Good Practices and lessons learned for IBM z/VM and Linux on IBM Z and LinuxONE

2018 VM Workshop
Room 209
Thursday, 28 June 2018 17:30

Paul Novák
Senior IT Specialist
IBM Washington Systems Center
z/VM & Linux on Z, Endicott NY

Topics Covered

- Silos, towers, and other operational segments
- Understanding order of magnitude
- Maintenance & Service
- Processors
- Dispatching
- Linux Runlevels & systemd equivalents
- Unnecessary baggage
- z/VM Memory Configuration
- Linux Virtual Memory Sizing
- z/VM Paging Subsystem
- Linux Swap Space
- z/VM Reorder Processing & SRM Settings
- z/VM SRM Settings
- Disk performance
- Linux filesystem types and options
- z/VM Dump & Spool Space
- Networking Configuration Options
- HiperSockets Bridge - Cross CEC
- MTU Sizes, Inbound QDIO Buffer, Checksums
- SYSCTL Settings
- SSI Cluster Configuration
- CTC Subchannel Addressing
- VMSSI Live Guest Relo & MAC Addressing
- VMSSI Virtual MAC Addressing
- Suggestions
- Assessments, Sizing, & Capacity Planning
- Installation, Planning, & Administration
- Reference materials

Silos, Towers, Service Drawers, Competency Bins & other operational segmentation

"This land is your land. This land is my land."

"Hey! You kids! Get your LPAR off my lawn!"

The best and worst thing about z/VM is you can share resources.

Collaborate!

z/VM System Programmers and Linux Administrators may not be in the same organization and are often split apart.

If your shop is split like this, do not think of this from the perspective of "we versus them".

Collaborate together and learn from each other!

Actively champion and support each other; find ways to automate, optimize, and attract new workloads to the platform.

Brass, woodwinds, strings, and percussion all play in the same symphony!

Experience-based viewpoints

Linux.
Unix.
Windows.
z/OS.
z/TPF.
z/VM.
z/VSE.

It is easy to over-allocate resources

Monitoring is important to examine resource usage

- hardware
- hipervisor
- virtual machines

Real-time and historical metrics demonstrate peak periods as well as average runtimes.

Be sure you are collecting z/VM MONITOR records! There is no good reason not to.

Hardware matters!

z/VM is actual virtualization plus hardware assistance

- Hardware instructions match the physical hardware being used
- Hardware offers bespoken qualities to assist with optimizing the hipervisor
- Nearly all other hypervisor solutions are virtualization with binary translations; the hypervisor is used to translate operating system functions in a way that fully abstracts the guest OS from the underlying hardware.

Cross-platform virtualization increases challenges

- Virtualization experience on another platform does not necessarily translate to others.
- Don’t assume.

Rough order of magnitude

Performance tuning and problem determination is typically done in the wrong order. Should be done as such:

- Tuning: Work MICRO to MACRO
  1. Application
  2. Environment
  3. Middleware / Software
  4. Guest OS
  5. Hypervisor
  6. Hardware
- PD: Work BACK to FRONT
  1. Application
  2. App Server (Software)
  3. App Server's Hypervisor
  4. App Server (Hardware)
  5. Proxy / Network

Why order of magnitude is important

1. Design

   Project Engineering / IT Architecture for both application and operating environment (dev/test & prod)
2. Implementation
3. Middleware / Software
4. Guest Operating System
5. Hypervisor
6. Physical Frames (CPCs), appliances, switches, or other hardware

- No amount of time or effort spent on items lower in the list will ever fully compensate for problems or shortcomings of items above them!
- In certain (most) cases, trying to resolve or minimize a problem via changes to one of the entries further down the list will make it exponentially worse and/or create other problems, sometimes even more serious.
- **Application design and implementation combined represent roughly 85% of where most problems originate**
- Additional breakdown and some examples on the next slide…

Examples: Order of magnitude

Architecture / Design

- **User Experience Design is CRITICAL!**
- Fit-for-purpose
  - DB use when unnecessary
- Blocking of I/O, loading, rendering, etc.
- Poor performing SQL
- Fault intolerance

Middleware

- Service/Fix level
- Version/Release level
- DBs indices
- Datasources and connectors
- .conf / .ini / tuning

Guest Operating System

- Service/Fix level
- Kernel & I/O parms
- Oversized logs
- Volume capacity
- NIC/TCP stack
- Scheduling method

Implementation

Java web app burdening JRE with requests for static objects instead of serving from filesystems

No acceleration (reverse caching proxy, compression, CDN, etc.)

No proper load balancing, keepalives, threading

Poorly formed code (HTML or XHTML)

Massive cookies, over-scoped cookies

Order of Magnitude

1. Architecture / Design
   - User Experience Design (UxD) CRITICAL but often ignored or overlooked
   - DB use when unnecessary
   - I/O blocks
   - Poor performing SQL
   - Fault intolerance

2. Implementation
   - J2EE app burdening JRE with requests for static objects from filesystem(s)
   - No reverse caching proxy
   - No compression
   - No proper load balancing
   - No keepalive parms set
   - Poorly formed HTML or XHTML

3. Middleware
   - Service/Fix level
   - Version/Release level
   - DBs indices
   - Datasources and connectors
   - .conf and/or .ini parms

4. Guest Operating System
   - Kernel parms
   - Oversized logs
   - Volumes near/at capacity
   - NIC/TCP stack parms
   - Scheduling method
   - I/O methodology

5. Hypervisor
   - User Directory parms
   - Buffer pools
   - Dispatching
   - Over allocation of RAM to guests
   - Improperly configured VSWITCH or QDIO NIC parms

6. Frame / Hardware
   - Microcode
   - Millicode
   - Firmware
   - I/O definitions
   - Cabling
   - Hardware fault

Stay Updated.
Apply Service.
Install Fixes.

Apply z/VM Service.

z/VM Service basically means system software service in the form of updates, patches, enhancements, new features, and the like.

