z/VM Performance Update

A Live Virtual Class
http://www.vm.ibm.com/education/lvc/
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Acknowledgements – Your z/VM Performance Team

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- **Xenia Tkatschow**

- **Brian Wade**

Agenda

- **z/VM 6.2 thoughts**

  – LGR and SSI

    • Performance notes
    • Management and monitoring thoughts

  – Various other line items

  – Monitor record changes

  – Performance-related service

- **z/VM 6.3 Sneak Peek**
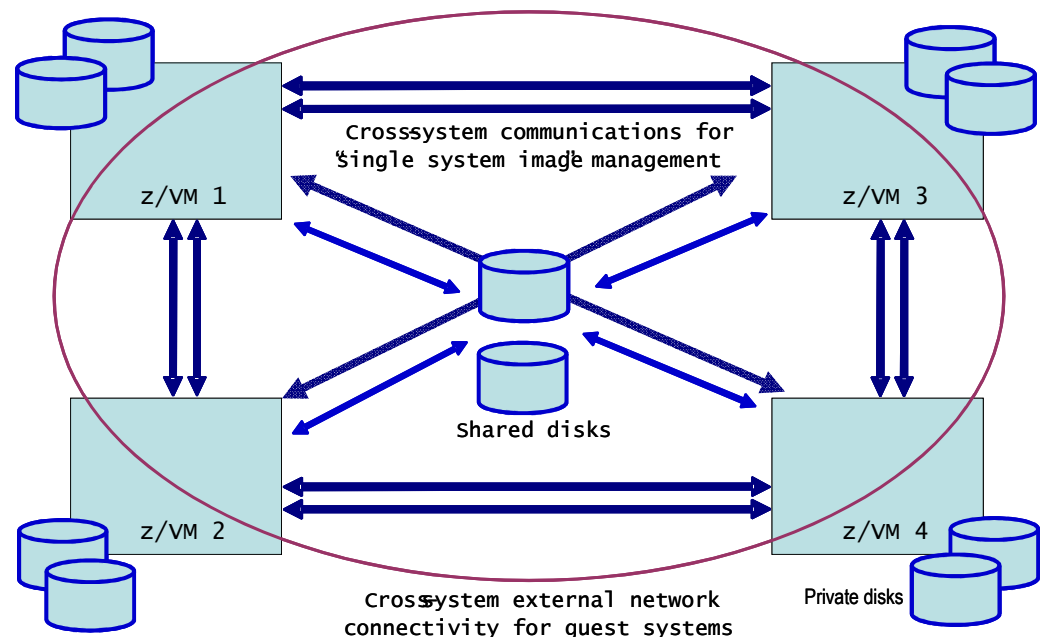
  – Scaling and efficiency improvements
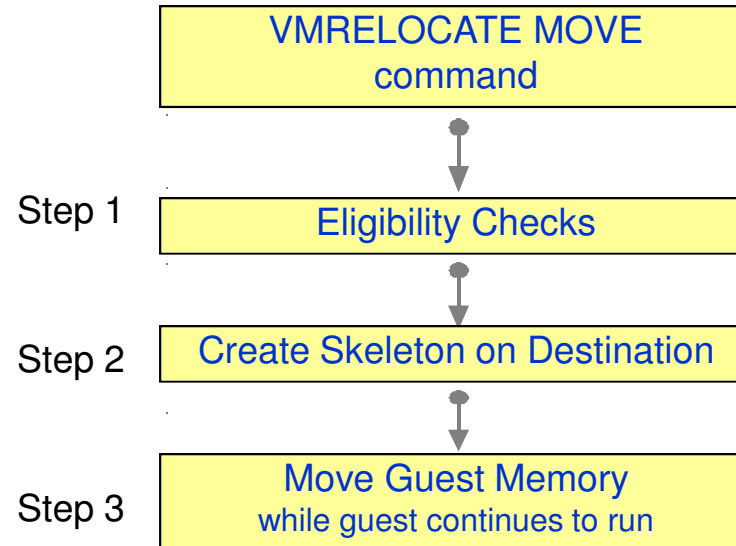
SSI and LGR Thoughts

Single System Image Feature
Clustered Hypervisor with Live Guest Relocation

- **Provided as an optional priced feature.**

- **Connect up to four z/VM systems as members of a Single System Image (SSI) cluster**

- **Provides a set of shared resources for member systems and their hosted virtual machines**

- **Cluster members can be run on the same or different System z servers**

- **Simplifies systems management of a multi-z/VM environment**

  - Single user directory
  - Cluster management from any member
    - Apply maintenance to all members in the cluster from one location
    - Issue commands from one member to operate on another
  - Built-in cross-member capabilities
  - Resource coordination and protection of network and disks
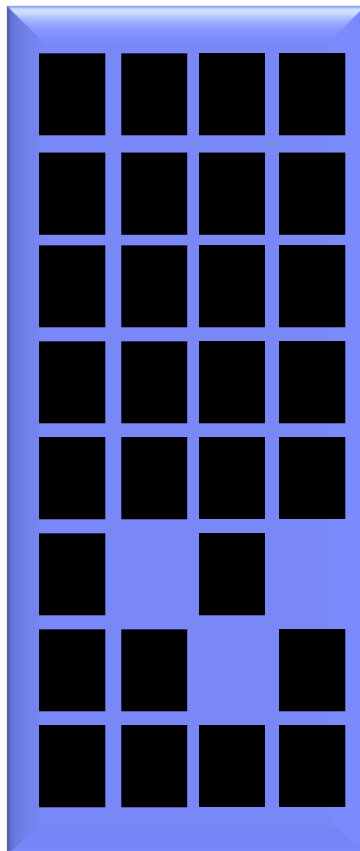
z/VM 1

z/VM 3

Crosssystem communications for
"single system image" management

Shared disks

z/VM 2

z/VM 4

Private disks

Crosssystem external network
connectivity for guest systems

Stages of a Live Guest Relocation

```
              ┌─────────────────────────────┐
              │     VMRELOCATE MOVE          │
              │        command              │
              └─────────────────────────────┘
                             │
                             ▼
Step 1        ┌─────────────────────────────┐
              │     Eligibility Checks       │
              └─────────────────────────────┘
                             │
                             ▼
Step 2        ┌─────────────────────────────┐
              │  Create Skeleton on Destination │
              └─────────────────────────────┘
                             │
                             ▼
Step 3        ┌─────────────────────────────┐
              │     Move Guest Memory        │
              │  while guest continues to run │
              └─────────────────────────────┘
```

LGR, High-Level View of Memory Move

Source

Destination
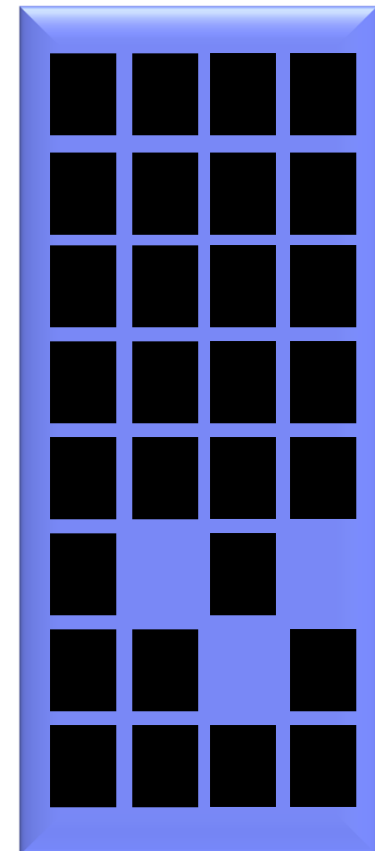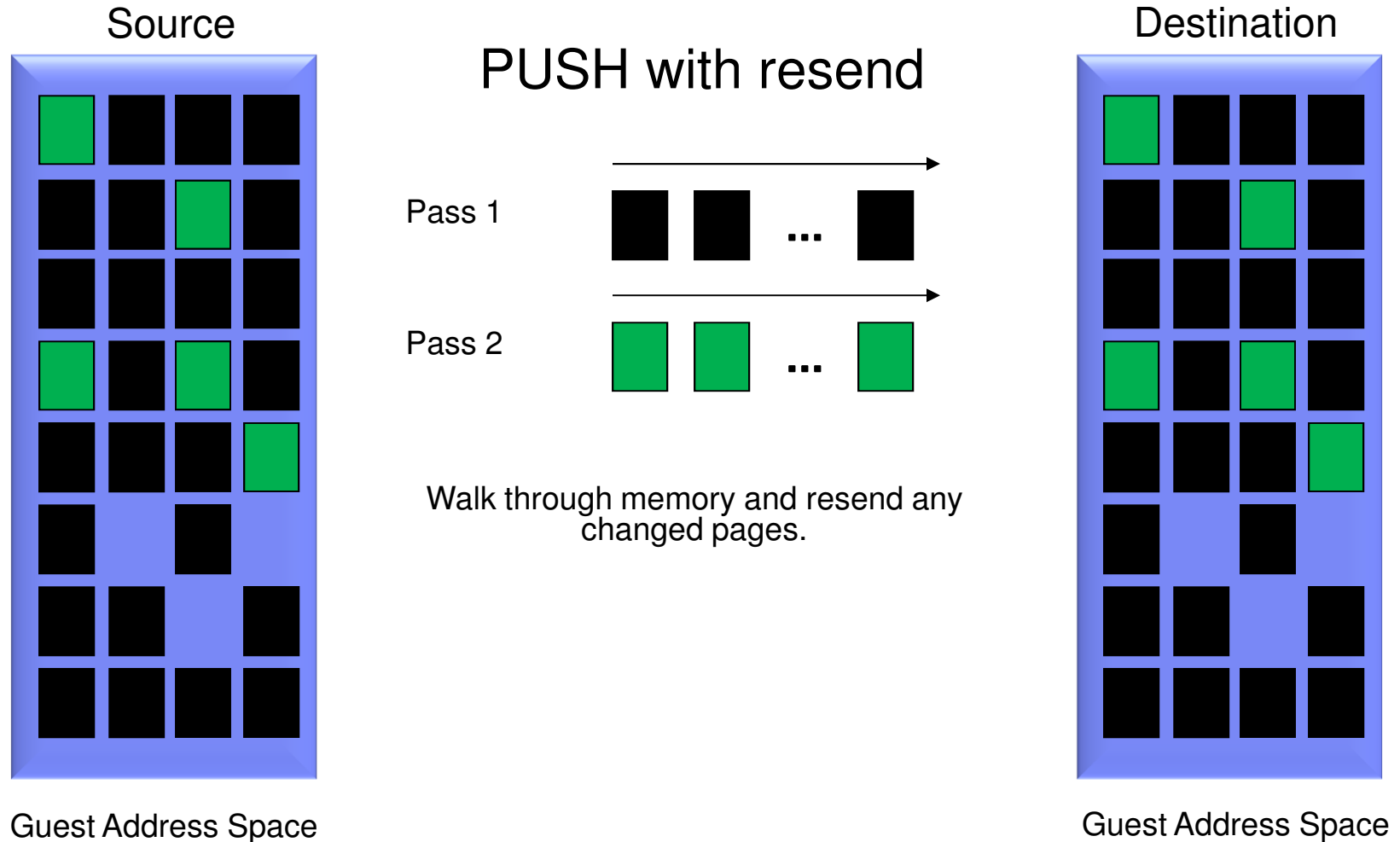
PUSH with resend

