachim Picht

Linux on System z Initiatives



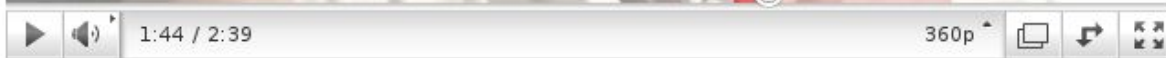
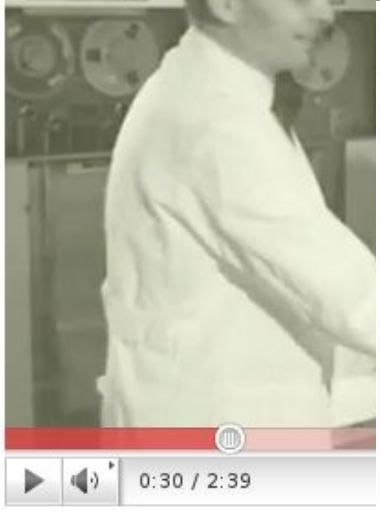
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hans@de.ibm.com*



How to explain the benefits of running Linux on System z in 2:39?

<http://www.youtube.com/watch?v=0i7kBnhN3Lg>



Your Linux on System z Requirements?

Are you missing a certain feature, functionality or tool? **We'd love to hear from you!**

We will evaluate each request and (hopefully) develop the additional functionality you need.

Send your input to hans@de.ibm.com



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NOTES: Linux penguin image courtesy of Larry Ewing (lewing@isc.tamu.edu) and The GIMP

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