Regular Service is published in a bundle called a Recommended Service Upgrade (RSU)

- Similar in concept to an AIX™ ML/TL, Linux Service Pack, or Windows® Cumulative Fixpack
- An RSU is typically released every 3 to 6 months and contains cumulative service and includes all pre and co-requisites. No guesswork!
- Includes service for all integrated components and pre-installed program products
- Includes service required by most customer installations and is pre-tested by z/VM development to help ensure a quick, smooth, successful result!
- Easy to install, just as easy to back-out if necessary
    - Install: SERVICE and PUT2PROD
    - Back-out: SAPL – IPL from CPLOAD MODULE then issue VMSES - VMFREM

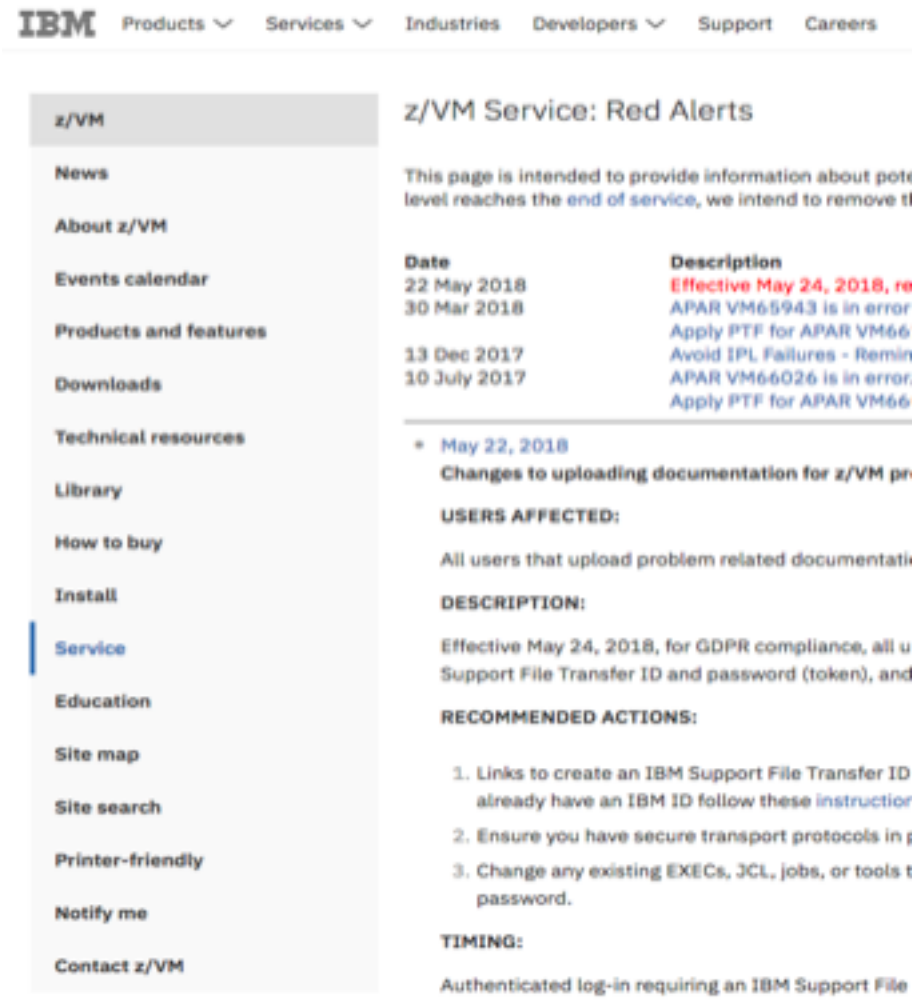
More about z/VM Service

Your governance model should include applying z/VM service (updates) on a regularly scheduled basis.

- **At a minimum, plan to install RSUs or PTFs quarterly.**
- Systems with VMSSI and LGR can utilize these features to reduce cycle time.
- Use the command `CP QUERY SERVICE` to display the service table of all installed service.

Visit the following pages on ibm.com for the full details:

- www.ibm.com/vm/service/news
- www.ibm.com/vm/service/redalert
- www.ibm.com/vm/service/rsu
- Strongly recommend using the subscribe feature (“notify me”) to be automatically notified of any changes for all three pages.



Stay Updated – Apply Linux Updates!

- While there is occasionally some risk involved with running at the cutting edge, there is much, much greater risk when you fall behind!
- Staying down-level can expose you to zero-day vulnerabilities.
- Recommend using the most current release or version for your Linux distribution of choice. Ensure it has been tested and officially supports all required middleware and/or applications.
- Distribution service pack updates include:
  - Fixes and Security patches
  - Performance enhancements
  - New functionality
- Leverage native utilities in your Linux distribution to stay current:
  - SLES: YaST Online Update (YOU) or Zyp UP
  - RedHat: Yum update or use the RedHat Network (RHN)
  - Debian & Ubuntu: Advanced Packaging Tool (APT)

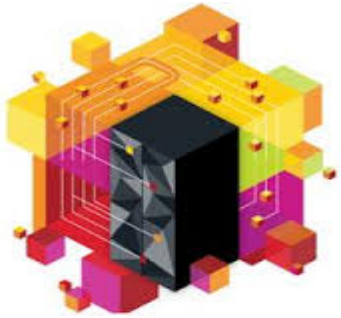
Stay Updated – Apply Linux Updates!

- Newer kernels typically include support for newer features, such as enhancements made for containerization.
- Check your kernel level easily from your Linux shell by issuing “uname -r”

Processors (Cores): Physical, Logical, and Virtual

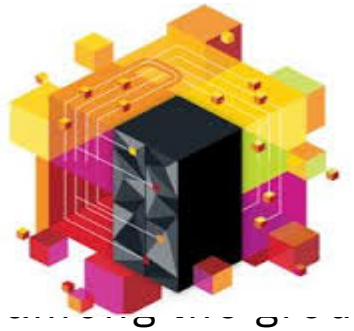
- Physical: Actual number of purchased cores / engines (CPs, IFLs, etc…)
- Logical: Number of cores / engines defined to an LPAR in the PR/SM activation profile or DPM server config.
  - Systems development recommends a max ratio of 4 logical to 1 physical in NON-PRODUCTION.
    - Real life experience is that 3:1 is about the max.
  - Always define reserved processors in z/VM LPAR Activation Profile to enable non-disruptive activation of additional engines in the future.
  - Use the command `QUERY PROCESSORS` from a class A,B,C, or E virtual machine to see details.
- Virtual: Number of cores / engines defined to a z/VM Virtual Machine (USER or IDENTITY).
  - Do not define more virtual processors than there are logical processors in the LPAR.
- Keep in mind engine types (specifically, CPs and IFLs) do not automatically mix together inside of a z/VM LPAR or it's virtual machines.
  - If you create an LPAR in "z/VM Mode" with both CPs and IFLs, z/VM will consider the CPs to be the IPL Processor Type, and all processor dispatching will use ONLY the CPs by default.