Pass 1

Walk through guest memory moving all non-zero pages

Guest Address Space
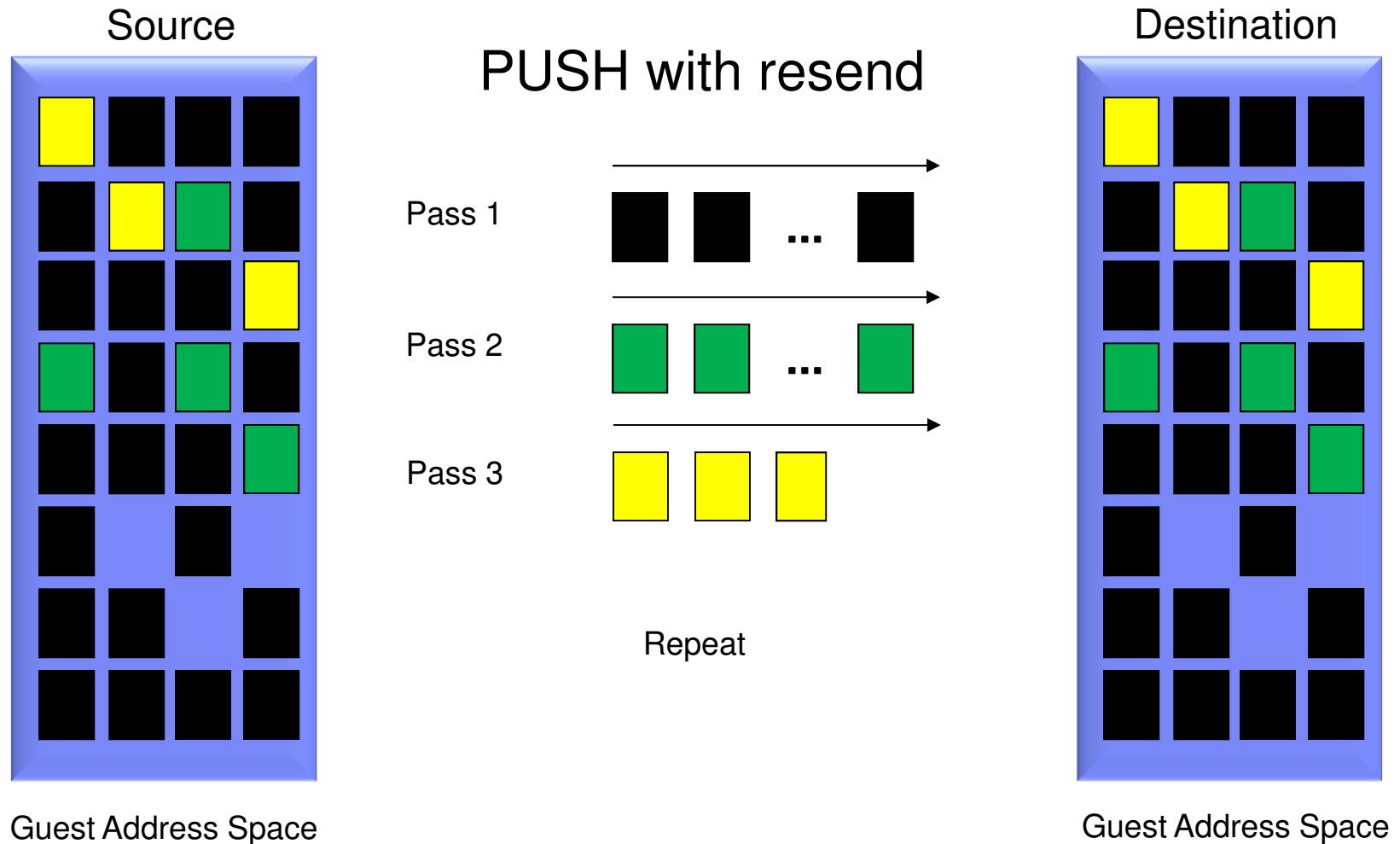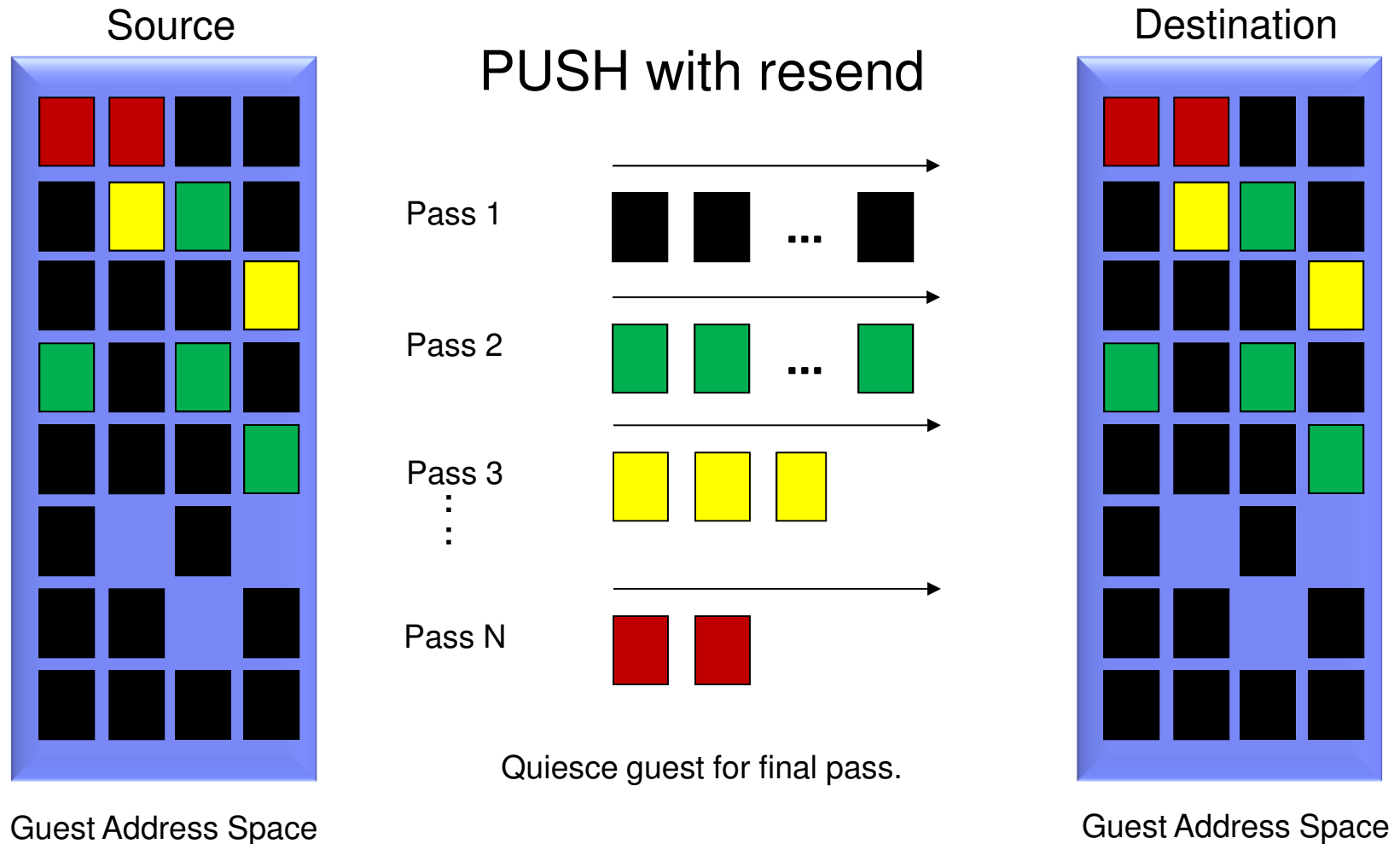
Guest Address Space

LGR, High-Level View of Memory Move

Source

Destination

PUSH with resend

Pass 1

Pass 2

Walk through memory and resend any changed pages.

Guest Address Space

Guest Address Space

LGR, High-Level View of Memory Move

LGR, High-Level View of Memory Move

Source

Destination

PUSH with resend

Pass 1

Pass 2

Pass 3

Pass N

Quiesce guest for final pass.

Guest Address Space

Guest Address Space

Stages of a Live Guest Relocation

```
              ┌─────────────────────────────┐
              │      VMRELOCATE MOVE         │
              │         command             │
              └─────────────────────────────┘
                            │
                            ▼
Step 1        ┌─────────────────────────────┐
              │      Eligibility Checks      │
              └─────────────────────────────┘
                            │
                            ▼
Step 2        ┌─────────────────────────────┐
              │  Create Skeleton on Destination │
              └─────────────────────────────┘
                            │
                            ▼
Step 3        ┌─────────────────────────────┐
              │      Move Guest Memory       │
              │   while guest continues to run │
              └─────────────────────────────┘
                            │
                            ▼
Step 4        ┌─────────────────────────────┐
              │        Quiesce Guest         │
              └─────────────────────────────┘
```

Step 5a   Step 5b   Step 5c

| Guest State Move | I/O Device Move | Penultimate Memory Move |

Step 6

| Final Memory Move Pass |

Step 7

| Guest Resumed on Destination |

Live Guest Relocation – Key Performance Metrics

- **Quiesce Time (QT)**
  - **Elapsed time that the guest is stopped (stunned) so z/VM can move the guest's last set of storage pages – probably the frequently-changed ones**
  - **To tolerate relocation, the guest and its applications must tolerate the quiesce time**
  - **VMRELOCATE can be invoked with a specified maximum quiesce time**
    - **If the quiesce would run past the maximum, z/VM cancels the relocation**

- **Relocation Time (RT)**
  - **Elapsed time from when the VMRELOCATE command is issued to when the guest is successfully restarted on the destination system.**
  - **Elapsed time must fit within the customer's window of time for planned outages for system maintenance, etc.**

Bottom line: there are some scenarios where LGR is not feasible as a result of the requirements for relocation time and quiesce time

LGR: Factors Affecting QT and RT

- **Size of the guest**
  - Amount of memory to move, time required to walk its DAT tables

- **How broadly or frequently the guest changes its pages**
  - It's an iterative memory push from source to destination

- **Time needed to relocate the guest's I/O configuration**
  - I/O device count, I/Os to quiesce, OSA recovery on target side

- **Capacity of the ISFC logical link**
  - Number of chpids, their speeds, number of RDEVs

- **Storage constraints on source and target systems**

- **Performance of paging subsystem**

- **Other work the systems are doing**

- **Other relocations happening concurrently with the one of interest**

- **Delays injected when LGR throttles itself back to prevent abends and other problems.**
  - End-to-end LGR throttling – triggered by paging intensities
  - Memory-move endpoint throttling – triggered by memory consumption
  - ISFC logical link throttling – triggered by ISFC running out of queued traffic buffers

LGR: Serial vs. Concurrent Relocations

- **By default, the VMRELOCATE command operates synchronously.**

- **There is a command option (ASYNCH) to run it asynchronously (a la SPXTAPE)**

- **You could also achieve concurrent relocations by:**

  - Use the asynchronous version of VMRELOCATE multiple times.

  - Run VMRELOCATE commands in multiple users concurrently.

The best practice, though, is to run only one relocation at a time.

- **QT and individual RT improves substantially when relocations are done serially**

  - … and total RT elongates only slightly

Effect of Serial vs. Concurrent on Quiesce Time
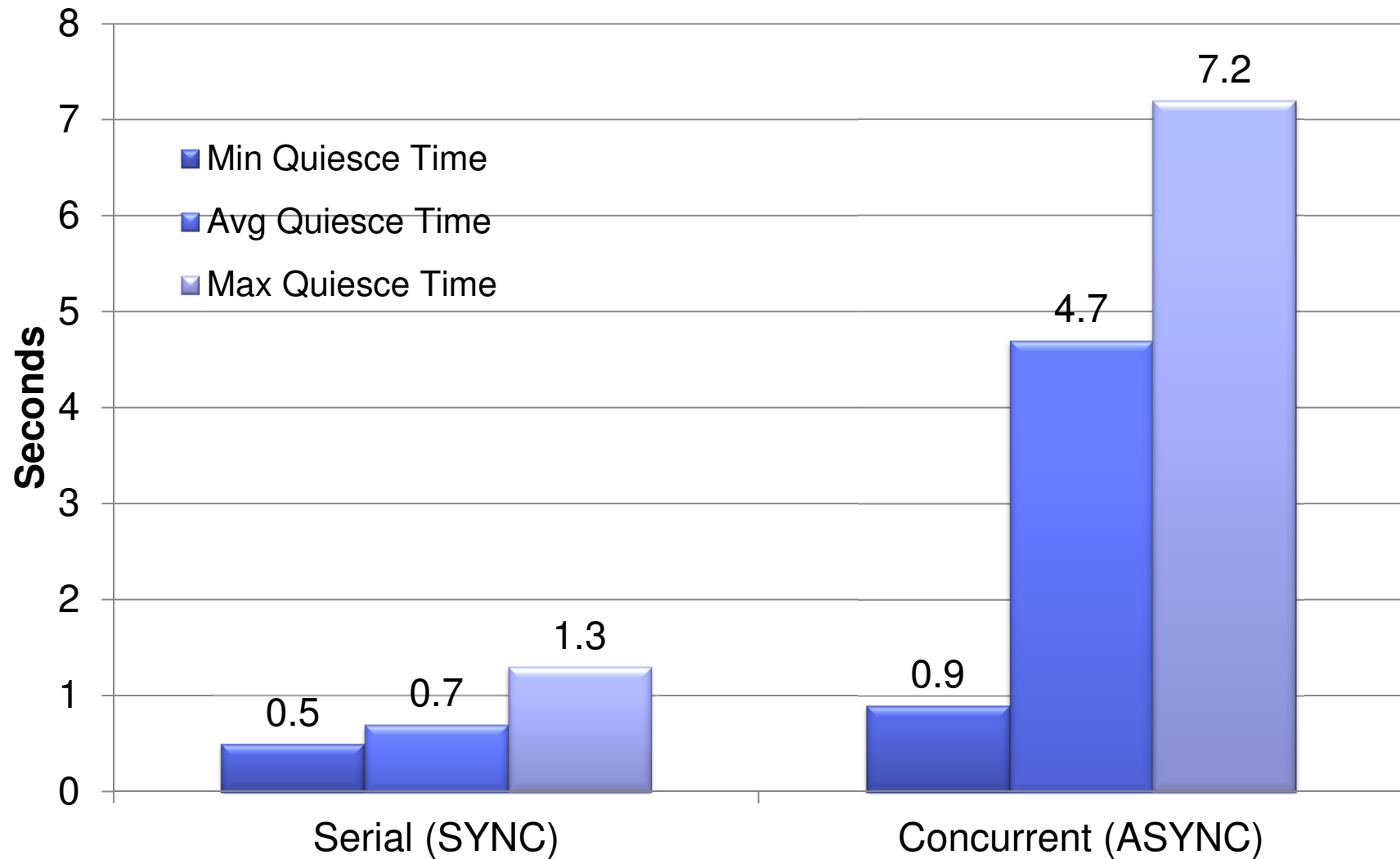
Relocation Parameters – 25 4GB Linux Guests

Effect of Serial vs. Concurrent on Relocation Time
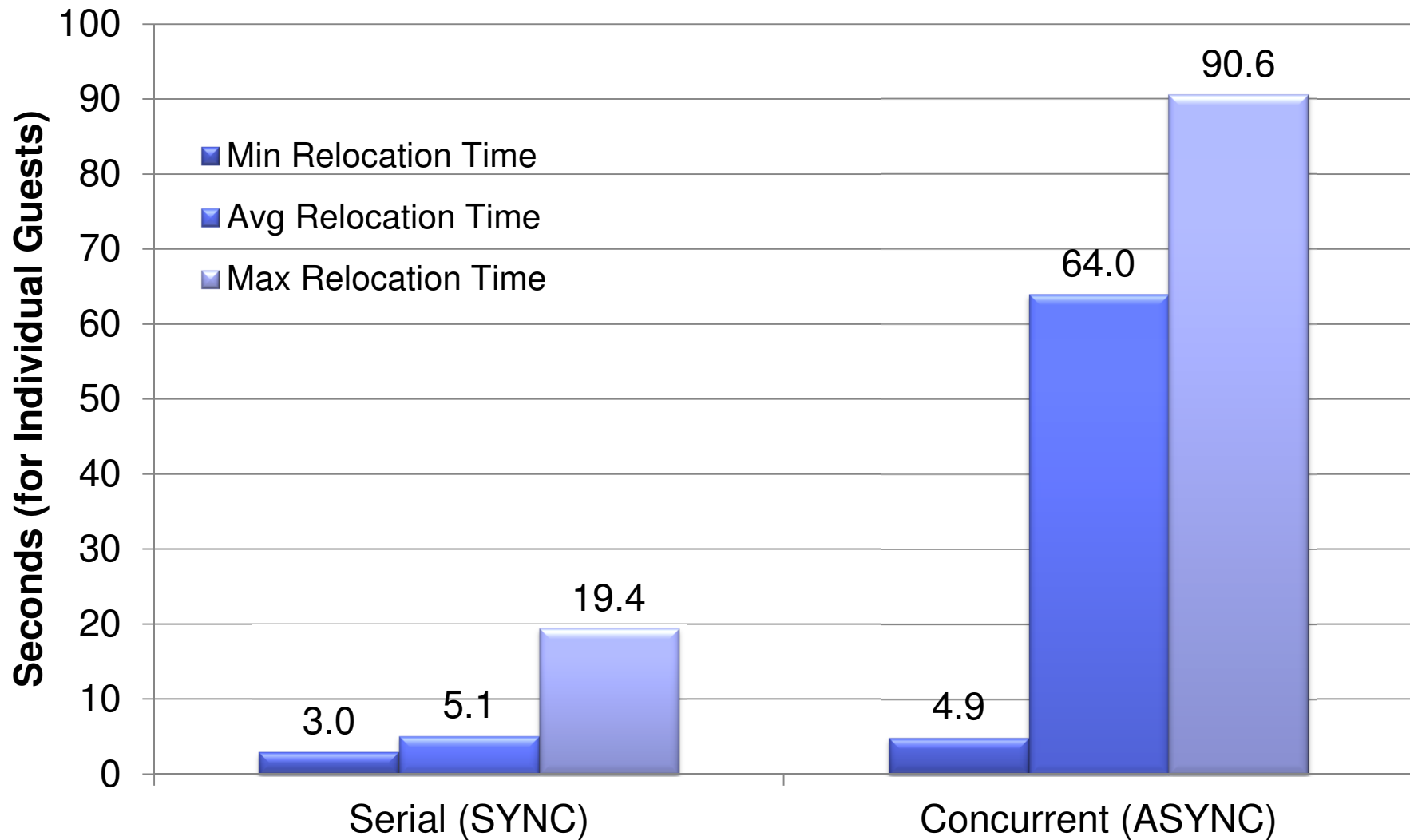
Relocation Parameters – 25 4GB Linux Guests

Effect of IMMEDIATE option on Relocation Time
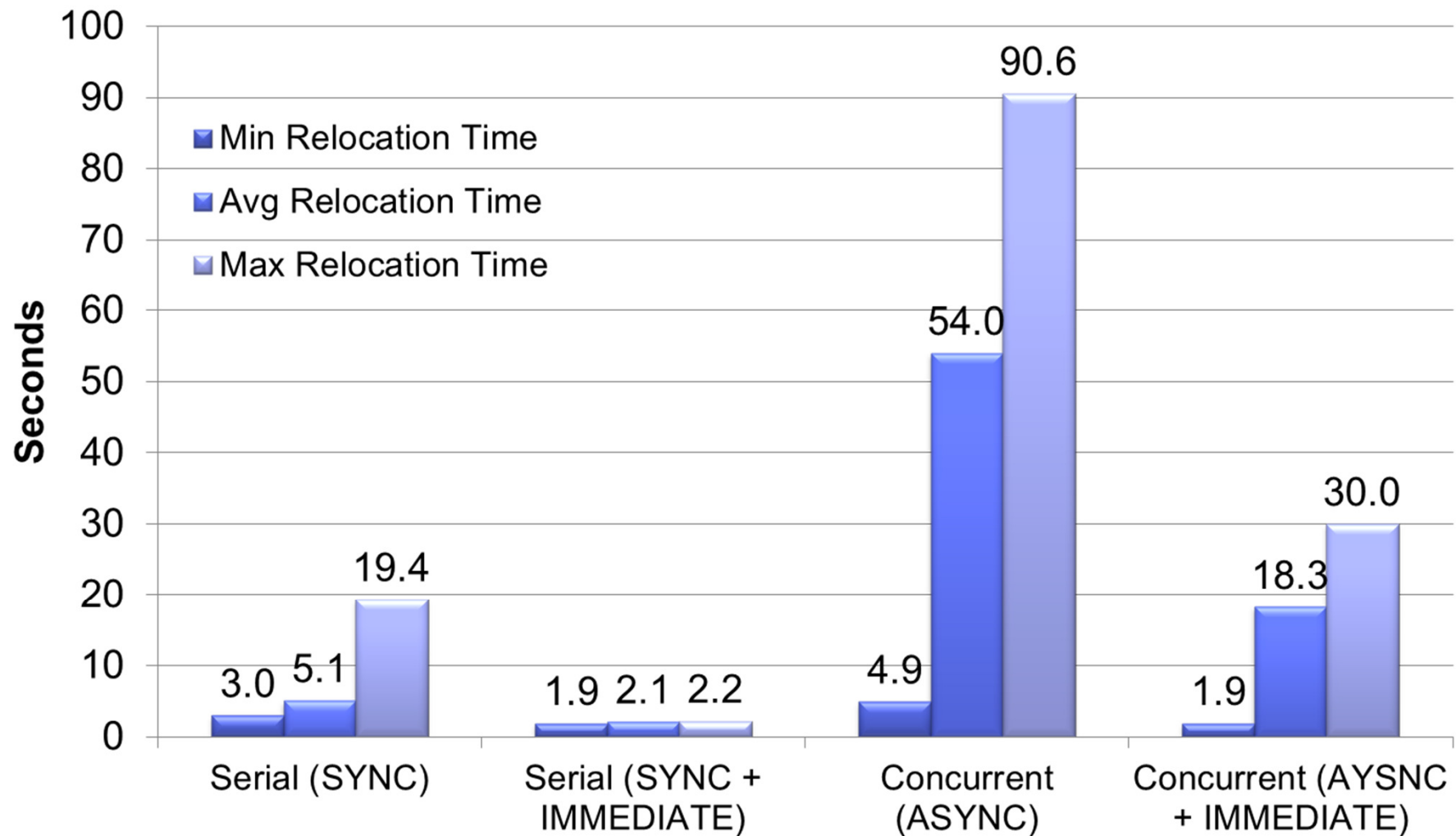
VMRELOCATE Options Summary

- **Best total relocation time for all virtual machines**
  - Concurrent (ASYNCH) + IMMEDIATE

- **Best individual relocation time**
  - Serial (SYNCH) + IMMEDIATE

- **Best quiesce times**
  - Serial (SYNCH)

- **Worst quiesce times**
  - Concurrent (ASYNC) + IMMEDIATE

Background on ISFC Capacity Test

Table 3. Evaluated ISFC Logical Link Configurations.

ISFC Logical Link CHPIDs	ISFC Capacity Factor *	CTCs/FICON CHPID	Total CTCs
1-2Gb, 2-4Gb, 1-8Gb	18	4	16
1-2Gb, 2-4Gb	10	4	12
1-2Gb, 1-4Gb	6	4	8
1-4Gb	4	4	4
1-2Gb	2	4	4

Note: * ISFC capacity factor is the sum of speeds of the FICON CTCs between the SSI member systems.

- "Logical Link" connects two members
  - Made up of up to 16 CTC devices
  - Spread across multiple FICON CHPIDs
- Recommend Chpids be of same type/speed
- Performance plateaus at 4 CTC devices per CHPID