Processors – Hiperdispatch and EII



- HiperDispatch
  - Provides more efficient utilization of CPU hardware resources for dispatched work.
  - Strengthens affinity between where work is dispatched and where associated data exists, avoiding delays to retrieve
  - Recommend using fewer, larger LPARs with HiperDispatch for better performance and improved throughput
- Environment Information Interface
  - Provides ability to obtain CPU resource information and to enable virtual machines to understand the characteristics of the environment in which they are running
  - Information is provided at many levels - the machine, logical partition, CPU pool, virtual machine.

Processors –Pooling



- Resource (CPU) pools
  - Define and limit resources a group of z/VM guests is allowed to consume as a whole among the group
  - Set a boundary on lower-priority workload guests when grouped together as a pool
  - Recommend defining pools to help ensure licensing compliance and better control priorities.
- In z/VM PerfKit, check reports:
  - FCX324 (CPU Pool Menu)
  - FCX308 (CPU Pool Configuration)
  - FCX309 (CPU Pool Activity Data)

Processors - Dynamic Simultaneous Multithreading

Dynamic SMT added to change the number of active threads per core without a system outage

- z/VM 6.4 allows one to dynamically change the number of active threads per core when SMT has been enabled in the SYSTEM CONFIG file.
  - `MULTITHREADING ENABLE TYPE ALL 1`
  - System configuration file statement enables SMT-1 (1 thread per core)
- Potential capacity gains going from SMT-1 to SMT-2
  - (one to two threads per core) can now be achieved dynamically
- Downgrade from SMT-2 to SMT-1 in extremely rare case that it is not optimal for workloads (response time concerns greater than capacity gains)
  - Once z/VM has started, toggle between 1 and 2 threads via CP command `SET MT TYPE ALL 2` and query status and information with CP commands `QUERY MULTITHREAD` and `INDICATE MULTITHREAD`
- Requires:
  - IPL with SMT enabled, but can vary active threads per core
  - Requires z13, z13s, LinuxONE Emperor or LinuxONE Rockhopper ....or newer CPC.
- If more than 32 cores are required per LPAR, can **not** use SMT -- even with one active thread per core.

Guest Virtual Processors

- Be aware:
  - Of the maximum per virtual machine based on VM version and your hardware.
  - That various guest operating systems and workloads scale differently
- Recommendations:
  - Configure number of virtual processors per guest for peak workload, no more
  - Do not define more virtual processors to a guest than logical processors defined to the z/VM LPAR
  - Watch data from z/VM Performance Toolkit (or other similar product)
- In z/VM PerfKit, check reports:
  - FCX100 (CPU)
  - FCX104 (Privileged Operations)
  - FCX114 (USTAT / Wait State Analysis by User)

Guest Virtual Processors – What to watch for

- In z/VM PerfKit
- Report FCX100 (CPU)
  - FCX100 look for Total:Virtual ratio (%CPU:%EMU). The closer to 1.00 the better.
- Report FCX104 (Privileged Operations)
  - High diagnose x’44’ or x’9C’ rates may be an indication of too many virtual processors
  - FCX104 thresholds to watch for:
    - x’44’ > 50,000/sec
    - x’9C’ > 5,000/sec
- Report FCX114 (USTAT / Wait State Analysis by User)
    - %CPU wait should be low

Adjust the ‘SHARE’ of Virtual MP Machines

- The default SHARE setting for all virtual machines is “Relative 100”:
  - VM dispatches users by VMDBK
  - There is one VMDBK per virtual processor defined
  - A users SHARE setting is divided among the defined virtual processors
- Recommend resetting the SHARE of Virtual MP Machines:
  - Set SHARE RELATIVE (100 * number of virtual CPUs defined)
  - This maintains a “level playing field”
- Adjust SHARE of guest virtual machines from this point, as required:
  - Increase SHARE to prioritize
  - Decrease SHARE to penalize
- A virtual machines SHARE only comes into play when there is contention for resources, primarily CPU
- As of 6.4, CP now honors SHARE settings more accurately than previous releases. For more details, see the SRP article listed at the end of the presentation.

More about shares

- Priorities of users (virtual CPUs) are controlled by the SHARE setting. There are 2 types:
  - Relative - valid range 1-10000
  - Absolute - valid range 0.1-100%
- Virtual machine share setting is divided by the number of virtual CPUs and assigned to each virtual CPU.
  - Minimum relative share per CPU is 1
- Set in the directory or with the CP SET SHARE {userid} command
  - Show the current setting with CP QUERY SHARE {userid}
- Absolute share users given resource first
  - If sum of absolute shares > 99%, normalized to 99%
  - Leftover share (minimum 1%) available for relative share users
- For relative share users - actual share depends on total relative shares of all virtual CPUs
  - A virtual CPU gets (vCPU relative share / total relative shares) %

Limiting shares

- There are two kinds of limits which can be set:
  - LIMITSOFT
  - LIMITHARD
- With the changes made to dispatching and SRM, if you're using either of these you may want to investigate if these are indeed producing the results you might be expecting.

Quick Dispatch

- Setting QUICKDSP traditionally would have:
  - Bypassed System Resource Management controls
  - Placed a virtual machine directly into the dispatch list
  - Made a virtual machine exempt from being placed in an eligible list
- QUICKDSP should be reserved for use only with:
  - Service Virtual Machines performing critical functions on behalf of other guests such as TCPIP, RACF, or DTCVSW#
  - Selected high-priority or key production guests running things like DB2, WebSEAL, Edge Load Balancer, DynaCache, IBM Directory Integrator, etc.
  - If you are not already using QUICKDSP for a virtual machine, you should only do so at the recommendation of IBM VM Support.
- Interested in learning more about how SRM used to function? See the reference materials slides at the end for an excellent detailed explanation by Malcolm Beattie (IBM) .