Effect of CTC Bandwidth on LGR

40GB Idle Virtual Machine
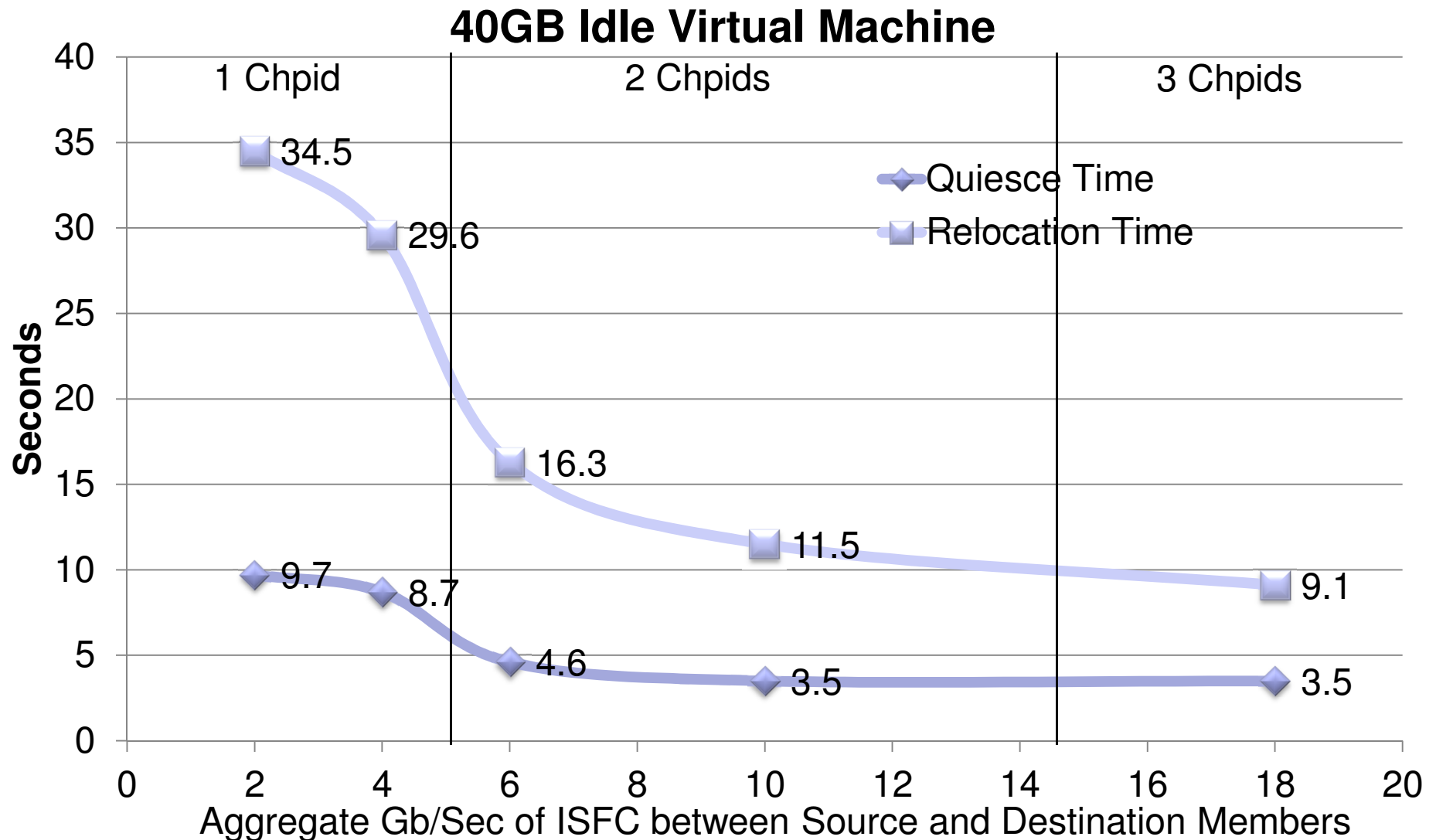
Effect of Virtual Machine Size on LGR
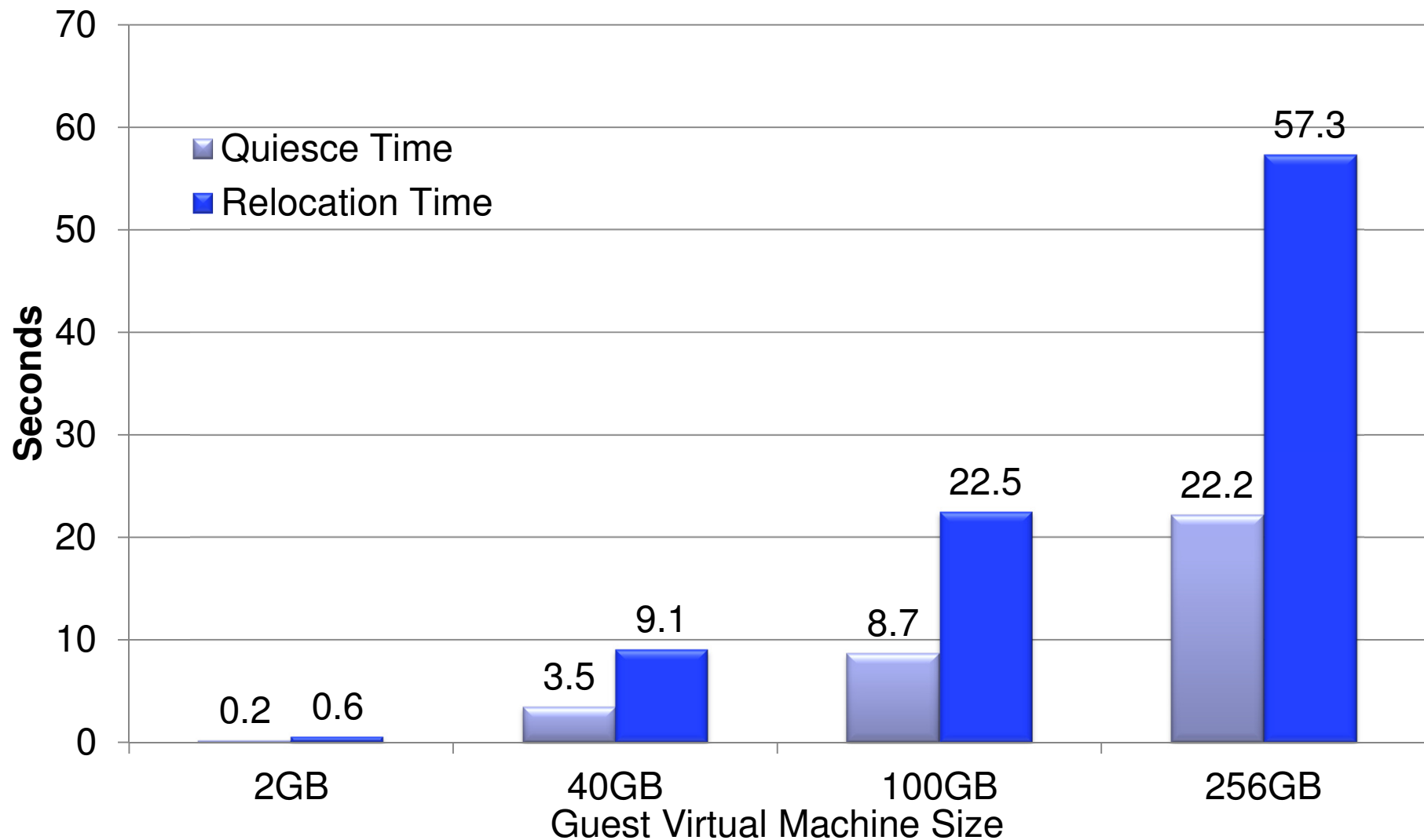
Impact of Virtual Machine Changing Memory on LGR

- **Idle case (0GB changing) there is less memory to move and fewer Memory Move Passes**

- **Number of Passes**
  - 0GB: 4
  - 25GB: 8

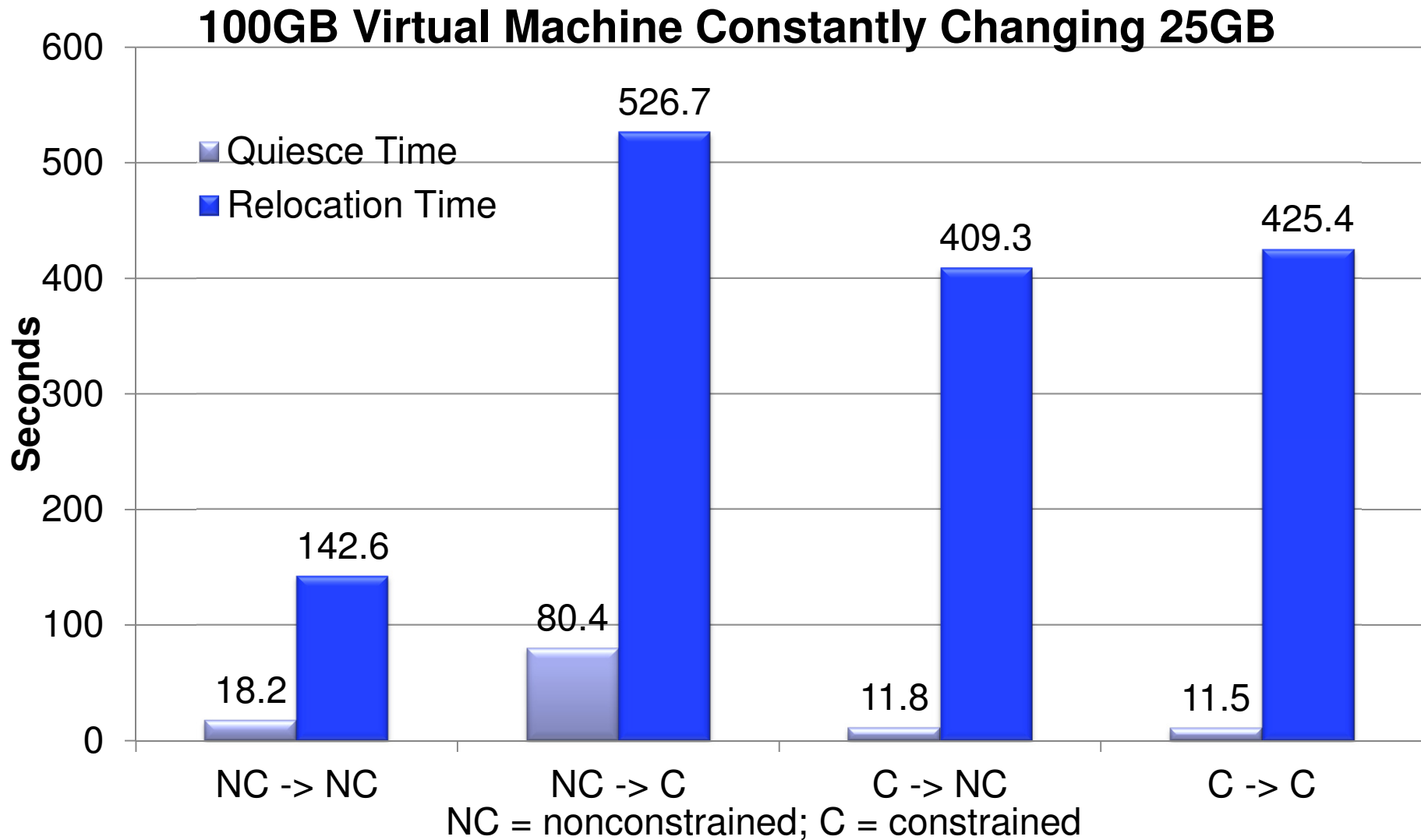- **Total Memory Moved**
 - 0GB: 4.9GB
  - 25GB: 160GB
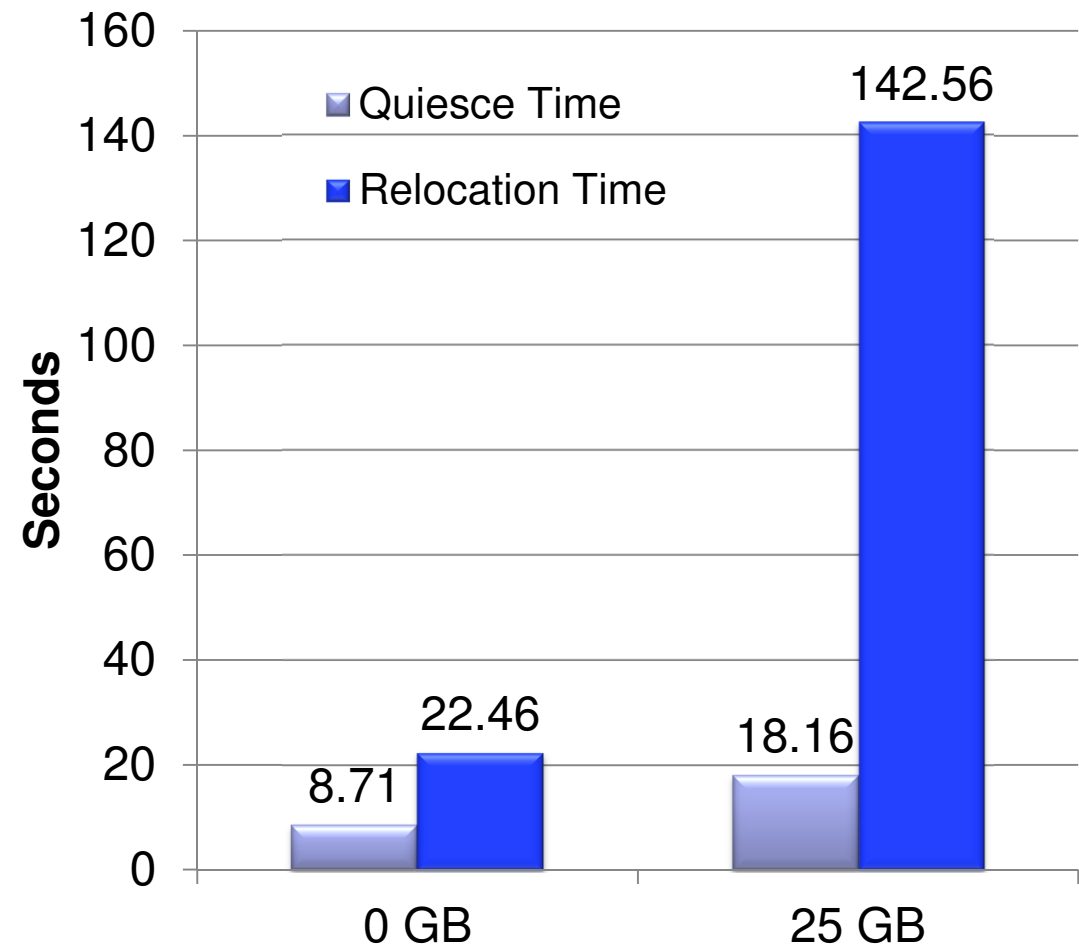
LGR: CPU and Memory Use Habits

- **CPU: generally LGR gets what it needs**

  – Taken "off the top" compared to your workload

- **Memory: CP tries really hard not to interfere**

  – End-to-end throttling, ISFC buffer limits, …

  – Socket memory-move throttling – triggered by memory consumption

  – ISFC logical link throttling – triggered by ISFC running out of queued traffic buffers

  – Considers effect on paging, memory use for specific relocations, …

Effect of System Memory Constraint on LGR

100GB Virtual Machine Constantly Changing 25GB

Legend:
- Quiesce Time
- Relocation Time

Y-axis: Seconds (0, 100, 200, 300, 400, 500, 600)

Data:
- NC -> NC: 18.2, 142.6
- NC -> C: 80.4, 526.7
- C -> NC: 11.8, 409.3
- C -> C: 11.5, 425.4

NC = nonconstrained; C = constrained

Effect of LGR on Existing Workloads

LGR Bounce and Apache Web Serving Workloads
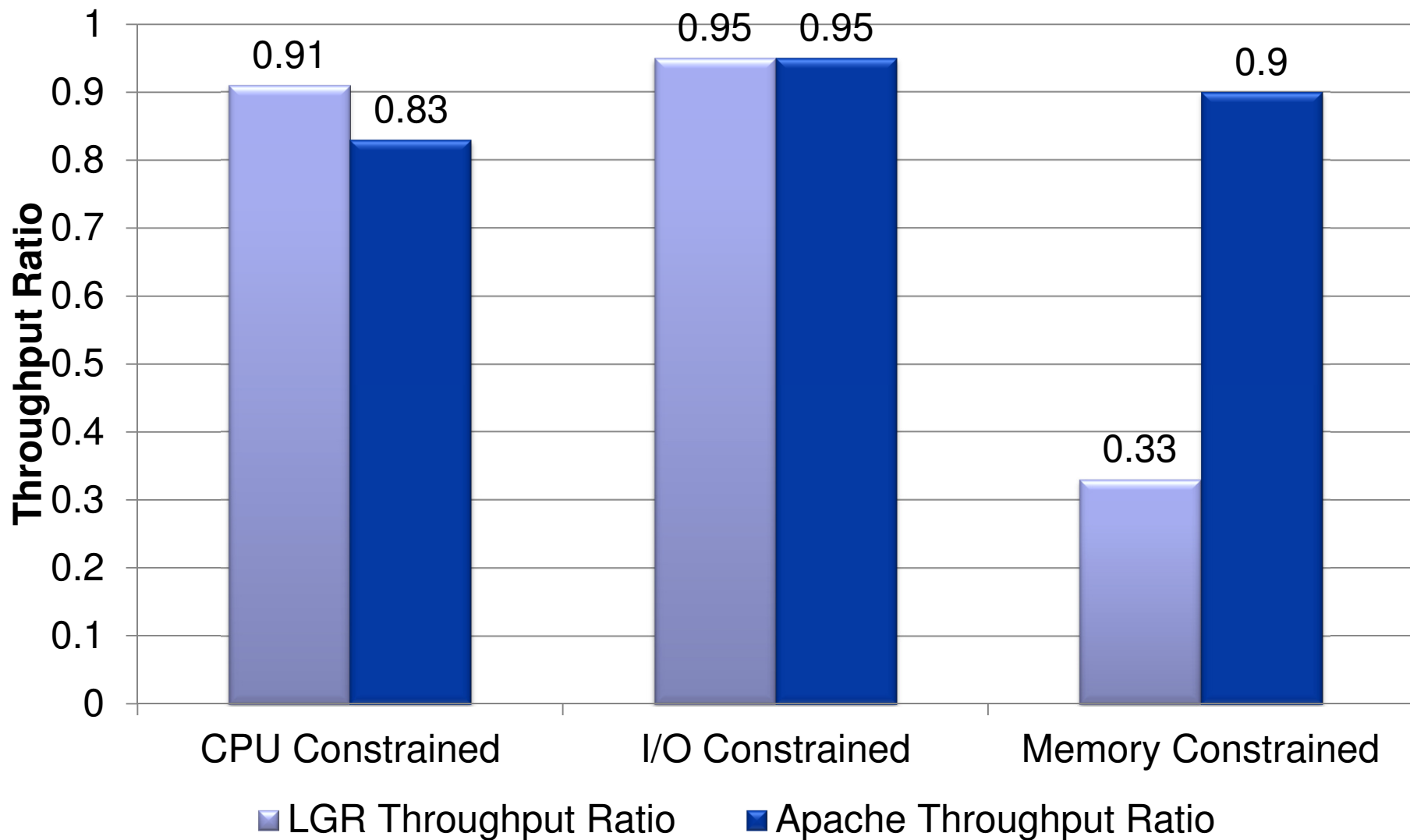
LGR: Keep These in Mind…

- **Charge back: can your procedures handle guests that suddenly disappear and then reappear somewhere else?**

- **Second-level schedulers: do you have them? Can they handle guest motion?**

- **VMRM: if VMRM-A tweaks the guest and then the guest moves to system B, what happens? And then what happens when the guest comes back?**

> Best practice is not to include relocating guests in VMRM-managed groups.

SSI Workload Distribution Measurements

Parameters	1 Member	2 Member	4 Member
Central Storage	43 GB	22 GB	11 GB
Expanded Storage	8 GB	4 GB	2 GB
Processors	12	6	3

- Series of measurements to see how a workload spread across a number of members would run compared to one larger systems of just one member.

- Resources kept the same, as shown above.

- Apache workload where clients and servers were all virtual machines was used.

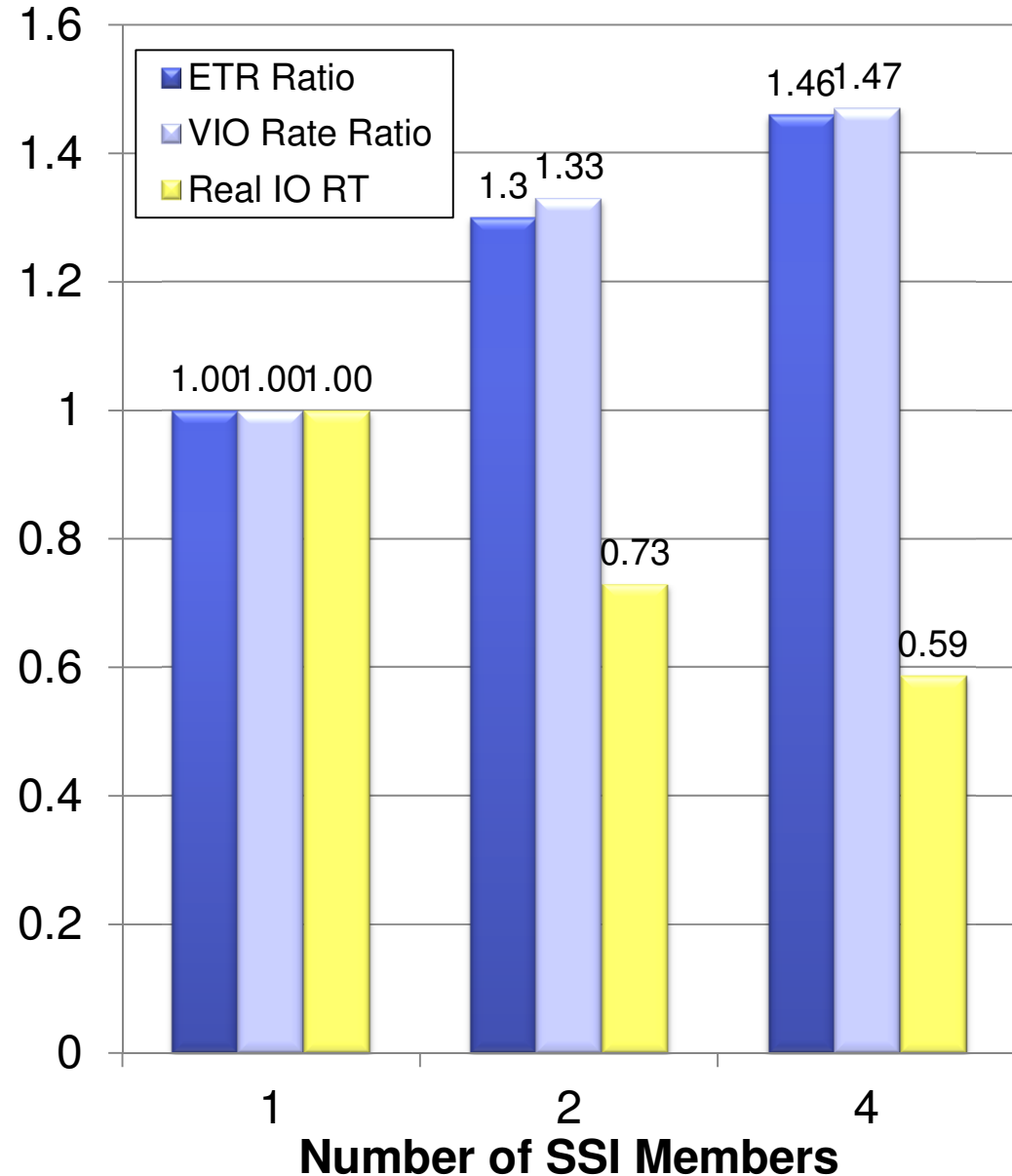 - Varied number of client and servers and use of MDC to create different stress points.

SSI Distribution: CPU Constrained Measurement

- **Keep the physical resources the same, but distribute over 1, 2, or 4 members.**

- **Apache Web Serving with the configuration being CPU bound.**

- **Benefits from running smaller n-way partitions**
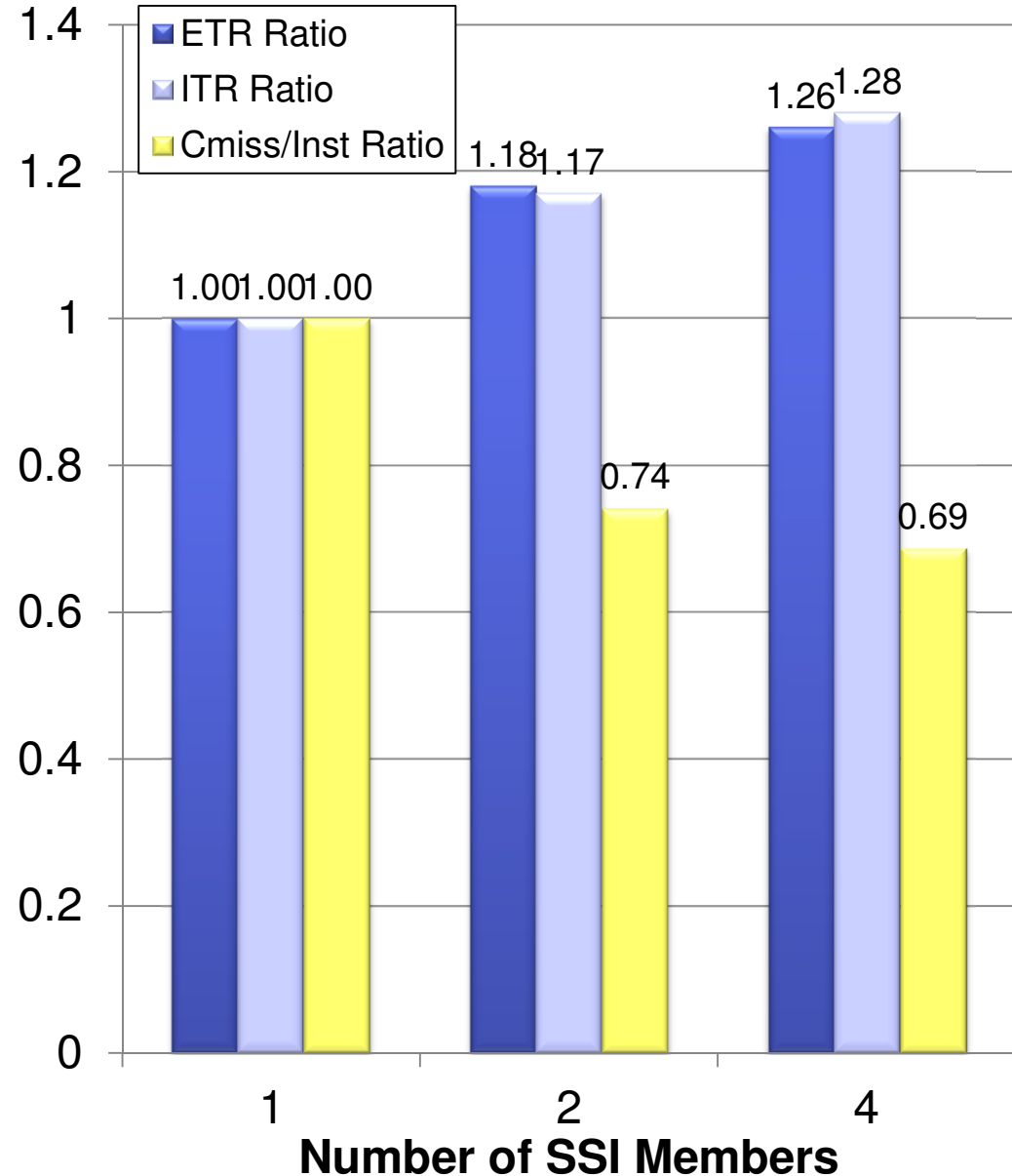
SSI Distribution: Virtual I/O Constrained Measurement