Linux Runlevels and target states

- Linux has different modes of operation.
  - Under system-v they are “runlevels”
  - Under systemd, they are target states

Linux Runlevels and target states

- Linux has different modes of operation.
  - Under system-v they are “runlevels”
    - The typical system-v runlevels are:
      - 0 - Halt the system
      - 1 - Single-user mode
      - 2 - Multi-user mode (without networking)
      - 3 - Multi-user mode
      - 5 - Multi-user mode (display manager, GUI)
      - 6 - Reboot the system
    - When you boot Linux, it will initialize to a pre-defined default runlevel (usually 3 or 5).
      - Most desktop Linux systems boot into RL 5 by default; users are presented with a GUI.
      - Most server Linux systems boot into RL 3 by default; users are presented with a CLI.
      - Query the current runlevel with the command: `runlevel`
      - You change between them with the command: `telinit {target #}  e.g.  telinit 3`

Linux Runlevels and target states

- Under systemd, they are target states
  - The typical systemd targets are:
    - poweroff.target (or runlevel0.target) - Halt the system
    - rescue.target (or runlevel1.target) - Single-user mode
    - multi-user.target (or runlevel3.target) - Multi-user mode
    - graphical.target (or runlevel5.target) - Multi-user mode (display manager, GUI)
    - reboot.target (or runlevel6.target) - Reboot the system
    - emergency.target
  - When you boot Linux, it will initialize to a pre-defined default target (usually multi-user or graphical).
    - Most desktop Linux systems boot into graphical.target by default; users are presented with a GUI.
    - Most server Linux systems boot into multi-user.target by default; users are presented with a CLI.
  - Check the default target with the command `systemctl get-default`
  - Set the default target with the command `systemctl set-default {choice}.target`
  - Change the running target level with the command `systemctl isolate {choice}.target`

Linux Runlevel

- Recommendation is RL 3 or multi-user.target for Linux guests of z/VM
- X services are very costly in terms of CPU cycles and RAM
- When improperly configured, graphical subsystems can pose a potential risk vector such as GDDM listening on all interfaces
- Production systems should never have full graphics enabled
- When necessary, use a lightweight X-server like VNC server instead of full GUI desktop and
  - Ensure that it is fully disabled once you are done

Unnecessary Guest Virtual Machines

- Shutting down unnecessary guest virtual machines helps to improve the overall performance of the system:
  - Linux guest virtual machines almost never go dormant
- Logoff:
  - Golden images used for cloning
  - Test machines and “sand boxes”

- Suspend:
  - Production guests not necessary during POC testing or benchmarking of another application or workload
  - See Chapter 39, Suspending and resuming Linux in the current Linux on System z Device Drivers, Features, and Commands Manual
- Reduce “SHARE” setting for virtual machines running lower priority workloads

Unnecessary Services/Applications

- There are a number of services in Linux that get started at boot depending on:
  - Distribution
  - Linux kernel level/version
  - Installed software packages

- Shutting down unnecessary services and unused applications helps to improve the overall performance of the system
  - Status of services can be queried/changed with the “chkconfig” command
- The cron daemon is useful for scheduling events to be kicked off automatically at a specific time or at regular intervals
  - Running many guests with identical schedules can cause CPU spikes and stress the z/VM paging subsystem:
    - Remove unnecessary events from cron
    - Consider switching to anacron for events which must remain
    - Stagger scheduled kick-off time of events – especially for high I/O tasks like backups

z/VM Memory Configuration – Central Storage

- Max 2TB (Initial plus Reserved) – Set in HMC LPAR Activation Profile
- Plan on a virtual to real (V:R) memory ratio in the range of 1.5:1 to 3:1
  - Production systems will typically be closer to the low end of range
  - Development/Test systems may be able to push the upper end of range
- STANDBY memory can be added and removed dynamically to central storage:
  - Storage must be defined as “RESERVED” in the LPAR Activation Profile
  - Under z/VM 7.1, memory can be added and removed dynamically.
  - Under z/VM 6.4 and older, memory cannot be removed dynamically, only added.
  - This is because linux tends to automatically address all memory available to it for use as cache. (Cached RAM is good under x86 distributed, but undesirable for a z/VM environment)

z/VM Memory Configuration – Expanded Storage

- As of z/VM 6.3 is no longer supported.
- z14 is the last CPC to even offer it at all in the HMC UI.
- Any storage previously configured as expanded should be combined into central.
- Convert any expanded storage to central storage (real memory) before bringing up z/VM 6.4
- See the STORCONF URL on the *Additional Information* slide for details

z/VM memory configuration – considerations

- z/VM 6.4 increases supported real memory from 1 TB to 2 TB at LPAR level (Central storage)
  - Individual Virtual Machine (USER / IDENTITY) limit remains at 1TB
- Ensure sufficient dump space
- Ensure sufficient paging space
  - Even if not increasing memory used, a good time to double check space guidelines
  - Check out the VIR2REAL utility on the z/VM Downloads page (See *Additional Information* slide)

z/VM memory configuration – considerations

- Support for Virtual Machine (Linux) 1 MB large pages in 6.4
  - Scale better and improve guest memory management
  - Be more fair across users
  - Honor reserved memory settings better
  - To use this from Linux:
    - Build a kernel containing large page exploitation (this is the default build), add hugepages=<n> kernel parameter (number of large pages to be allocated at boot time)
    - If desired, set sysctl variable to enable allocating large pages from moveable memory
- Be proactive in writing out memory pages to disk
  - Read and write blocks of pages
  - Use parallel channel paths (PAV) when available.

Linux virtual memory sizing

- The maximum supported virtual machine memory allocation is 1TB
- The most common mistake made by customers running Linux guests under z/VM is over-provisioning virtual memory due to lack of understanding
- In a commodity hardware environment – including both dedicated servers and other virtualization solutions:
  - Traditional wisdom suggests installing as much memory as possible
  - Excess memory is used as I/O buffer and file system cache
  - This cache and buffer is usually required to overcome the architectural limitations of the most popular commodity processor cores
    - Also the reason you typically see a drop off in performance at around 80-85% CPU utilization on these cores…

Linux virtual memory sizing

- The z/VM platform is not a commodity platform
  - Using thinking and methodologies from x86 does not apply!
- In a virtualized environment under z/VM, guests with excessively allocated RAM place unnecessary stress on the VM paging subsystem and can easily make guests run VERY POORLY
    - Real memory is a shared resource. caching pages in a Linux guest reduces memory available to other Linux guests
    - Larger virtual memory requires more kernel memory for address space management
    - Live Guest Relocation takes longer to complete
  - Rightsizing Linux memory requirements on z/VM:
    - Is accomplished through iterative tuning of the STORAGE value for the virtual machine
    - Monitored with the “free” or “vmstat” commands along with /proc/meminfo
  - Reference the following document by Stephen Wehr (IBM):
    - ftp.software.ibm.com/common/ssi/sa/wh/n/zsw03049usen/ZSW03049USEN.PDF

z/VM paging subsystem

- Block paging changes eliminated the benefits of 50% page space, making monitoring very important.
  - No loss of efficiency above 50% page space utilization
  - Contiguous storage no longer needed for block paging
- Recommend monitoring focused on availability versus performance (avoid ABEND)
  - Monitor for rapid growth in page space as well as overall size thresholds
- Early writing's goal is to keep the bottom 10% of the global aging list prewritten.
- Whether written-on-demand or pre-written, page space is still being used. From a monitoring perspective, this is all that matters.
- The closer your monitoring threshold is to 100%, the more automation is necessary to avoid an ABEND (how quickly page space can be added).
- Do not mix page space with any other space on a volume