- **Keep the physical resources the same, but distribute over 1, 2, or 4 members.**

- **Apache Web Serving with the configuration being I/O bound due to virtual read I/O.**

- **PAV not used in base case, so SSI essentially gives PAV like benefits.**

- **Real I/O RT shown is for one of the shared Linux volumes containing files being served.**

Legend: ETR Ratio, VIO Rate Ratio, Real IO RT

X-axis: Number of SSI Members (1, 2, 4)

Values:
- Members 1: 1.00, 1.00, 1.00
- Members 2: 1.3, 1.33, 0.73
- Members 4: 1.46, 1.47, 0.59

SSI Distribution: Memory Constrained Measurement

- **Keep the physical resources the same, but distribute over 1, 2, or 4 members.**

- **Apache Web Serving with the configuration with there being memory constraint.**

- **Similar savings as in CPU bound measurement.**

- **Additional efficiencies in memory management.**
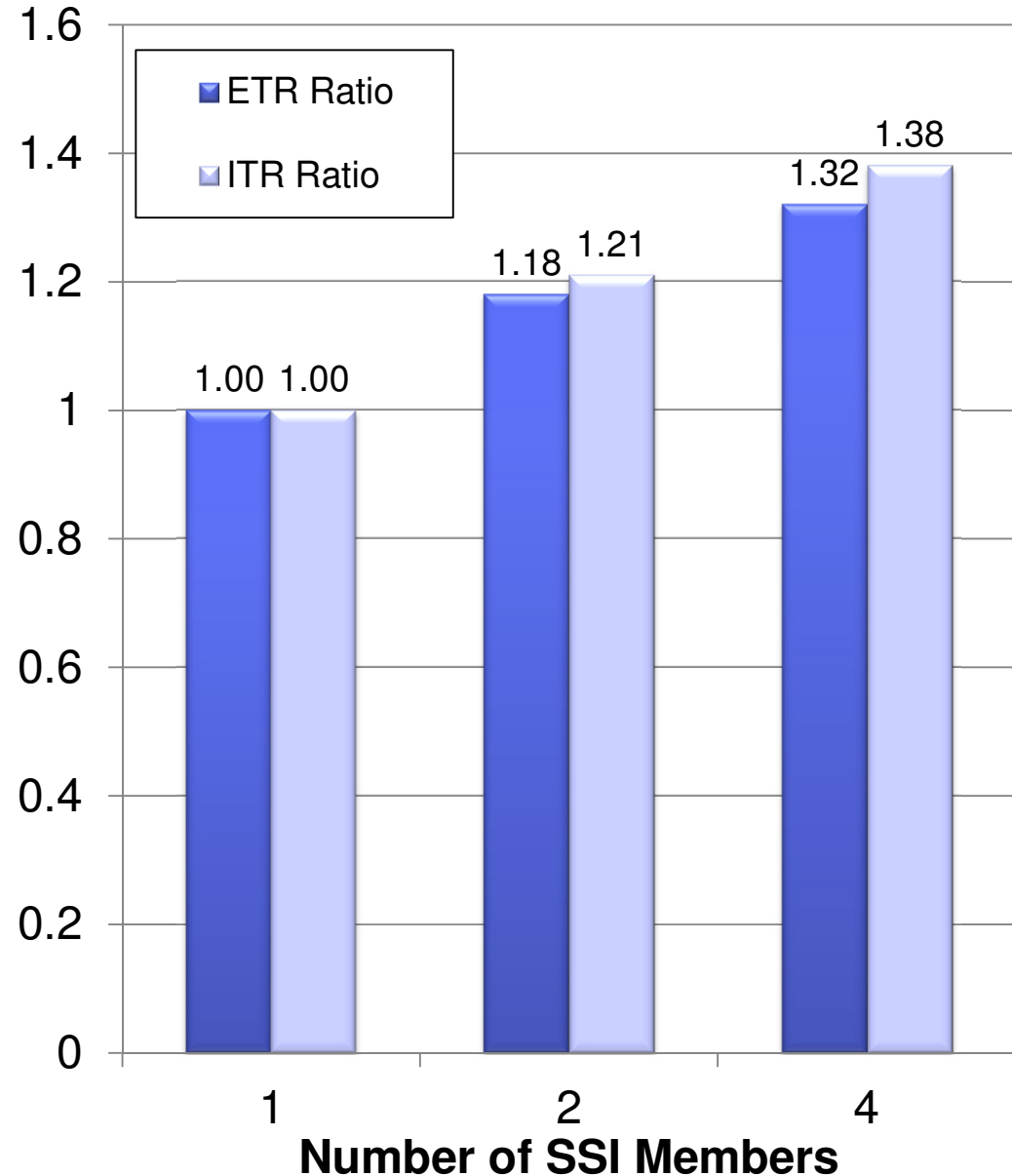
SSI Workload Scaling Measurements

z/VM Limits	1 Member	2 Member	4 Member
Central Storage	256 GB	512 GB	1 TB
IFLs	32	64	128

- Measurements were made to see how well z/VM scales within an SSI cluster.

- Resources increased with each new member added to configuration.

- Apache workload where clients and servers were all virtual machines was used.

  - Apache clients and servers scaled accordingly.

- Needed to mix processor types to get 128 IFLs, so 1 & 2 Member runs are z10, 4 member adds in z196.

- Scaled down memory to make runs more feasible.

SSI Scaling Measurements

- **The SSI Cluster overhead for a running environment is very low.**

- **Note: z196s were added to get the 3rd and 4th Member.**

- **"Scaled ITR Ratio is an estimate of the Ratio if the entire cluster were on z10 processors.**
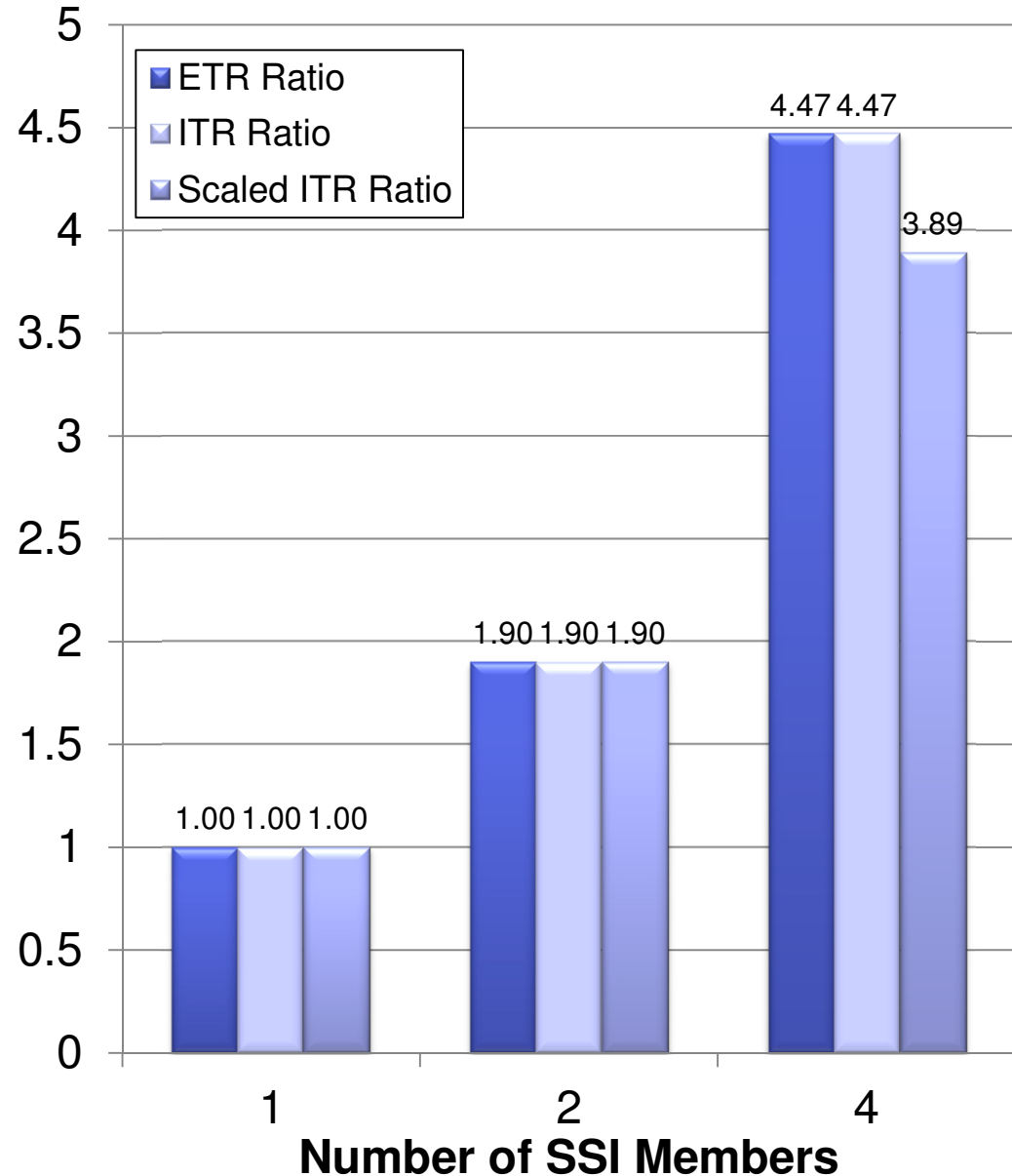
SSI Transition Measurement

- **Measurement to determine if activity or Cluster management would influence performance.**

- **Four Member environment where 3 of the members are constantly transitioning through states:**
  - Joined
  - Leaving
  - Down
  - Joining
  - *repeat*