z/VM paging subsystem – continued

- Rule Of Thumb - Plan for a DASD page space utilization < 90%:
  - Monitor usage with Q ALLOC PAGE command and automation
  - Block page size is the key performance indicator:
    - Aim for double digits, 10 or more 4K pages per block set
    - Perfkit report - FCX109 (CP Owned Device)
- Use multiple channels to spread out I/O to paging devices
- Recommend using devices of the same size/geometry
- Leverage HYPERPAV for paging devices and use fewer, larger devices
  - Recommend enabling via command and if no surprises, update system configuration file
    - Command: `SET PAGING ALIAS ON`
    - Configuration file: `FEATURES ENABLE PAGING_ALIAS`
    - Can also be controlled at control unit level

z/VM paging subsystem – continued

- For environments where the overcommit level is low and large amounts of real memory are being used, you will want to consider disabling early writes and keep slot
  - `SET AGELIST EARLYWRITES NO KEEPSLOT NO`
- EDEVs as paging drives are an option:
  - Have observed 1.6 I/Os per emulated FBA volume
  - At slightly higher CPU costs
- Page space calculation guidelines are located in the CP Planning and Administration Manual

Linux swap

- The traditional recommendation in a dedicated server environment is that swap space should be twice the memory size of a Linux machine
  - This does not apply to a z/VM Linux guest:
    - Some swap space should be defined to prevent Linux from hanging and/or a kernel panic during unexpected memory demands
    - Properly sized Linux guests should have minimal swapping under normal load
- z/VM offers multiple options for swap devices
- Recommendation:
  - One or two small V-disks (256MB - 512MB)
  - If necessary, additional minidisk(s) or dedicated volume(s)
    - Set priorities in fstab so that the V-disk(s) are used first
- See *Additional Information* slide for more details and test results for various swap device options
- Virtualization Cookbook series covers how to setup VDISK and automatically format them at boot time

Memory management assist considerations

Collaborative Memory Management Assist (CMMA)

- Sometimes referred to as just “CMM”
- Extends coordination of memory and paging between Linux and z/VM to the level of individual pages
- CP reclaims so-called “unused” pages at a higher priority, to reduce wasted memory
- Bypasses host page writes for unused and volatile pages, effectively cleaning up disk cache pages
- Be sure you test out the effects of CMMA on any virtual machines running Java with large heap sizes or databases, as these kinds of workloads can be intolerant sometimes.

VM Resource Manager Cooperative Memory Management (VMRM-CMM)

- Sometimes referred to as “CMM2”
- VMRM detects when there is memory constraint and notifies specific Linux virtual machines with a CP SMSG
- The notified Linux VMs can then take actions to adjust their memory utilization in order to relieve this constraint on the system, usually issuing a CP DIAGNOSE X'10' instruction to release pages of storage.
- Also important to test before using with production workloads

SFS is your friend!

- As of z/VM 6.4 the default location for components is SFS instead of minidisks
  - Minimizes having to waste time to mess around resizing (move to new & copy contents) minidisks:
    - This can be disruptive (usually is)
    - Can also create fragmentation on your DASD
  - You could still elect to override and use minidisks instead, but why?
    - When you install Linux, do you create separate non-LVM volumes of fixed sizes for each individual path you intend to mount?
    - Spend more of your time on optimizing your system instead of managing disks

z/VM minidisk cache

- z/VM minidisk cache is a write-through cache:
  - Improves read I/O performance, but, it’s not free in terms of system resources
- Not recommended for:
  - Memory constrained systems
  - Non-shared Linux file systems
  - Linux swap file disks
- Default system settings are less than optimal. Recommended settings:
  - Disable MDC for non-shared Linux minidisks
    - Code `MINIOPT NOMDC` operands on the MDISK directory statement
  - Limit MDC in central storage, amount depends on usage
    - `SET MDC STORE 0M 256M`
  - Monitor with Q MDC command and/or a performance monitor
    - Perfkit report - FCX103 (Storage Utilization)

Disk performance

- Hardware connectivity choices:
  - FICON available in 1Gb, 2Gb, 4Gb, 8Gb, 16Gb channel speeds
- SCSI verses ECKD/FBA recommendations:
  - ECKD or FBA for z/VM and Linux “/” file system
  - SCSI LUNs for application data and databases
- Maximize hardware performance:
  - Use maximum speed channels
  - Configure maximum number of channel paths
  - Spread disks over multiple ranks within a storage subsystem
  - Use logical volumes with striping
  - Consider exploiting PAV or HyperPAV to prevent queuing
- References and more information on the *Additional Information* slide

Linux filesystems – EXT

- EXT2 – Formerly the most widespread, falling out of favor due to lack of journal
- EXT3 – Evolution of EXT2 with the addition of file system journal. Still 32-bit, so file sizes and file systems limited in size (you can push these limits somewhat, but can introduce instability doing so)
- EXT4 – The latest evolution - 64-bit:
  - Supports HUGE sizes for both individual files and overall file systems
    - Maximum individual file sizes can be up to 16 TB!
    - Overall maximum file system size is 1 EB (exabyte).
      1 EB = 1024 PB (petabyte) ; 1 PB = 1024 TB (terabyte)
  - Directories can contain a up to 64,000 sub directories (EXT3 was 32,000 max.)
  - Multi-block allocation and delayed allocation
  - Journal checksum
  - Fast fsck
  - These new features have improved the performance and reliability of EXT4, making it a clear choice when compared to EXT3.

Linux filesystems – others

- JFS - a port of OS/2 Warp Server JFS to Linux. Very popular for file systems with large numbers of BIG files. Supports max file size of 4 PB and max FS size of 32 PB.
- Reiserfs – The former default for SuSE. Journaling behavior is comparable to EXT3 in order mode. EXT4 exhibits better performance and is favored over Reiser.
- XFS - the IRIX file system, which was released in 2000 as open source. Also extremely popular in systems with large files. Max size of both individual files and FS is 8 EB. The default for Redhat as of version 7.

Linux file systems

- Recommend using EXT4 or XFS:
  - Journal capabilities
  - Widely used across major distributions
  - Reduced CPU load compared to other journaled file systems
- Using EXT4:
  - Use the proper journal for your workload: Three options are journal, ordered, writeback
  - /etc/fstab should use the flags `nodiratime,noatime` unless you really need them on because you're using some really cheap commodity disks

Linux file systems

- Temporary and volatile files:
  - Utilize fstab to mount /tmp as a tmpfs in RAM or mount several smaller ramdisks
    `tmpfs  /tmp  tmpfs  defaults,noatime,mode=1777  0  0`
  - Leverage shared dynamic ramdisk (/dev/shm or /run/shm) if your distribution creates it for writing out many tiny files, but monitor utilization closely – make sure you don't fill it to more than around 80-85% capacity.
  - If none of the above work for you, create an EXT2 filesystem for temp file use. You don't need a journal, LVM, striping, mirroring, or atimes on volatile data!

I/O options and considerations

Direct I/O (DIO) transfers data directly from the application buffers to the device driver, and avoids copying data to the page cache.

- Advantages: Saves page cache memory, avoids double-caching data, allows larger database buffer pools
- Disadvantages: Sizes of requests may be smaller, potential for corruption on access violations

Asynchronous I/O (AIO) does not block / hold back the application while waiting for an I/O operation to complete. The operation continues in the background, notification is generated upon completion.

- Advantages: No waiting for I/O completion, reduction in utilization of RAM and CPU via reduced quantity of I/O processes/threads.

- Disadvantages: Most applications or middleware must be specifically coded to leverage this type of I/O operation.

- When possible, use BOTH:
  - Use direct I/O to avoid double buffering of files in memory
  - Use asynchronous I/O to continue program execution while data is fetched

z/VM dump space

- Dump Space
  - Ensure there is sufficient dump space defined to the system
    - Recommend to re-check twice annually at least. You do not want to find out you don't have enough dump space during a problem
    - Recommend defining dedicated dump volumes
  - Dump space requirements vary according to memory usage
  - `QUERY DUMP` command identifies allocated dump space.
  - Calculation guidelines are located in the CP Planning and Administration Manual

z/VM spool space

- Spool Space
  - Various uses:
    - User printer, punch, reader files (console logs)
    - DCSS, NSS, system files
    - Page space overflow
- Spool Management:
  - Monitor with `QUERY ALLOC SPOOL` command
  - Recommend using the `SFPURGER` utility on the MAINT 193 minidisk
    - Rule-based, used to clean up spool space
    - Included in the no charge CMS Utilities Feature (CUF)
    - Virtualization cookbook covers how to set this up to run automatically
    - Or, run manually if needed to quickly take action
      Test first: `VMLINK MAINT 193 < = = RR > ( INVOKE SFPURGER TEST)`
      If test looks ok: `VMLINK MAINT 193 < = = RR > (INVOKE SFPURGER FORCE)`

Networking configuration options

Three basic configurations for external network connectivity:

- Dedicated OSA (not recommended)
- Routed LAN
- VSWITCH is recommended:
  - Lower CPU costs
  - Built-in failover
  - Operates in Ethernet or IP modes (Ethernet is recommended)
  - Supports 802.1q VLANs (by port or by user)
  - Supports port isolation
  - Supports 802.3ad link aggregation

Cross LPAR network connectivity:

- Shared OSA Express
- HiperSockets
- HiperSockets Bridge

References:

- z/VM Connectivity Manual (SC24-6174-03)
- Networking Overview for Linux on Z Redpaper (See *Additional Information* slide)

VSWITCH options

- Keep in mind that Live Guest Relocation requires the option for PORTBASED or USERBASED to be set identically on the z/VM systems you will be relocating your Linux VMs within
- Recommend using PORTBASED
  - Easier to conceptualize since physical switches use port numbers for everything
  - Easier to keep track of and manage from an SCM perspective
- Recommend using VLAN AWARE NATIVE NONE when using ETHERNET
- Example of PORTBASED ETHERNET with VLAN AWARE NATIVE NONE:
  - `DEFINE VSWITCH VSW1 ETHERNET PORTBASED RDEV xxxx xxxx VLAN AWARE NATIVE NONE`

Directory Network Authorization

- As of z/VM 6.4 RSU 1702, Directory Network Authorization (DNA) made it so that the virtual NIC for each (Linux) Virtual Machine is now fully configured by statements in the user directory entry:
  - Inclusion of NICDEF statement(s) in a directory entry will now:
    - Define the virtual NIC
    - Grant authorization for the virtual machine to couple a VSWITCH
    - Couple the virtual NIC to the VSWITCH
    - Example:

```
NICDEF F001 TYPE QDIO LAN SYSTEM SWITCH1
NICDEF F001 MACID F30006
NICDEF F001 VLAN 256
```

- DNA eliminates requirement to include directory statements (or under AUTOLOG#, etc.):
  - MODIFY VSWITCH
  - SET VSWITCH GRANT
  - COUPLE

MTU sizes matter

- Set MTU to the maximum supported by all hops on the path to the final destination to avoid fragmentation:
  - Use Linux command `tracepath destination` to verify the path MTU size
  - If the application data is <=1400 bytes, use an MTU size of 1492 instead of Linux default of 1500
  - If the application is able to send larger chunks of data, use an MTU size of 8992 for jumbo frames
- TCP uses the MTU for the window size calculation, not the actual application send size
- For VSWITCH, an MTU size of 8992 is recommended:
  - OSA card is optimized for use with an 8992 MTU
  - Synchronous operation, SIGA required for every packet
  - No packing like a dedicated OSA card
  - Be sure PATHMTU discovery is turned on & your network will pass ICMP type 2 packets
- For HiperSockets, select an MTU size to suit the workload:
  - If an app is capable of sending large packets, larger MTU will increase throughput & decrease CPU use
  - An MTU size of 56K is recommended only for data streaming workloads with packets >32KB

Inbound QDIO Buffer

- The QDIO inbound buffer queue can be increased for high volume workloads:
  - The default is 16
  - Valid range is 8–128
  - QDIO OSA buffer size is 64K
  - IQDIO HiperSockets buffer size is equal to the HiperSockets MFS (16K, 24K, 40K, 64K)
- Current buffer count can be displayed with the Linux command `lsqeth -p`
- A QDIO OSA buffer count of 128 equates to 8MB locked memory: 128 x 64KB = 8MB
- Set the inbound buffer queue size in the appropriate config files:
  - SLES 12: /etc/udev/rules.d/51-qeth-0.0.f200.rules add:
    `ACTION=="add", SUBSYSTEM=="ccwgroup", KERNEL=="0.0.f200", ATTR{buffer_count}="128“`
  - RHEL 6: /etc/sysconfig/network-scripts/ifcfg-eth0 add:
    `OPTIONS="buffer_count=128"`