Number of SSI Members
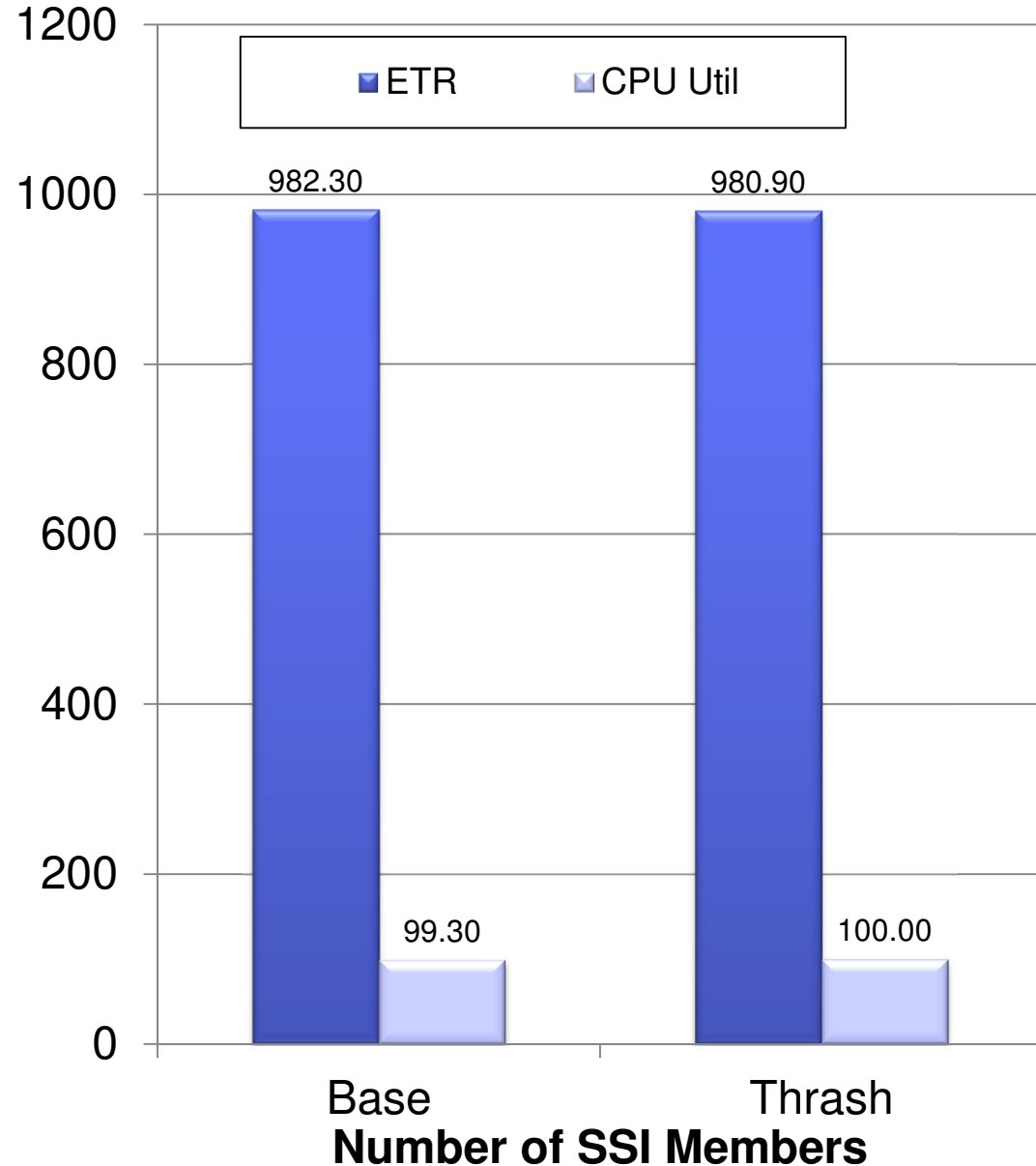
SSI: Performance Toolkit, Considerations

- **Performance Toolkit continues to run separately on each member of the cluster**
  - There continues to be a unique z/VM monitor data stream for each member.
  - There will be a PERFSVM virtual machine on each member

- **Configuration and usage**
  - Configure so that you will log onto or connect to a different PERFSVM on each system.
  - Configure Performance Toolkit to use the Remote Performance Monitoring Facility, which allows local and remote performance monitoring from a single screen.

- **In general, Performance Toolkit does not produce "cluster view" reports**
  - DASD device-busy view, for example

SSI: Performance Toolkit, New Reports

- **New Reports for SSI**
  - SSICONF: SSI configuration
  - SSISCHLG: SSI state change synchronization activity log
  - SSISMILG: SSI state/mode information log

- **New ISFC reports related to SSI**
  - ISFECONF: ISFC end point configuration
  - ISFEACT: ISFC end point activity
  - ISFLCONF: ISFC logical link configuration
  - ISFLACT: ISFC logical link activity
  - ISFLALOG: ISFC logical link activity log

SSI: MONWRITE Considerations

- **IBM often asks you to run MONWRITE**

    – PMR diagnosis, for example

- **You should be running MONWRITE anyway**

- **You should now be running MONWRITE on every member of the cluster**

- **Make sure it's easy to go find the MONWRITE data for all members for a specified time interval**

z/VM 6.2 – More Than Just SSI and LGR

z/VM 6.2 Regression Performance

- **Ran our standard library of workloads**

  – CMS interactive, various Apache configurations

- **Results are within usual 5% regression criteria**

- **Some workloads will see improvements:**

  – Overprovisioned for logical PUs compared to utilization

  – Storage-constrained with heavy contention for <2 GB real storage

  – High virtual CPU to logical CPU overcommit with virtual CPUs often in a ready-to-run state

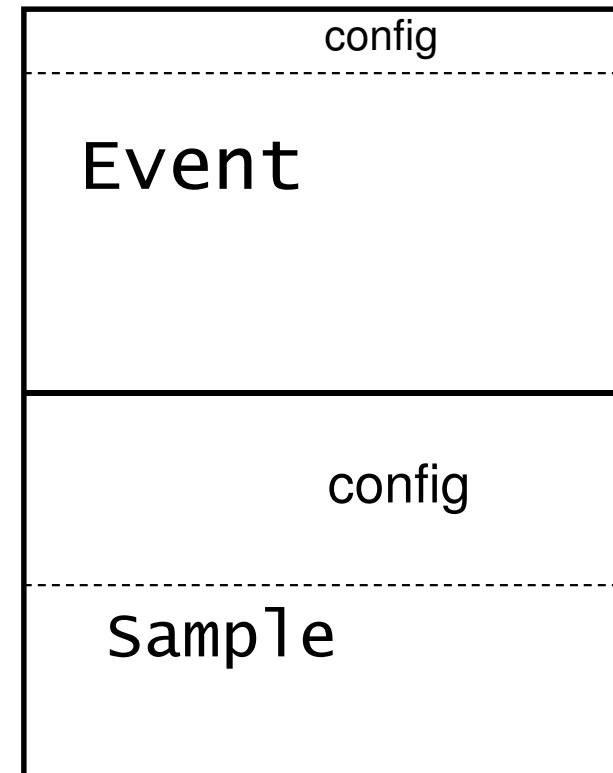# Memory Management: Needle-in-Haystack Searches

- **Searching for a below-2-GB frame in lists dominated by above-2-GB frames**
  - In months of study we identified about 10 of these searches
  - Development prototype that shut off all unnecessary use of <2GB storage gave us tremendous results

- **z/VM now does not allocate pageable buffers <2GB if:**
  - Dynamically, usable >2GB to usable <2GB is beyond a certain threshold
  - Statically, if the partition is beyond a certain size, for the life of the IPL

- **Result: no more needle searches**

- **Practically speaking, systems with 128 GB or more of real memory use below-2-GB memory only when it is architecturally required.**

MONDCSS and SAMPLE CONFIG Changes

- **The old defaults are too small for most systems nowadays**

- **So we have changed the default layout**

- **MONDCSS is 64 MB now (16384 pages)**
  - Half (32 MB) for EVENT
  - Half (32 MB) for SAMPLE
    - Half (16 MB) for SAMPLE CONFIG

- **As before, empty pages are not instantiated**

- **Remember, config pages evaporate after a short time**

- **MONWRITE 191 disk also increased to 300 cylinders.**

If you use your own MONDCSS, the new default SAMPLE CONFIG size may be too large, requiring you to set it manually or to change your MONDCSS.

MONDCSS – 16384 pages

```
                config
. . . . . . . . . . . . . . . . . .

    Event



                        config
. . . . . . . . . . . . . . . . . .
    Sample

```

Default STORBUF Changes

- **Many parties were noticing that the old defaults of 125 105 95 were not appropriate for Linux workloads**

- **We considered several different proposals**
  - From IBM ATS
  - From vendors
  - From Redbooks
  - From customer data

- **After careful consideration by "top people" we came to 300 250 200 as new defaults**

- If you already override defaults, the only impact would be if you also use SET SRM STORBUF INITIAL at some point.

- For CMS-intensive workloads, the old defaults might be more appropriate, and you should validate the settings for these workloads when you migrate to z/VM 6.2

z/CMS

- **Prior to z/VM 6.2, z/CMS was supplied as a sample.**

- **z/VM 6.2 supports z/CMS as an optional alternative to the standard CMS that runs in ESA and XC mode virtual machines and 31-bit addressing.**

- **z/CMS can run in a z/Architecture guest**
  - Allows programs to use z/Architecture instructions, including 64-bit addressing

- **Standard CMS function does not exploit memory above 2GB**

- **Remember that z/Architecture is not XC**
  - No VM Data Spaces
  - No SFS DIRCONTROL-in-data-space
  - No DB/2-for-VM data space use

- **The standard, usual, XC-mode CMS is still there**

CPU Measurement Facility Counters

- **CPU MF counters are a System z hardware facility that characterizes the performance of the CPU and nest**
  - Instructions, cycles, cache misses, and other processor related information
- **Available on z10 EC/BC, z196, z114, and zEC12**
- **The CPU MF counter values:**
  - Help IBM to understand how your workload stresses a CEC for future design
  - Help IBM to map your workload into the LSPR curves for better sizing results
  - Help IBM better understand your system when there is a processor performance related problem.
- **z/VM 6.2, 6.1, and 5.4 can all collect the CPU MF counters from the hardware**
  - z/VM 5.4 and 6.1: VM64961, UM33440 (5.4), UM33442 (6.1)
  - Counters are put in new z/VM monitor record
- **We want volunteers to send us MONWRITE data!**
  - Your contributions will help us to understand customer workloads!
  - Contact Richard Lewis for details rflewis at us.ibm.com

z196 and z114 Support for Energy Savings

- **Processor performance (capability) can change due to over heating condition or static energy savings mode.**

- **Reflected in monitor data and QUERY CAPABILITY command.**

```
Response (may only get first line on system with no changes):
CAPABILITY: PRIMARY 696      SECONDARY 696        NOMINAL 696
CAPACITY-ADJUSTMENT INDICATION 100   CAPACITY-CHANGE REASON 0
RUNNING AT NOMINAL CAPACITY.
```

```
Response for static power savings mode:
RUNNING WITH REDUCED CAPACITY DUE TO A MANUAL CONTROL SETTING.
```

```
Response possible for ambient temperature exceeded specified maximum:
RUNNING WITH REDUCED CAPACITY DUE TO AN EXTERNAL EXCEPTION CONDITION.
```

z/VM 6.2: Service Integrated in Base of z/VM 6.2

- **VM64774 SET/QUERY REORDER command**

- **All of the SSL scaling fixes**

- **VM64721 LIMITHARD now works**
  - SET SRM LIMITHARD CONSUMPTION is default now

- **VM64767/64876 VARY PROCESSOR causes hangs**

- **VM64850 VSWITCH failover buffer mixup**

- **VM64795 Enhanced Contiguous Frame Handling**

- **VM64927 Spin Lock Manager Improvement**

- **VM64887 Erratic System Performance (PLDV overflow)**

- **VM64756 Long CPEBK Chains, Master-only work, and SYSTEMMP**

Service to z/VM 6.2 – Performance Sensitive

- **VM65011 – corrects VM64943 which in combination with this avoids abends and other problems when the *Monitor system service is used on a System z Server where Global Performance Data has been disabled.**

  – R540 PTF UM33450 – future RSU candidate

  – R610 PTF UM33480 – future RSU candidate

  – R620 PTF UM33512 – future RSU candidate

z/VM Performance: April 2012 SPEs

High Performance FICON: Outline

- **VM65041 lets z/VM guests use transport-mode I/O if channels and control units are so capable**

- **Transport-mode I/O uses a simpler command word structure that is easier for the channel subsystem and FICON adapter to handle, compared to conventional command-mode I/O**

- **On comparably configured workloads, transport-mode I/O gave us:**
  - About 35% increase in I/O rate
  - About 18% decrease in I/O service time
  - About 45% to 75% in CP CPU time per I/O

- **Workloads doing large I/Os tended to benefit most**

- **www.vm.ibm.com/perf/reports/zvm/html/620jb.html**

High Performance FICON: Interaction with MDC

- **Transport-mode I/O directed at a minidisk will shut off MDC for said minidisk**

- **QUERY MDC command output will reveal that it happened**

```
Off for FRED 1234
Disabled by Transport Mode I/O
```