Checksumming

- Recommend turning off checksumming for HiperSockets because:
  - It is a memory-to-memory operation protected by ECC, checksumming is a total waste of CPU!
  - Turning off checksumming for HiperSockets can save between 7%-13% in CPU costs
- The default setting is sw_checksumming. To turn it off:
  - SLES 12: /etc/udev/rules.d/51-qeth-0.0.f200.rules add:
    ```
    ACTION=="add", SUBSYSTEM=="ccwgroup", KERNEL=="0.0.f200",
    ATTR{checksumming}="no_checksumming"
    ```
  - RHEL 6: /etc/sysconfig/network-scripts/ifcfg-eth0 add:
    ```
    OPTIONS="checksumming=no_checksumming"
    ```

SYSCTL settings

- sysctl settings can be changed
  - temporarily by the `sysctl` command, or,
  - permanently in the config file /etc/sysctl.conf
- If less than 2500, the processor input queue length should be increased to at least 2500
  - using sysctl: `sysctl -w net.core.netdev_max_backlog =2500`
- Adapt the inbound and outbound window size to suit the workload
  - The following values are recommended for OSA devices:
    - sysctl -w net.ipv4.tcp_wmem="4096 16384 131072"
    - sysctl -w net.ipv4.tcp_rmem="4096 87380 174760"
  - System wide window size applies to all network devices
  - Applications can still use `setsockopt` to adjust the window size

SYSCTL settings – continued

- As a general rule of thumb, the default send/receive window size should be at least twice the MTU size
  - The SAP Enqueue Server requires a default send/receive window size of four times the MTU size
- For modern kernels, the following are recommended:
  - sysctl -w vm.dirty_ratio=10 (default is 20)
  - sysctl -w vm.dirty_background_ratio=5 (default is 10)
  - sysctl –w vm.swappiness=5 (default is 60)

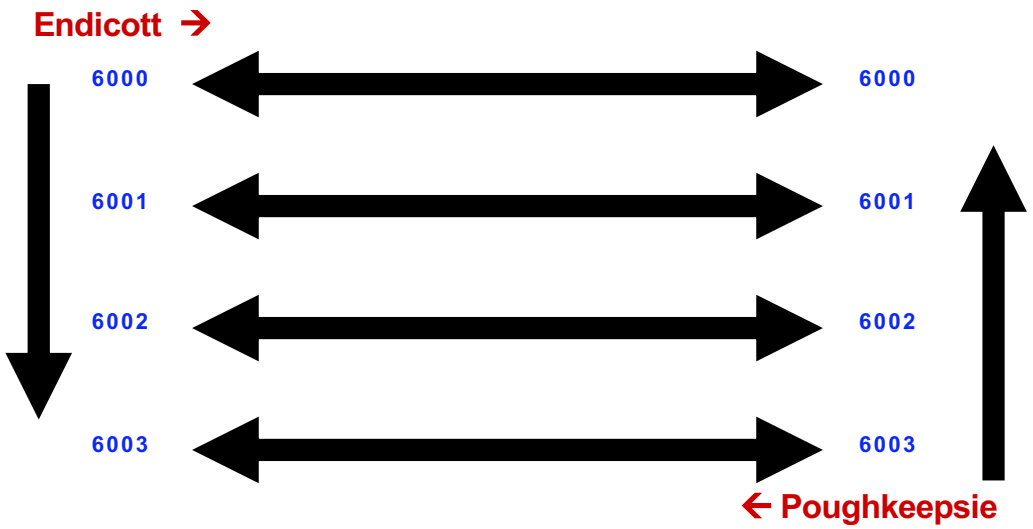
VMSSI cluster configuration considerations

- Suggested configuration for 4-member cluster is 2 LPARs on each of 2 CPCs
- Guest relocation time can be impacted by several key factors:
  - Number of ISFC Links (1 – 16)
  - Speed of ISFC Links (1Gb – 16Gb)
  - Size of guest virtual machine (memory)
  - How active the guest virtual machine is
  - Resource contention/availability on destination member
- Recommendation:
  - Minimum 4 CTCs between each cluster member: 2 FICON CHPIDs, 2 CTCs per CHPID
  - Maximum 16 CTCs between each cluster member: 4 FICON CHPIDs, 4 CTCs per CHPID
  - Testing has shown that 4 CTCs per CHPID provides the most efficient data transfer rates
    - Performance begins to degrade as the number of CTCs are increased beyond 4 per CHPID

CTC subchannel addressing

Use the same real device number for the same CTC on each SSI cluster member

- Potential performance impact
  - Algorithm does not use Round Robin
  - The more CHPIDs the greater the impact
- ISFC communications between two cluster members is done by:
  - Member name first in alphabet uses lowest subchannel address to highest
  - Member name second in alphabet uses highest subchannel address to lowest



Live Guest Relocation (LGR)

- To qualify for relocation, a guest virtual machine must meet eligibility requirements, including:
  - It must be logged on, but in a disconnected state
  - Architecture and functional environment on destination member must be comparable to origin member
    - A relocation domain defines a set of members among which virtual machines can relocate freely
  - Destination member must have the capacity to accommodate the guest
    - CPU
    - Memory
    - Paging Subsystem
  - Devices and resources needed by guest must be shared and available on destination member
    - Network Connections
    - DASD
- Use VMRELOCATE command with TEST operand
- Recommend relocating guests serially as quiesce time is much shorter

Reserve all slots in the SYSTEM CONFIG file

- CP OWNED volumes in an SSI Cluster
  - There is still a total of 255 slots but:
    - DUMP and SPOOL volumes are shared and must be assigned to a unique slot number
    - RES, PAGE, and T-DISK volumes are not shared and can be assigned the same slot number on each cluster member
- Recommendations:
  - Adopt an easily recognizable volume naming convention that uses the RDEV in it
  - Separate shared and non-shared volumes
    - DUMP and SPOOL volumes begin in slot 10 and are assigned in ascending order
    - PAGE and T-DISK volumes should begin in slot 255 and assigned in descending order:
      - Avoids interference with SPOOL volumes
      - All unused slots in-between are defined as “RESERVED”

Networking: virtual MAC addressing

- MAC address assignments are set through the VMLAN config statement
  - MACPREFIX **must** be set to different value for each VM system
    - Especially if systems are on the same network segment!
    - Default is 02-00-00 for each member
    - Recommend last two bytes be replaced with a unique number for each system
    - DO NOT leave this as the default. It will come back to haunt you eventually!
  - USERPREFIX must be set for SSI members
    - More on the next slide…

Networking: VMSSI cluster virtual MAC addressing

- MAC address assignments are coordinated across the SSI cluster through the VMLAN config statement
  - MACPREFIX **must** be set to different value for each member
    - Default is 02-00-00 for each member
    - Recommend last two bytes be replaced with the "system number" of each member
  - USERPREFIX must be set for SSI members
    - Must be identical for all members
    - Must not be equal to any member's MACPREFIX value
    - Default is 02-00-00
  - MACIDRANGE is ignored in an SSI cluster because MAC assignment is coordinated among members
- Examples:
  - `VMSYS01: VMLAN MACPREFIX 021111 USERPREFIX 02AAAA`
  - `VMSYS02: VMLAN MACPREFIX 022222 USERPREFIX 02AAAA`
  - `VMSYS03: VMLAN MACPREFIX 023333 USERPREFIX 02AAAA`
  - `VMSYS04: VMLAN MACPREFIX 024444 USERPREFIX 02AAAA`

Log vmsyscon onto the console at bootup

- Create the user in Linux with the standard method (e.g… useradd –g root vmsyscon)
- This can be a lifesaver for times when you need to quickly get onto the system with the authority to fix an issue like a full filesystem, an out of control process, or otherwise.
- With the user being automatically logged on, you will not be shut-out from logging in (like you would via SSH or otherwise) in case of the dreaded “Fork: unable to fork”
- Pre-requisites:
  - In production environments, you should be using an ESM anyway; so when this is setup correctly using the ESM, there is a full audit trail of who has logged onto the console to access this and when
- Pre-requisite: make sure that LOGONBY is set for each Linux VM, and prevent use of an actual logon password for each Linux VM

Installation, planning, and administration

- The following documentation can be extremely helpful for Installation, Planning and Administration:
  - z/VM CP Planning and Administration (SC24-6178)
  - Getting Started with Linux on System z (SC24-6194)

ADDITIONAL INFORMATION

Web Sites

- z/VM Performance: www.ibm.com/vm/perf/
- z/VM Library: www.ibm.com/vm/library/
- Linux on Z Performance: www.ibm.com/developerworks/linux/linux390/perf/
- SRP Article: www.ibm.com/vm/perf/reports/zvm/html/640srp.html
- STORCONF page: www.ibm.com/vm/perf/tips/storconf.html

Disk & Disk Performance

- www.ibm.com/vm/perf/reports/zvm/html/scsi.html
- public.dhe.ibm.com/software/dw/linux390/perf/ECKD_versus_SCSI.pdf
- public.dhe.ibm.com/software/dw/linux390/perf/disk_performance_optimizing.pdf

Networking

- www.ibm.com/redbooks/redpapers/abstracts/redp3901.html

Linux swap

- www.ibm.com/redbooks/abstracts/sg246926.html

IBM Redbooks www.ibm.com/redbooks

- An Introduction to z/VM SSI and LGR (SG24-8006)
- Performance Toolkit for VM (SG24-6059)
- Performance Measurement and Tuning (SG24-6926)
- The 4-volume series: The Virtualization Cookbook for z/VM and Linux on IBM Z Systems and IBM LinuxONE (SG24-8345)

Suggestions

- Managing Memory with VMRM Cooperative Memory Management

For the curious:

- Detailed explanation by Malcolm Beattie of IBM on how SRM used to function before z/VM 6.4
- Old VM/ESA Storage Management with Tuning Guidelines book. Most of this is not current, but still excellent background info
- Linux on Z interest site maintained by Mark Post of Suse: www.linuxvm.org

Visit the new function page on the z/VM section of ibm.com

http://www.ibm.com/vm/newfunction/

Special Notices and Trademarks

Special Notices

This presentation reflects the IBM Advanced Technical Skills organizations' understanding of the technical topic. It was produced and reviewed by the members of the IBM Advanced Technical Skills organization. This document is presented "As-Is" and IBM does not assume responsibility for the statements expressed herein. It reflects the opinions of the IBM Advanced Technical Skills organization. These opinions are based on the author's experiences. If you have questions about the contents of this document, please contact the author at linuxats@us,ibm.com

Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.

Any and all customer examples cited or described in this presentation are presented as illustrations of the manner in which some customers have used IBM products and the results they may have achieved. Actual environmental costs and performance characteristics will vary depending on individual customer configurations and conditions.
This publication was produced in the United States. IBM may not offer the products, services or features discussed in this document in other countries, and the information may be subject to change without notice. References in this document to IBM products or services do not imply that IBM intends to make them available in every country. Consult your local IBM business contact for information on the product or services available in your area.

All statements regarding IBM's future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only.
Information about non-IBM products is obtained from the manufacturers of those products or their published announcements. IBM has not tested those products and cannot confirm the performance, compatibility, or any other claims related to non-IBM products. Questions on the capabilities of non-IBM products should be addressed to the suppliers of those products.
Any proposed use of claims in this presentation outside of the United States must be reviewed by local IBM country counsel prior to such use.

The information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this information to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk

Trademarks

The following are trademarks or registered trademarks of International Business Machines Corporation in the United States, other countries, or both.

IBM, the IBM logo, DB2, Redbooks, Tivoli Enterprise Console, WebSphere, z/OS, System z, z/VM.

A full list of U.S. trademarks owned by IBM may be found at http://www.ibm.com/legal/copytrade.shtml.

Microsoft, Windows, Windows NT, Internet Explorer, and the Windows logo are registered trademarks of Microsoft Corporation in the United States and/or other countries.

Java and all Java-based trademarks and logos are trademarks or registered trademarks of Sun Microsystems, Inc. in the United States, other countries, or both.

Linux is a trademark of Linus Torvalds in the United States, other countries, or both.
UNIX is a registered trademark in the United States and other countries licensed exclusively through The Open Group.

Intel and Pentium are registered trademarks and MMX, Pentium II Xeon and Pentium III Xeon are trademarks of Intel Corporation in the United States and/or other countries.

Other company, product and service names may be trademarks or service marks of others.

Thanks for listening!

धन्यवाद
Hindi

多謝
Traditional Chinese

감사합니다
Korean

Спасибо
Russian

Gracias
Spanish

Thank You
English

Obrigado
Brazilian Portuguese

شكرا
Arabic

Danke
German

多谢
Simplified Chinese

Grazie
Italian

Merci
French

நன்றி
Tamil

ありがとうございました
Japanese

ขอบคุณ
Thai

Paul Novak
IBM Washington Systems Center
pwnovak@us.ibm.com