VSWITCH HiperSockets Bridge

- **Connects VSWITCH world to HiperSocket chpid**

- **Gives HiperSocket clients a route to the external network**

- **New monitor records**

- **CP: VM65042 / UM33691, TCP/IP: PM46988 / UK77220**
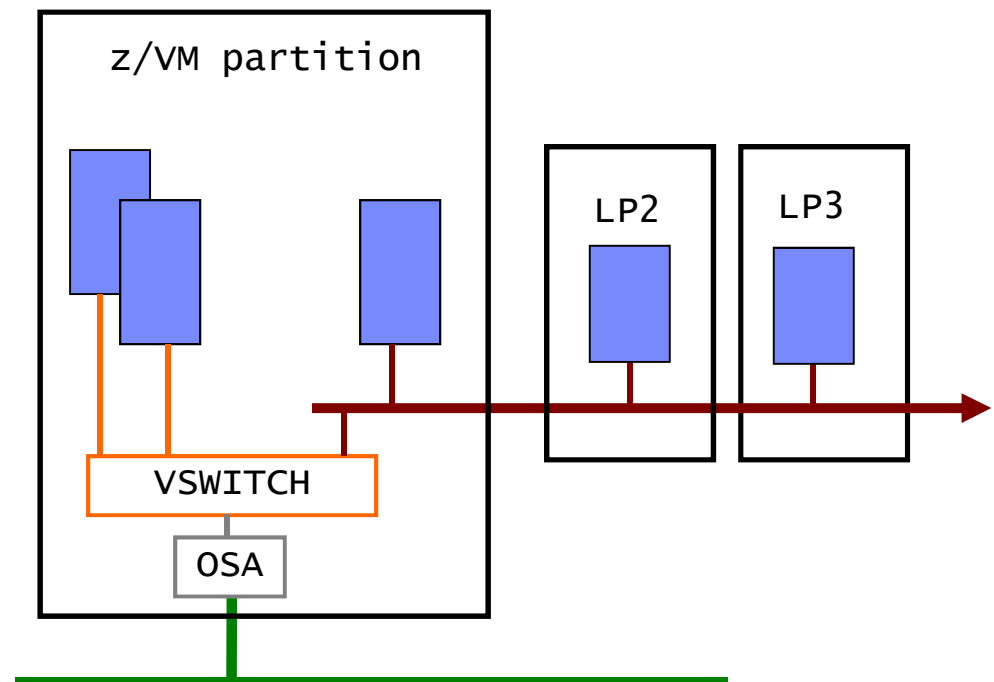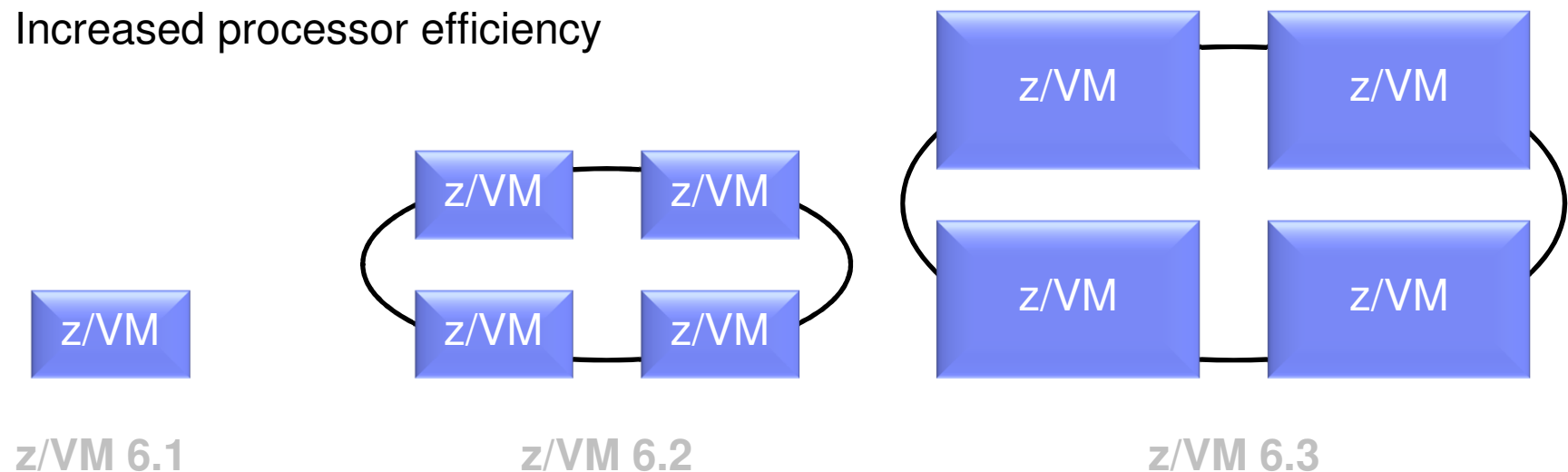

Performance Toolkit: VM65044 provides basic support.

z/VM 6.3

z/VM 6.3 – Making Room to Grow Your Business

- **Preview Announcement introducing z/VM 6.3 to be made February 5, 2013**

- **Planned Availability 3rd Quarter 2013**

- **Major Enhancements for Scalability and Performance**
  - Support for larger amounts of real memory
  - Increased processor efficiency

z/VM 6.1   z/VM 6.2   z/VM 6.3

Large Memory Support

- **Increases the real memory limit from 256GB to 1TB**

  – Proportionately increases total virtual memory based on tolerable over commitment levels and workload dependencies

  – Individual virtual machines up to 1TB

- **Paging DASD utilization and requirements change**

  – Proactive writing of pages to DASD increases need to have properly configured paging subsystem

  – Removed the need to double the paging space on DASD

    • Some additional space will continue to be recommended to avoid problems.

- **Expanded Storage continues to be supported with limit of 128GB**

Large Memory Support

- **Page selection algorithms rewritten**

  – Reorder processing removed

  – Greater separation from the scheduler lists

    • Better handling of Linux guests that do not go truly idle

- **Improved effectiveness of the CP SET RESERVE command**

  – Pages protected better than previously

  – Support for reserving pages of NSS or DCSS space

    • Example: Use with the Monitor Segment (MONDCSS)

  – Ability to limit the overall number of reserved pages for a system

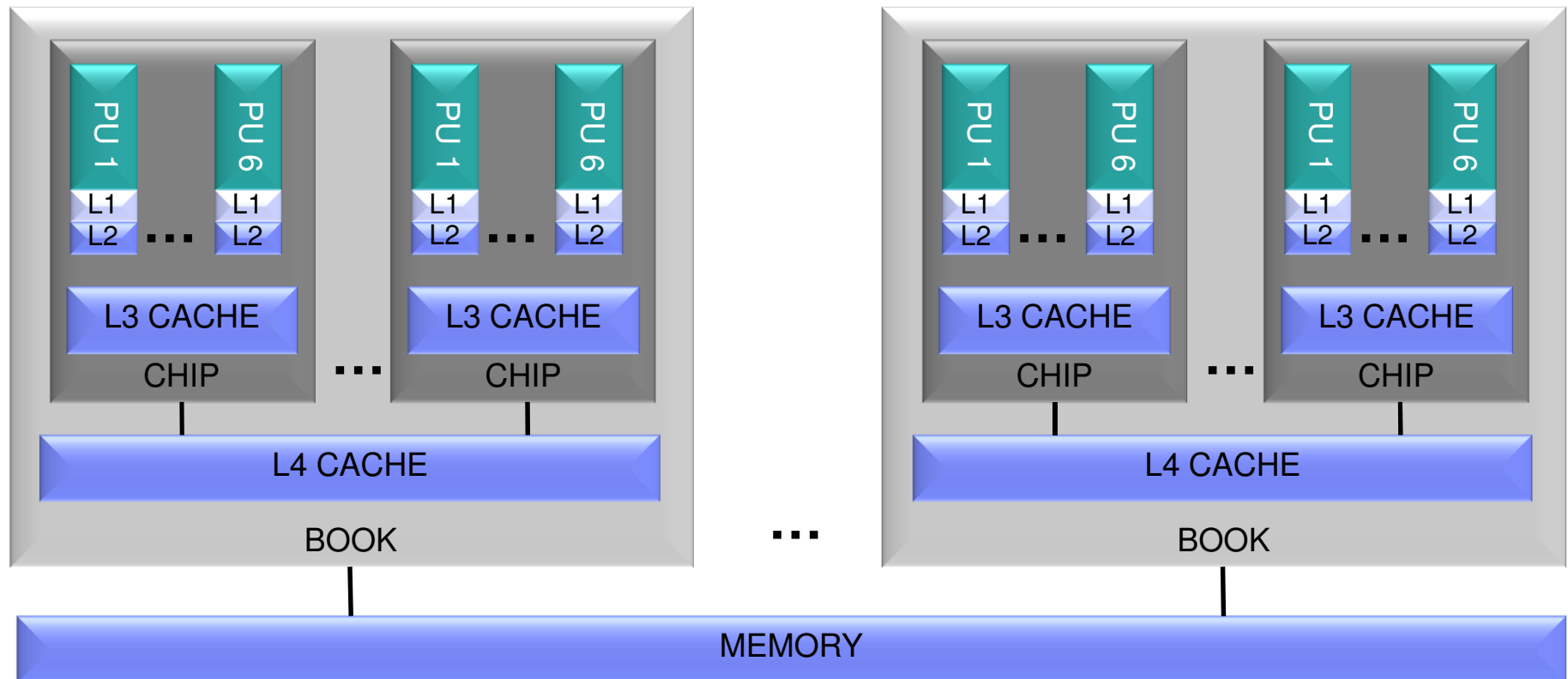# HiperDispatch

- **Improves processor efficiency**

  – Better n-way curves

    • Supported processors limit remains at 32

  – Better use of processor cache to take advantage of cache-rich system design

- **Two components:**

  – Dispatching Affinity: dispatching cognizant of processor cache topology

  – Vertical CPU Management: cooperation with PR/SM to distribute physical processor resources to logical processors more efficiently for some configurations

HiperDispatch: Dispatching Affinity

- **Processor cache structures become increasingly complex and critical to performance**

- **Goal is to re-dispatch work close (in terms of topology) to where it last ran**

HiperDispatch: Dispatching Affinity

- **Dispatcher changed to be aware of the cache topology and dispatch work accordingly**
  - Dispatch virtual CPU near where its data may be in cache based on where the virtual CPU was last dispatched
  - Keep virtual CPUs of the same virtual machine near one another

- **Potentially increases cache efficiency, lowering processor costs by reducing CPI (Cycles Per Instruction)**

- **Previously, z/VM used soft affinity to processor in dispatching virtual CPUs**
  - No awareness of chip or book

HiperDispatch: Vertical CPU Management

- **Attempts to align system workload processor resource requirements to a minimal number of logical processors to improve efficiencies of system management and cache use**

- **Currently, horizontal management, weight of LPAR processor type evenly distributed across the logical processors of the z/VM LPAR**

- **Example Scenario:**

  - 10 Physical IFLs

  - LPAR A: 7 Logical IFLs, Weight of 400 out of 1000

  - LPAR A's entitlement is 4 IFLs so 7 is more than necessary if it only gets its entitlement

  - z/VM & LPAR will cooperate

    - z/VM will concentrate the workload on a smaller number of logical processors
    - LPAR will redistribute the partition weight to give a greater portion to this smaller number of logical processors

Summary

z/VM Performance Update: Summary

- **z/VM 6.2: SSI and LGR, plus more**

  – Horizontal Scaling with SSI Clusters

  – LGR – Mobility done right

  – Recognition of systems becoming larger

    • Memory management improvements
    • Better defaults: MONDCSS, SAMPLE CONFIG, STORBUF

  – Lots of good service rolled into the base

  – See http:/www.vm.ibm.com/perf/ for more details

- **z/VM 6.3: Growing z/VM to meet growing needs**

  – Large memory

  – HiperDispatch

Upcoming Education – Events/Conferences
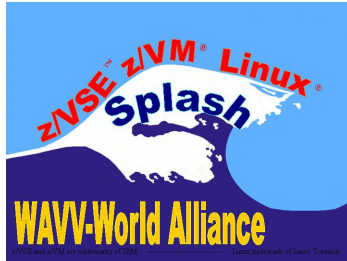
WAVV – World Alliance of VSE, VM, Linux Users

April 7 – 10, 2013

Covington, KY (right outside Cincinnati, OH)

Reg Fee $400, Embassy Suites $99 + breakfast

More info: http://www.wavv.org

IBM System z Technical Symposium

May 8 – 10, 2013 in New Orleans, LA

Two Events, One Location, One Price:
Co-located with IBM Power Systems™ Technical Symposium

Info: www.ibm.com/training/us/symposium/systemz

IBM System z Technical University

June 10 - 14, 2013
Munich, Germany
Info: www.ibm.com/training/conf/systz

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